EXCESS VOLATILITY OR VOLATILE FUNDAMENTALS?

THE IMPACT OF FINANCIAL SPECULATION ON COMMODITY MARKETS AND IMPLICATIONS FOR COCOA FARMERS IN GHANA

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Declaration for SOAS PhD thesis

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Abstract

The rising prices and high volatility in commodity markets, observed since 2002, have triggered a debate about whether these dynamics are in excess of what could be explained by market fundamentals alone. It has been argued by many that the price dynamics generated are linked to the behaviour of financial investors, in particular to that of a new class of investors known as index traders. This has given rise to two questions: firstly, what explains this high price volatility and, secondly, what are the implications of such price volatility for commodity producers?

To answer the first question, this thesis investigates the relationships between dynamics in cash and futures prices, and between dynamics of futures with different maturities for selected grain and soft commodities using time series econometrics. By analysing the relationships between price series that follow common market fundamentals, price dynamics generated by non-market fundamental factors can be identified. To answer the second question, cocoa producers in Ghana were chosen for a case study, and semi-structured interviews with stakeholders in the cocoa–chocolate chain were conducted. These interviews revealed the institutional structure of the cocoa chain and the nature of transactions across the different chain nodes.

Chapter 1 contextualises the research and develops research questions. Chapter 2 presents a review of theoretical and empirical literature relevant to the first research question. Chapter 3 empirically tests assumptions about traders' behaviour underlying the relevant theories. Chapters 4 and 5 provide investigations into the influence of different investor groups on price dynamics in commodity futures markets. Chapter 6 presents an institutional theory for price relevant to the second research question. With reference to this theory, Chapter 7 discusses the case of the Ghanaian cocoa sector. Chapter 8 summarises key findings and discusses implications for theories and policies, as well as for future research.

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List of Abbreviations

ADF	Augmented Dickey-Fuller
ADM	Archer Daniel Midland
AFCC	Association Francais du Commerce des Cacaos
AR	Auto Regressive
ARDL	Autoregressive Distributed Lag
ARIMA	Autoregressive Integrated Moving Average
BC	Barclays Capital
BIS	Bank of International Settlements
CAL	Cocoa Association London
CAPM	Capital Asset-pricing Model
CBOT	Chicago Board of Trade
CFTC	US Commodity Futures Trading Commission
CIT	Commodity Index Trader Supplement
CMAA	Cocoa Merchants' Association of America
CMB	Cocoa Marketing Board
CMC	Cocoa Marketing Company
CMWAC	Commission on the Marketing of West African Cocoa
COT	Commitment of Traders Report
CPC	Cocoa Purchasing Company
CPP	Convention People's Party
CRADF	Co-integrating Regression ADF
CRIG	Cocoa Research Institute Ghana
CSSVSC	Cocoa Swollen Shoot and Virus Disease Control Unit
DCOT	Disaggregated Commitment of Traders Report
ECM	Error Correction Model
ECX	Ethiopian Commodity Exchange
FAO	United Nations Food and Agricultural Organisation
FAVAR	Factor-augmented VAR
FCC	Federation of Cocoa Commerce
FED	Federal Reserve
FOB	Free on Board
GARCH	Generalized Autoregressive Conditional Heteroskedasticity
GATT	General Agreement on Tariffs and Trade
IATP	Institute for Agriculture and Trade Policy
ICA	International Cocoa Agreement
ICCO	International Cocoa Organisation
ICO	International Coffee Organsiation
IFS	International Financial Statistics
IMF	International Monetary Fund
ITC	International Trade Centre
KPSS	Kwiatkowski-Phillips-Schmidt-Shin
LBA	Licenced Buying Agent
LBC	Licenced Buying Company
NGO	Non-governmental Organisation

OECD	Organisation for Economic Co-operation and Development
OTC	Over the Counter
PBA	Producer Buying Agency
PNP	People's National Party
PP	Phillips-Perron
PPRC	Producer Price Review Committee
QCD	Quality Control Division
TCC	Tropical Commodity Coalition
UCA	United African Company
UGFCC	United Ghana Farmers' Council Co-operative
UK	United Kingdom
US	United States
USDA	United States Department of Agriculture
VAR	Vector Autoregressive
WAPD	Western Africa Programmes Department
WTI	West Texas Intermediate

Chapter 1 Introduction

1.1 Introduction and Motivation

Two decades of low prices of primary commodities came to an end in 2002 when prices across commodity markets experienced a steep and synchronised upward trend, peaking in 2008. The subsequent global financial crisis unleashed a 'free fall' of prices, which was followed by a short period of stabilisation and a bounce back of some prices to almost pre-crisis levels in 2011 (Figure 1.1). Although debates have started as to whether or not the increase in terms of real prices was unprecedented, volatility surely was extraordinary (Figure 1.2).

Figure 1.1: Commodity Market Prices
(monthly indices of nominal prices 2005=100, Jan. 2005–Apr. 2014)

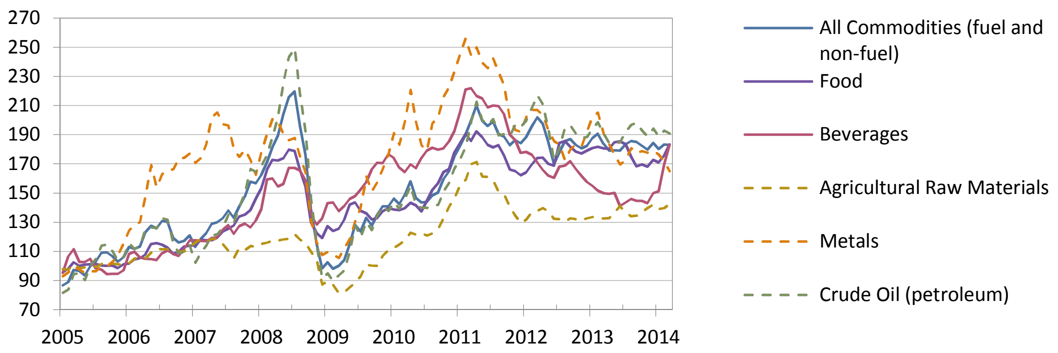
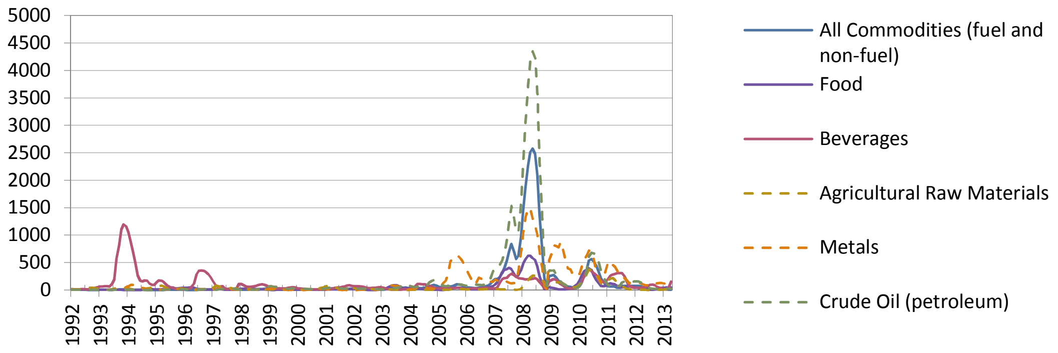


Figure 1.2: Commodity Market Volatility
(12 months centred moving variance of price indices, Jan. 1992–Apr. 2014)



Source: International Monetary Fund (IMF), International Financial Statistics (IFS): Commodity Indices (author's calculation).

General equilibrium theory explains co-movements of seemingly unrelated commodities and extreme price volatility, as observed in Figures 1.1–2, by strong systematic factors in commodity market fundamentals and intrinsically low short-run supply or demand elasticities. Low elasticities can lead to substantial price hikes or falls from small supply and demand disruptions (Labys, et al. 1991, 4-5). Within this theoretical framework, *market fundamentals* are factors that drive supply and demand of fully rational, utility-maximising agents. A commodity's *fundamental value*, then, refers to the hypothetical price at which the physical commodity would trade in the general market equilibrium of a perfectly efficient market.

Regarding the price trends in the past decade, it is argued that commodities have entered a 'super price cycle', spurred by increasing demand from emerging market economies, which has reversed previously decreasing terms of trade (Kaplinsky 2006). On the supply side, (1) low investment in the preceding decades of the 1980s and 1990s, (2) low world stock inventories during 2007–08, (3) increasing costs of transportation and production due to rising fuel prices (Baffes 2007), and (4) a depreciation of the dollar against other major currencies have further accelerated the price increase (Jumah and Kunst 2001). For agricultural commodities, (1) the shift of arable land from food production to production of biofuel, (2) the effects of climate change, and (3) the repercussions from two decades of market liberalisation that has left an 'institutional vacuum' in many producer countries are additional factors contributing to high prices (Nissanke 2012a).

Although these factors are widely accepted as influential, doubts have been raised about whether they are sufficient to explain anomalies like the synchronised price movements and unprecedented volatility in commodity markets over the last decade—see Basu and Gavin (2011) and Frenk (2011). Due to the difficulty of fully attributing price dynamics to developments in market fundamental factors, various researchers have suggested that the applications of novel investment instruments and strategies have caused a structural break in market behaviour. The arrival of formerly excluded trader types in commodity derivatives markets, such as index traders, precipitated these instruments and strategies. Structural breaks are reflected in 'excess' volatility and 'excess' co-movement of commodity prices—that is, price dynamics that are in excess of what can be explained by market fundamental factors (Institute for Agriculture and Trade Policy (IATP) 2011; Nissanke 2011; 2012a).

As hypothesised by Mayer (2009), the renewed interest[1] of financial market investors in commodity markets can be attributed to: (1) a general shift in portfolio strategies since the early 2000s; (2) the fact that commodity futures, due to their low correlation with stock markets, were found to have favourable diversification properties if added to a portfolio; and (3) possibilities of gaining higher returns on price trends and volatility in commodity

[1] In the 1970s primary commodity futures markets had already seen a substantial increase in investment interest, and this phenomenon, similar to today, triggered a debate about a causal link between price volatility and investment activity (Labys and Thomas 1975, Maizels 1992). However, the situations differ in the scale of investment inflow and the nature of investment instruments used.

futures markets against the background of a low-interest-rate environment. Different from previous episodes of financial liquidity inflow into commodity futures markets, desired exposure to commodities is achieved mainly through investing in commodity index funds. For US commodity futures markets, the Commodity Futures Modernization Act in December 2000 made possible the availability and spread of index-based and other more complex instruments (US Commodity Futures Trading Commission (CFTC) 2008; Frenk 2011).

The phenomenon of an unprecedented inflow of financial investments into commodity derivatives markets and, in particular, futures exchanges associated with the entry of speculative traders applying new investment instruments and strategies shall be referred to as the *financialisation* of commodity derivatives markets in this thesis. This interpretation of the term 'financialisation' follows the United Nations Conference on Trade and Development (UNCTAD 2009; 2011) and should not be confused with a wider literature on financialisation, which refers to the 'growing importance of financial motives, financial markets, financial actors and financial institutions' (Epstein 2005, 3). Although these developments are linked (Newman 2009), the thesis focuses on the investment aspect.

Speculation, in this context, is defined as any buying or selling in the futures or the physical markets that is motivated by an expected gain through a future change in the price relative to the going price and not by an expected gain through the use of the commodity or any kind of transformation or transfer between different markets (Kaldor 1939). A *speculator* is someone whose main business does not involve the sale, acquisition, use, or transformation of the physical commodity. Following these definitions, commercial hedgers, active in commodity futures markets, are not speculators, but can engage in speculation in both the physical and the futures market. Non-commercial traders, active in commodity futures markets, whose main line of business does not involve the sale or acquisition of the physical commodity, are always speculators and engage in speculation. Hence, speculators always trade speculatively, while not every trader who speculates is a speculator per se.

At the heart of the *financialisation hypothesis* is not necessarily the novelty of the instruments but rather the general detachment of investment strategies from market fundamental factors. In this context, proponents of this hypothesis argue that such speculative investments cause commodity futures prices to divert from their fundamental value and commodity markets to progressively behave like asset markets (Domanski and Heath 2007). This thesis presents empirical evidence in support of this hypothesis; however, it substantiates and amends it in important ways.

The growth in the activity of commodity derivatives markets since the early 2000s is indeed impressive. As estimated by the Bank for International Settlements (BIS)[2], the volume, in US dollars, of commodities traded over-the-counter (OTC)[3] increased more than 12-fold (Figure 1.3). Over the same time period, the number of contracts outstanding on commodity exchanges almost quadrupled between 2002 and 2008 (Figure 1.4). In the aftermath of the 2008 crisis, the appetite for OTC products decreased, but the number of exchange-traded contracts grew continuously. However, the jump in exchange-traded contracts in 2013 does not solely reflect new liquidity, but is partly attributable to a change in regulations for US commodity markets, which dictated clearing for swaps previously traded OTC. Contracts hence existed already, but only became visible in 2013 (Heidorn, et al. 2014).

Figure 1.3: Amount of Outstanding Commodity-linked Derivatives (in trillions of US$, 1998–2014)

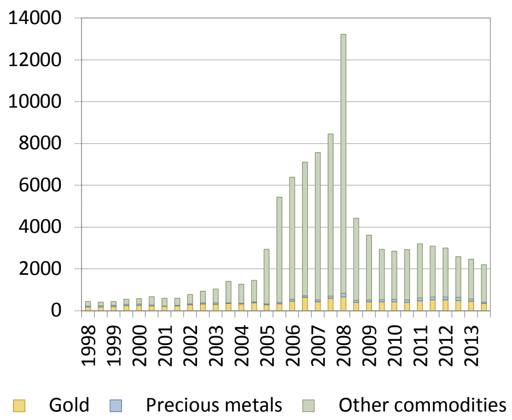
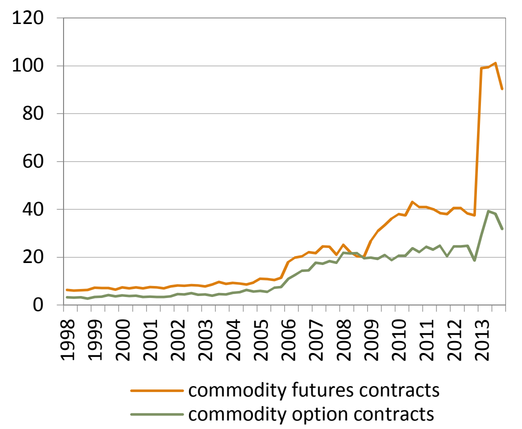


Figure 1.4: Number of Outstanding Commodity Exchange Contracts (in millions of contracts, 1998–2014)



Source: BIS, 2014, BIS Quarterly Review: OTC Commodity Derivatives & Exchange Derivatives.

Given the almost explosive liquidity inflow, the narrative of the latest commodity crisis opens parallels to well-known, self-fulfilling crisis models, drawn from experiences in currency markets (Nissanke 2012a; 2012b). The global savings glut provided money at a low cost, which, spurred by a low-interest environment, led to increasing investments in derivative instruments by traders in search of higher returns. The liquidity poured into commodity derivatives could not be fully absorbed, causing prices to increase excessively. Conversely, the anticipated recession and the resulting tightened credit conditions led to massive liquidations and triggered a synchronised price fall across commodities.

[2] Data is based on semi-annual reports of 13 countries and triennial data of another 34 countries (BIS 2013).
[3] OTC refers to contracts that are not cleared via registered exchanges, but traded privately.

However, this conjecture remains contested. The five points, outlined below in italics, condense the main arguments put forward *against* a causal relationship between the latest liquidity inflow and price dynamics in commodity futures markets (Hailu and Weersink 2011). The arguments are contrasted with counter arguments in non-italicised text:

(1) A speculative bubble must be accompanied by a rise in inventory holdings (Hamilton 2009). *This is because, although the cash price could be forced to increase by futures price movements through arbitrage, a price level above the market fundamental value can only be sustained by artificial scarcity*[4]*. However, for some commodities inventories were depleted during the price rise* (Irwin and Sanders 2011).

Inventory depletion only occurred in metal and energy markets (Korniotis 2009; Pirrong 2008). For other commodity markets, inventory holdings increased during the pre-2008 price rise (Lagi, et al. 2011). As metals and oil, unlike non-extractive resources, can be stored below ground, non-extraction has the same effect as inventory build-up. Hence, these cases do not serve as a convincing argument against the financialisation hypothesis (Caballero, Farhi and Gourinchas 2008).

(2) For the reason that futures traders take the counter position of any contract opened, there is no limit to the number of futures contracts possibly bought and sold at any given price level. Therefore, there is no excess in demand or supply that could cause price changes (Krugman 2011).

While there is no limit to the number of contracts that can potentially be cleared at any commodity exchange, demand for long over short positions will lead to higher prices in order to attract new shorts for the market to clear, and *vice versa* (Petzel 2009). As in any other marketplace, prices will move in order to attract the more scarce counterparty (Daigler 1994). If counterparty positions are less than perfectly elastic, prices can change substantially (Mayer 2009).

(3) Index investments are predictable and, as such, cannot have any (prolonged) price impact. Other market participants always know that the liquidity added by index traders is unrelated to market fundamentals. Since prices are ultimately driven by traders' expectations, prices do not change in response to a change in index traders' positions (Irwin and Sanders 2010).

Although market participants are possibly aware of the presence of index investors, as well as the timing of their repositioning, the market entry and exit decisions of index traders are unpredictable (Irwin and Sanders 2012).

[4] An alternative possibility is a perfectly inelastic demand, which might be the case in the short-run but probably not in the long-run.

(4) If index trading caused the 2002–08 price rise and price volatility, these effects should be more pronounced in commodity markets with larger index trader participation than in markets with few index investments. However, commodities that lack futures markets completely, or have only thinly traded futures markets, saw similar price dynamics over the same period (Redrado, et al. 2009; Stoll and Whaley 2011).

There is a substantial selection bias when comparing price behaviour in commodity markets with large index investments against price behaviour in commodity markets with low index trader participation. Commodity markets with low or no index participation either lack futures exchanges or have only thinly traded futures markets. Thinly traded markets have always been more volatile than liquid markets. Furthermore, physical markets are prone to political interventions, as evidenced by the example of rice, for which export bans in several countries were imposed in 2008 in the wake of rising food prices (Timmer 2009). Last, but not least, if one commodity is a close substitute to another commodity with a liquid futures market, cross-price elasticity is likely to result in higher prices for the substitute as well.

(5) With reference to Working's T-index, which is commonly used to measure the excess of speculators relative to hedgers (Working 1960)*, it is argued that the presence of speculators is not excessive when compared to historical data* (Buyuksahin and Robe 2014; Sanders, Irwin and Merrin 2010).

However, the trader-position data used for the T-index's calculation is not equivalent to trading behaviour, and the index does not distinguish between index and other speculative traders. Although historically, speculators' market weight might have been non-excessive, speculative trading may have shifted towards strategies which are more unrelated to market fundamentals. Moreover, speculators (except index traders) often follow short-term trading strategies, which implies that they frequently close out their positions at the end of the trading day. Therefore, although open interest data by speculators at the end of the trading day, on which the T-index is based, is small, speculators' trading volume during the day might be large.

For each argument against the financialisation hypothesis, counterarguments can be presented. Therefore, objections against the hypothesis are fragile. Yet, the exact mechanisms by which the financialisation of commodity derivatives markets affects price dynamics in commodity markets—derivatives and physical—is not well understood. One reason for this lack of comprehension, as argued in this thesis, concerns confusion between two different strands of literatures. Proponents of the financialisation hypothesis explain price dynamics in commodity futures markets with reference to asset-pricing theories.

Opponents of the financialisation hypothesis explain price dynamics in commodity markets with reference to general equilibrium and rational expectation models. Both strands of literature, however, lack a framework that takes into account the commodity market's specific interplay between futures, cash and inventory markets and the implications for price formation. When this interplay is considered in the literature, deliberations are tangential, without a deeper understanding of how speculative mechanisms in both markets can feed on each other.

This gap in the literature is particularly surprising, since the link between financial and commodity markets is thought to have served as the main transmission channel of the financial meltdown in 2008 to world trade and the real economy, with severe consequences for food security and income for some of the world's poorest (Nissanke 2012a). Rising fuel and food prices sparked social and political unrest globally, and the livelihoods of the poor were particularly hard hit (Harrigan 2011). The sharp decline in prices in mid-2008 threatened the income of smallholder commodity producers and the stability of those developing countries, which are heavily reliant on primary commodities for exports.

Commodity futures markets fulfil two main welfare-enhancing functions, which are price discovery and risk management. If the claim of the financialisation hypothesis proves to be true, these critical functions are compromised. A failure of futures markets in performing these functions does not only have ramifications for the stakeholders of the particular commodity sector, relying directly or indirectly on these functions for their businesses and livelihoods, but the failure further undermines the very legitimacy of commodity futures markets. Further, in this scenario, the reliance of market practitioners on futures market prices as a yardstick is misguided. While the preservation of these core functions is crucial, malfunctioning—often not considered in the existing debates—can have detrimental effects on the commodity sector as a whole, as well as on those countries depending heavily on primary commodities for imports and exports.

The remainder of this chapter is divided into three sections. Section 2 presents the research questions, and the hypotheses and methodology, which aim to answer these questions. Section 3 discusses the main contributions of this thesis in the context of the broader debate in the literature. Finally, Section 4 presents the structure of the thesis and provides a short description of each chapter of this thesis.

1.2 Research Questions and Hypotheses

Against the background of the discussion in Section 1, this thesis is guided by one overarching research question and two hypotheses:

Question—How, and in what way, are commodity prices affected by the latest episode of financialisation?

> **Hypothesis 1 (H1)**—Commodity futures markets are increasingly driven by speculative liquidity, leading to these markets behaving like asset markets and price dynamics becoming unrelated to commodity markets' specific fundamentals.
>
> **Hypothesis 2 (H2)**—These price dynamics in futures markets both directly and indirectly affect price dynamics in the physical market, and speculation in both markets feeds on each other.

Two sub-questions (Q1 and Q2), which decisively guide the structure of this thesis, are derived from the main question.

Q1—How, and in what way, is price formation in commodity futures markets affected by financialisation?

> **H1.1**—Price formation in commodity futures markets is driven by traders' expectations that, in turn, inform investment strategies.
>
> **H1.2**—Investment strategies based on expectations unrelated to market fundamentals materialise empirically in excessive volatility, and other anomalies in market basis[5] and market term structure[6] occur.

Q2—How, and in what way, do price dynamics in commodity futures markets affect commodity sectors and, in particular, commodity producers and producing countries?

> **H2.1**—Price dynamics in the financial market spill over to the physical markets not only through arbitrage and traders' expectations, but also through the institutional framework, which guides price formation and risk allocation processes in a commodity sector.

[5] The basis is the difference between the underlying cash price of a commodity and the price of the respective futures contract at any given point in time $[B_t = S_t - F_{t,T}]$.

[6] The term structure refers to the price structure of simultaneously traded futures contracts with different maturity dates.

H2.2—If there are asymmetric power relationships within a commodity sector, market risk and price pressure are passed on to the weaker end of the commodity chain.

H2.3—In the case of cash crops and agricultural commodities, this weaker end is comprised of farmers.

The overarching research question and two sub-questions are assessed empirically on the example of soft and agricultural commodities, which differ in their exposure to financial investments, nature of the commodity and structure of the commodity sector.

Regarding Q1, the International Commodity Exchange (ICE) cocoa ('cocoa', hereafter) is analysed in comparison with ICE Arabica coffee 'C' ('coffee', hereafter) and the Chicago Board of Trade (CBOT) soft red winter wheat ('wheat', hereafter). Time series econometric techniques and other non-parametric techniques are chosen in order to investigate trader behaviour and the relationship between financial investments and price dynamics.

Regarding Q2, Ghana's cocoa sector, the second largest globally in terms of production, serves as a case study. Semi-structured interviews were conducted with stakeholders in the Ghanaian and global cocoa sector. On the basis of these interviews the institutional structure of the global and Ghanaian cocoa sector is identified.

Cocoa and coffee production is confined to a small area around the equatorial belt. Production cycles are highly sensitive to climate conditions and the political stability of the few producing countries. Therefore, these markets have always been highly volatile. While cocoa and coffee supply patterns are similar due to the physical resemblance of the crops, coffee futures markets saw a greater inflow of financial investments than cocoa futures markets. These commodities hence make a good comparative case study on anomalies in the market term structure, which is driven by supply cycles as well as financial investments. The CBOT soft red winter wheat market is one of the most liquid commodity futures and saw the second highest inflow of index-based investments between 1992 and 2008, only after crude oil (CFTC 2008). The wheat market is therefore a prime choice for an investigation into the impact of index investments on price dynamics.

As the availability of trader-position data—an essential ingredient for the empirical analysis—is confined to US markets, only US-based commodity futures markets are analysed in the context of Q1. Data availability further confines the analysis to particular categories of trader-position data. Publicly available[7] trader-position data is highly aggregated into predefined categories. These categories can only serve as an approximation of trading strategies, which are subject to the following analyses.

The approximation to trading strategies by aggregated position data, as shall be shown later in this thesis, is relatively precise for index traders, but not for other traders. While index traders have played an important role in the latest commodity price cycle due to their large market weight and deserve particular attention due to their relatively recent arrival in commodity futures markets, other speculative traders are equally important. However, due to the heterogeneity of trading strategies employed by traders in the remaining predefined categories, statistical inference about the impact of these traders on price dynamics is impeded. The focus of the empirical analyses is hence on the role of index traders with some imploratory insights into the role of other speculative traders.

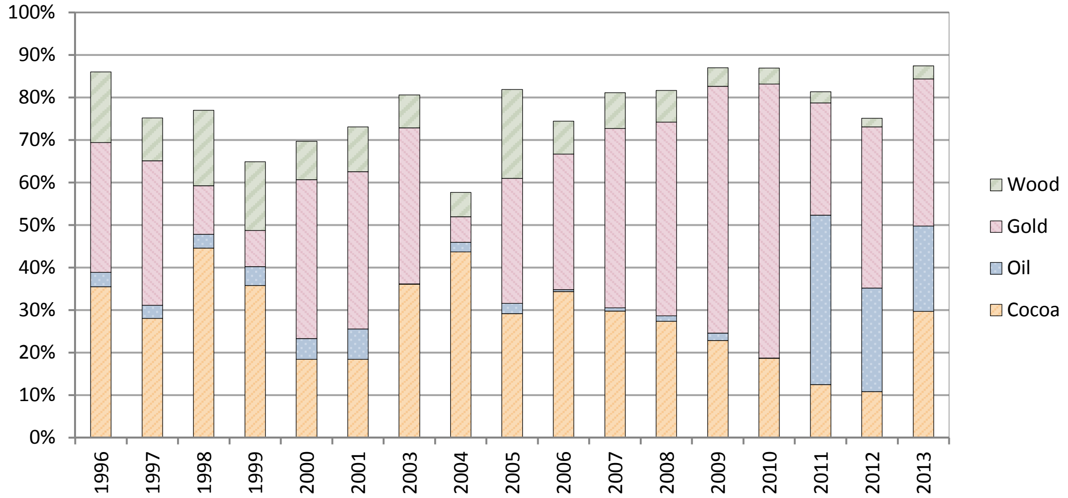
Cocoa is chosen as a case study with respect to Q2. In the case of cash crops like cocoa, the implications of price volatility and malfunctioning of futures markets are highly developmental. Major cocoa growing regions are located in West Africa, South America and Southeast Asia. Price fluctuations, therefore, affect the economies of some of the world's poorest countries. Secondly, cocoa, especially in West Africa, is a smallholder crop, providing livelihoods for 40 to 50 million people, and producer prices directly affect rural family income (UNCTAD 2008). Thirdly, the cocoa–chocolate chain is highly centralised in the hands of few multinational grinders[8] and brand-name companies. In 2010 five companies controlled more than 50 per cent of the market for export and processing, while another five companies controlled almost half of the world's total confectionary sales (Tropical Commodity Coalition (TCC) 2010). Since then, market concentration, especially in the grinding segment, has grown even further with three more mergers among the ten biggest companies in the trading, grinding, and processing segment. Cocoa trade is hence a prime example of asymmetric bargaining power.

Ghana, as the second largest cocoa producer globally, depends heavily on the sector for foreign exchange earnings and trade income (Figure 1.5). Further, the Ghanaian cocoa sector is a particularly interesting case study because of its unique institutional structure. As the only cocoa-producing nation that has withstood the pressure from international donors to fully liberalise its cocoa sector, Ghana, through its cocoa marketing board ('Cocobod', hereafter), maintains a monopoly on Ghanaian cocoa beans in the world market. This

[7] Non-aggregated trader-position data exists, but is not publicly available and the researcher was denied access upon request, due to the sensitivity of the data.
[8] Companies who process raw beans into cocoa powder, liquor, butter and even finished chocolate.

arguably has implications for market power and price formation, as well as risk allocation processes within the Ghanaian cocoa sector and the global cocoa market.

Figure 1.5: Ghana's Export Earnings
(annual composition % share, based on US$ values, 1996–2013)



Source: Comtrade Database (author's calculation).

Moreover, taking Ghana's cocoa sector as a case study is especially timely, as the recent commodity crisis has revived a debate about market-based price risk management for cash crop farmers (World Bank (WB) 2011). A series of projects, which have been implemented in order to empower farmers in this regard, have shown only limited success—e.g., Ethiopia Commodity Exchange (ECX) (Jayne, et al. 2014). The case of Ghana could pose an alternative to the widely promoted market-based risk management strategies (Williams 2009).

1.3 Contribution and Originality

The dissertation attempts to contribute to the literature with respect to Q1 and Q2, empirically and theoretically.

In an attempt to answer Q1, the thesis provides a synthesis of two strands of theoretical literatures: asset-pricing theories and commodity market-specific no-arbitrage models. It is argued that with the increasing inflow of financial investments into commodity futures markets, commodity futures increasingly behave like asset markets, and asset-pricing theories are needed in order to understand price dynamics observed in commodity futures markets. However, while these theories have informed the debate about the financialisation of commodity derivatives markets, they ignore the commodity-specific interplay between physical, storage and futures markets. In order to understand the complex feedback mechanisms between markets, no-arbitrage theories are taken into consideration. The synthesis of both strands of literatures allows me to incorporate the interdependence between derivatives and physical markets to show how speculation in both markets can feed on each other. Further, the synthesis facilitates a better understanding of implications of financialisation for the commodity sector as a whole in anticipation of Q2.

The empirical literature, which investigates the impact of financialisation on dynamics in commodity futures markets, predominantly focuses on price dynamics in single futures markets. Such investigations seek to identify the excess in price level and price volatility. This is an almost impossible task, since fundamental factors are either not well defined or not easily quantifiable. Hence, the extent to which a price series moves against its fundamental value is difficult to identify.

This thesis proposes an alternative approach that is based on the difference between two commodity price series, as, for instance, the futures price and its underlying physical price, or price series of futures contracts with different maturity dates. Since these pairs of price series are driven by almost the same commodity-specific fundamentals, the difference in level and variability can be attributed to factors that are specific to the particular price series, including the different composition of traders in the particular market or contract.

The composition of trading positions in the physical market differs from the futures market due to the presence of financial speculators in the latter. Further, the composition of traders differs across contracts with different maturity dates, since traders are heterogeneous in their investment interests and strategies. While some trading strategies involve taking positions in longer-dated contracts, other speculators might take positions in shorter-dated contracts. Since different traders are active in physical and futures markets and futures contracts with different maturity dates, differences in price dynamics can be linked to differences in trader composition.

This novel approach does not only enable the researcher to sidestep the difficulties associated with determining the fundamental value of a commodity, it also provides insights into the impact of speculative trading on the relationship between futures and physical markets, as well as the market term structure. Both relationships are relevant for and closely watched by market practitioners. Despite the practical relevance, these relationships have been almost neglected in the empirical literature.

The analytical framework proposed by the thesis in order to answer Q2 draws on the global commodity chain literature, which is combined with institutional economics. It is argued that although the global commodity chain framework is useful for an analysis of the institutional structure and embedded power relationships within a particular commodity sector, existing literature in commodity chain analysis at present neglects price formation, as well as risk allocation processes (Gilbert 2008b). An institutional theory on price and, in particular, the transaction theory advanced by John R. Commons (1934) is used together with global commodity chain frameworks in order to shed light on these processes.

The analytical framework is empirically backed by semi-structured interviews with key stakeholders in the Ghanaian and global cocoa sector. The interviews were conducted during three months of fieldwork in Ghana, as well as in-person contacts and telephone interviews with stakeholders in the US, Germany and the UK. These interviews provide a systematic analysis of the Ghanaian cocoa sector, which enables the researcher to link price formation and risk allocation to the evolution of the institutional structure of global, regional and national cocoa trade.

1.4 Thesis Outline

The rest of the thesis is divided into seven chapters:

Chapter 2 presents a critical review of existing theories on price formation in commodity markets in the context of the overarching research question and sub-question Q1. The theoretical literature is divided into two strands, which are arbitrage and rational expectation theories. Underlying assumptions of both theoretical traditions are outlined and critically assessed before the two strands are synthesised towards a theoretical foundation for the financialisation hypothesis, as outlined in H1 and H2. The theoretical discussion is followed by a literature review of empirical studies, which aim to test different components of the financialisation hypothesis. Shortcomings in method and methodology of the empirical literature are identified, and an outlook towards a more fruitful empirical approach is presented.

Chapter 3 provides an empirical analysis of hypothesis H1.1. Assumptions about trader behaviour are formalised, before traders' position data are analysed descriptively for the three markets serving as case studies: cocoa, coffee and wheat. A detailed discussion about the quality of the data available on traders' positions and the ability of the data to capture traders' behaviour precedes a time series econometric analysis, which tests whether traders engage in extrapolation, herding and other investment strategies unrelated to market fundamentals. The empirical analysis, together with the discussion on limitations in the available data, lay the foundation for the empirical investigations in Chapters 4 and 5.

Chapter 4 provides an analysis of the relationship between cash and futures markets with respect to hypothesis H1.2. The cocoa and wheat markets serve as case studies. Firstly, the continuous relationship between physical and futures market prices is analysed using time series econometric techniques, including Granger non-causality and co-integration analysis. It is further tested for structural breaks in the co-integrating relationship, which could indicate differences in price dynamics in both markets. Secondly, the convergence between cash and futures markets at each futures contract's maturity date is analysed using simple regression analysis. Although, no-arbitrage theories dictate convergence, non-convergence has emerged in both the wheat and the cocoa market over the last decades.

Chapter 5 further contributes to the empirical investigation into hypothesis H1.2 and presents an analysis of intertemporal pricing between futures contracts with different maturity dates. The cocoa and coffee markets serve as case studies. Firstly, the relationships between pairs of consecutive futures contracts is analysed using dynamic econometric models. Secondly, a two-step econometric method is applied, which links traders' positions and other explanatory variables to the particular shape of the futures curve. In a first step, the shape of the futures curve is extracted in a parsimonious way, using non-parametric methods. In a second step, the relationship between the shape of the futures curve and explanatory variables is estimated.

After investigating the financial markets of cocoa, coffee and wheat, Chapter 6 and 7 present, with reference to Q2, an analysis of the relevance of price dynamics in the futures market for the commodity sector as a whole, taking the Ghanaian and global cocoa sector as a case study.

Chapter 6 develops an analytical framework that enables the researcher to reveal the institutional structure governing price formation and risk allocation mechanisms at all stages of a commodity sector in the context of hypothesis H2.1. Towards this aim, the global commodity chain and value chain literature is critically reviewed and combined with institutional theories of price formation and, in particular, with the work of John R. Commons (1934).

Chapter 7 presents a case study of the Ghanaian cocoa sector in the context of hypotheses H2.2 and H2.3, and with reference to the analytical framework outlined in Chapter 6. The analysis commences with an assessment of the historical evolution of the institutional structures of the cocoa sector. In a second step, the structure of the Ghanaian cocoa sector is outlined, followed by an in-depth analysis of price formation and risk allocation processes at different nodes of the cocoa chain. The analysis is based on material collected through semi-structured interviews with stakeholders in the global and Ghanaian cocoa sector.

Chapter 8 concludes with a summary of the findings and discussions on implications for theory and policy, and suggests directions and issues for future research.

Chapter 2 Fundamentals versus Financialisation

2.1 Introduction

Chapter 1 hypothesised that the financialisation of commodity derivatives markets, understood as the increasing inflow of financial investments into commodity derivatives markets for portfolio diversification or speculation, has caused commodity markets to behave like asset markets. This behaviour materialises empirically in the synchronised price rise across commodity and asset markets and in the unprecedented volatility in commodity markets since 2002. These price dynamics are considered excessive, that is, in excess of what existing theories on price formation in commodity markets could explain with market fundamentals.

Existing neoclassical theories on price formation in commodity markets are based on general equilibrium and rational expectation frameworks applied to the physical commodity market. The possibility of arbitrage ensures a close relationship between physical and derivatives markets. However, these theories fail to account for price formation mechanisms in commodity futures markets beyond mechanical arbitrage relationships. For an understanding of such price formation mechanisms, asset-pricing theories are more appropriate. These two theoretical approaches are consistent in their prediction of price dynamics, as long as asset-pricing theories assume that traders' expectations in commodity futures markets are driven by fundamental factors of the underlying physical market. In that way, the consensus of futures traders' expectations coincides with general equilibrium conditions in the physical commodity market.

However, as argued further in this chapter, the validity of asset-pricing theories that link price dynamics in commodity futures markets exclusively to market fundamental factors depends on stringent and unrealistic assumptions about traders' behaviour and uncertainty. Relaxing these assumptions, in the tradition of bounded rationality, rational herding and Post-Keynesian literatures, opens the way towards a more fruitful discussion about price formation in commodity futures markets. However, these asset-pricing theories fail to incorporate the interplay between futures, cash and inventory markets. This interplay is peculiar to commodity markets and can lead to complex speculative feedback mechanisms.

Therefore, Chapter 2 aims to synthesise existing theories on price formation in commodity and asset markets in order to lay the ground for a theoretical framework for the financialisation hypothesis. It will be shown that the synthesis provides a more appropriate framework for explaining price dynamics in commodity markets, which accounts for the mechanisms through which speculative influences in physical and derivatives markets feed on each other. A thorough investigation of these mechanisms is essential to understand the impact of financialisation on price formation and risk management in commodity markets.

The remainder of this chapter is structured as follows: Section 2 reviews theories on price formation in commodity markets. While those theories capture the interrelationship between cash, inventory and futures markets, they locate the price formation process in the physical market. Speculative influences on price formation enter through inventory hoarding in the storage market. Section 3 reviews theories on price formation in asset markets. It is shown that by easing some of the stringent assumptions of the neoclassical rational expectations framework, price dynamics such as excessive volatility and speculative bubbles can be explained by financial traders' heterogeneous investment strategies. Speculative influences on price formation processes enter through financial traders' behaviour. Section 4 provides a synthesis of the two theoretical approaches on price formation. Synthesising both literatures allows me to construct a theoretical foundation for the financialisation hypothesis of commodity markets, which accounts for the dynamic interplay between physical and futures markets and for the speculative influences in both markets. Section 5 provides a critical overview of methodologies used in empirical studies on the influence of financial investments on price dynamics. The chapter concludes in Section 6 by identifying gaps in the existing empirical literature and suggesting ways forward.

2.2 Theories on Price Formation in Commodity Markets

Historically, two strands of theories describe the dynamics of price formation in commodity markets: the *theory of storage* ascribed to Kaldor (1939), Working (1949) and later, to Brennan (1958), and the *theory of normal backwardation* advanced by Keynes (1930) and Hicks (1939). In both theories, prices are understood to be discovered in the physical markets in a general equilibrium framework, while the possibility of arbitrage ensures alignment of the futures price[9] to its underlying physical market.

A simple no-arbitrage condition between the futures and the cash price, which is the price in the physical market for immediate delivery[10], therefore builds the foundation of both

[9] Originally, these concepts were developed on the relationship between the physical and the forward price, not the futures price. However, subsequent literatures have adopted the formal representation to describe the relationship between cash and futures markets—e.g., Hull (2011), Geman (2005), and Fabozzi, Fuss and Kaiser (2008).

[10] The 'cash price' is often denoted as 'spot price'. In the literature, the spot price is commonly approximated with the closest-to-maturity futures price. Since the following debate emphasises the distinct dynamics in the physical and derivatives market, we will retain the term 'cash price'.

theoretical strands. If no riskless arbitrage opportunity exists, the futures price must equal the cash price plus a compensation for the 'carry cost proper' (Kaldor 1939). The 'carry cost proper' consists of the opportunity costs incurred by buying the physical commodity now, i.e., the forgone risk-free interest rate[11] $[r_{f\ t,T}]$ and the storage costs $[w_{t,T}]$ for carrying it until the futures contract's maturity date. Let t be the current point in time and T the futures contract maturity date, then the no-arbitrage condition between the futures price $[F_{t,T}]$ and cash price $[S_t]$ can be written as[12]:

$$F_{t,T} = S_t(1 + r_{f\ t,T}) + w_{t,T} \qquad (2.1)$$

As the carry cost proper approaches zero with $t \rightarrow T$, the futures price at maturity equals the cash price at time T. If this were not the case, risk-free arbitrage opportunities would arise. Hence, Equation 2.1 must always hold under the law of one price (see Appendix 2.1 for a discussion). However, empirical data have shown that futures and cash prices do not necessarily comply with this law. In particular, the situation in which the futures contract trades below the cash price (backwardation) has received some attention, since according to Equation 2.1, futures contracts are bound to trade above the cash price (contango) at all times (as $r_{f\ t,T}, w_t \geq 0$). The theory of storage and the theory of risk premium offer two distinct, although complementary, explanations for deviations from Equation 2.1. Those two theories shall be discussed in turn.

2.2.1 Theory of Storage

The theory of storage explains backwardation with the distinct economic properties of the physical good compared to its derivative. Kaldor (1939) was first to argue that 'net carrying costs' are also determined by a utility-based reward ('yield of goods') from owning a commodity, which must be subtracted from the carry cost proper. Hence, the compensation for holding the commodity consists of the carry cost proper $[r_{f\ t,T} + w_{t,T}]$ less the yield of goods or 'convenience yield' $[\varphi_{t,T}]$, which is received because of the flexibility gained from holding inventories (Brennan 1958). Kaldor (1939) argues that if *speculative stocks* – that is, stocks that exist in excess of what is required for normal business – are positive, net carrying cost (carry cost proper minus convenience yield) is likely to be

[11] While the theory refers to the risk-free rate, empirical research usually considers the LIBOR rate instead. The LIBOR rate is more appropriate in applied studies, since for the execution of an arbitrage trade, one has to borrow money in order to buy the physical commodity.

[12] The equation is a simplification valid for linear rates—see Pindyck (2001), Hernandez and Torero (2010). In more general terms, the futures price can be rewritten as the continuously compounded cash price, following Hull (2011, 123-5): $F_{t,T} = S_t e^{(r_{f\,t} + w_t) * \tau}$, with $\tau = T - t$. As the carry cost proper approaches zero with $t \rightarrow T$ and hence $\tau \rightarrow 0$, the futures price at maturity must equal the current cash price.

positive, and if the stocks are zero, net carrying cost is likely to be negative. Therefore, the market would 'normally' be in contango, accounting for the cost of carry, and in backwardation only if the convenience yield strongly exceeded the costs associated with storing the commodity. That is the case when speculative stocks are depleted (Working 1949). Extending Equation 2.1, accordingly, yields:[13]

$$F_{t,T} = S_t\left(1 + r_{f,T}\right) + (w_{t,T} - \varphi_{t,T}) \qquad (2.2)$$

The futures price is thus determined by the cash price, the foregone interest rate over the period *t* to *T*, physical storage cost over the same period and utility gained from inventories. Equation 2.2 implies that if the convenience yield is high, the market basis is strongly positive. The net storage cost determines if cash prices exceed futures prices ($w_{t,T} - \varphi_{t,T} \ll 0$, strong backwardation and positive market basis) or futures exceed cash prices ($w_{t,T} - \varphi_{t,T} > 0$, contango and negative market basis)[14]. While the extent of backwardation has not a limit, a contango has its maximum in the carry cost proper (Lautier 2005). A negative basis, in theory, cannot exceed $w_{t,T}$ (with $\varphi_{t,T} = 0$; physical full carry[15]), while a positive basis depends on the 'size' of the convenience yield.

The convenience yield found multiple interpretations in the literature. Kaldor (1939) originally introduced the yield as the inverse of Keynes 'own rate of interest'. Keynes (1936, 142-54) argues that every durable commodity has a "rate of interest in terms of itself". The nature of the commodity rate of interest is, according to Keynes, commodity-specific and is constituted by the yield or output that a commodity produces by assisting some production or supply service and by its power of disposal, that is, its liquidity premium. Since commodity futures are denominated in money terms and not commodity terms, the difference between two futures contracts in money terms reflects both the own rate of interest of money and the own rate of interest of the commodity. Although not explicit in Keynes's writings, this leads to the functional form as specified by Kaldor (1939)—see Appendix 2.2 for a discussion. Hence, in Keynes's terms, the convenience yield is determined by the demand for the physical commodity relative to money.

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[13] For non-linear rates, (Hull 2011, 120-1): $F_{t,T} = S_t e^{(r_{f\,t} + w_t - \varphi_t) * \tau}$.

[14] If the net convenience yield is zero, the cash price equals the discounted futures price: $S_t = F_{t,T}/(1 + r_{f,t})$. If the cash price is less than the futures price but greater than the discounted futures price, the market is said to be in weak backwardation.

[15] Physical full carry is the situation in which the price difference between physical and futures price, or between futures prices of contracts with different maturity dates, fully compensates for the storage costs incurred.

Later authors moved away from Keynes's concept towards a utility-based explanation of the convenience yield. Brennan (1958) assigns the convenience yield to the utility received by an owner of a commodity due to the opportunity gained by taking advantage of an unexpected increase in demand. Bozic and Fortenbery (2011) and Pirrong (2011) understand the convenience yield as an insurance-like reward, which accrues to the inventory owner in times of market uncertainty. Despite the different opinions on what constitutes the convenience yield, authors agree on a close link between the yield and the storage market through an inverse relationship between the yield and the commodity's availability. Since the convenience yield converges to zero when a futures contract approaches maturity, the no-arbitrage condition implies convergence of cash and futures prices at the end of each contract's maturity.

Thus, the convenience yield links the futures market not only to the cash market but also to the inventory market. Pindyck (2001), in his structural model, formally illustrates the relationships between all three markets and shows that if a commodity is storable, the equilibrium in the physical market is not only governed by production and consumption over one period, but also by changes in inventories. Thus, for the physical market to be in equilibrium, net demand has to equal net supply. Therefore, the inverse demand function is a function of supply-and-demand-shifting variables (market fundamentals) and inventory. In reference to the convenience yield concept, Pindyck (2001) argues that consumers and producers hold inventories for precautionary reasons—to reduce costs of adjustment, to avoid running out of stock and to manage price variation. Hence, the utility gained from the insurance properties of inventory drives the demand for storage. The futures market price, in the tradition of theories of storage, is derived from the no-arbitrage condition outlined previously. It is interesting to note that in Pindyck's (2001) model the futures market does not serve a price discovery function but an information function as it reveals the size of the convenience yield and hence, storage availability, as well as agents' preferences (under the assumption that the structural model holds).

Four important insights can be derived from these deliberations. Firstly, the impact of any shift in demand for, or supply of, the physical commodity on the cash price depends on what happens to inventories, which serve as a buffer. Secondly, the convenience yield is a negative function of inventories. Thirdly, greater cash price volatility and market uncertainty will result in an upward shift in the demand for storage, as the insurance property of inventories becomes more desirable. Fourthly, greater cash price volatility also results in an upward shift of the net demand in the cash market, as greater volatility causes an increase in the value of the producers' 'operating options'[16].

These theoretical considerations are empirically endorsed by Bozic and Fortenbery (2011), who find that inventories are moving not only with levels, but also with second and third moments of prices. Their explanation is similar to Pindyck's (2001). However, they stress that the relationship between inventory and price is non-linear, since inventories can only reduce upward pressure until stock runs out. Pirrong (2011) suggests that with increasing price volatility, actors in the physical market accumulate precautionary inventories. Consequently, higher orders of commodity futures prices affect inventory management, and hence, cash prices. Deaton and Laroque (1992) develop a 'competitive storage' model, based on the consideration that traders might hold back inventories if expecting higher returns. This behaviour drives up cash prices, as conditions in the physical market tighten. Such a scenario was empirically confirmed by Singleton (2014) for the crude oil market.

In essence, the availability of inventories affects both the level and variance of the cash market price and the relationship between the cash and the futures market through the convenience yield. This triangular relationship unfolds complex feedback mechanisms. Positive price trends in volatile markets can be intensified through inventory hoarding, either because inventories serve as physical options or because they are accumulated for precautionary reasons. Further, owners of the physical commodity might hold back inventories in the expectation of a future price rise, and hence, amplify positive price trends.

2.2.2 Theory of Risk Premium

A second, arbitrage-based approach to commodity futures pricing assumes that prices should be subject to a risk premium. This idea is informed by the theory of 'normal backwardation' advanced by Keynes (1930) and based on the conjecture that non-commercial speculators demand a premium for taking on commercial hedgers' risk. Commercial traders, who hold the physical commodity over a particular time period for their regular business, can insure themselves against declining prices, i.e. a depreciation of their storage value, by entering into a short futures position. If prices decline, the gain from the short futures position, in theory, offsets the loss in the long physical position. Market actors with a future buying obligation adopt a similar hedging strategy when they take a long futures position.

[16] In a similar way to financial options, volatility imposes opportunity costs to exercising the option rather than preserving it, i.e., to selling the commodity rather than storing it.

If there were as many long hedgers as short hedgers were in the market, only commercial hedgers would be needed for the futures market to function. Since this is an unlikely scenario, non-commercial speculators are invaluable in providing liquidity. Commercial traders are not exposed to any price risk after entering into the hedging position, while non-commercial traders take on risk exposure. Keynes (1930) and later, Hicks (1939, 147-8) argued that the speculators would demand a premium for their insurance service to hedgers. Depending on the relative weight of short and long hedgers in the market, futures markets would be in contango if consumers' hedging demand exceed that of producers (more long than short hedgers are in the market), or in backwardation if producers' hedging demand exceed that of consumers (more short than long hedgers are in the market). Since Keynes assumes commercial hedgers to be short, he referred to such a situation as 'normal backwardation' (Keynes 1930). However, as noted by Kaldor (1939), the premium does not necessarily relate to backwardation, as both producers and consumers can be hedgers. Although Hicks (1939, 146) raises the same point as Kaldor, he argues in favour of the assumption of predominantly short hedging, and indeed Keynes's theory remains unchallenged for most commodity futures markets (see Chapter 3).

Working (1949) adds the profile of an arbitrageur to hedgers. He stresses that commercial traders are likely to actively position themselves in line with their market expectations, rather than passively hedge their risk exposure. He argues that hedging is both a form of arbitrage and, following the definition given in Chapter 1, speculation. While the hedger enters into the hedge if she believes that the price will move to her disadvantage, the non-commercial arbitrage trader only enters into a trade if there are significant price deviations already. Therefore, according to Working (1949), hedgers trade even more speculatively than speculators. Kaldor (1939) makes a similar argument, noting that a market with more short than long hedgers can either be a result of expectations or of physical exposure.

Although the theory of storage is not controversial, the theory of normal backwardation is frequently contested (Fama and French 1987). The convenience yield relates back to the concept of utility, which has a well-elaborated theoretical foundation in neoclassical economic theory, but the argument of Keynes's risk premium is based on the assumption of excess demand, which is not easily compatible with neoclassical theorising (Cootner 1960). Two strands of theories, which seek to make Keynes's risk premium coherent with neoclassical theories, have been derived from his original ideas: (1) theories of asset-pricing, which assign a risk premium to (systematic) risk; and (2) theories of hedging pressure, which incorporate market imperfections, like transaction costs, into multiple-period pricing models.

With reference to Keynes (1930), Kaldor (1939) synthesises the convenience yield and risk premium approach. He links the premium to the uncertain expectations on future prices and thereby builds the foundation for asset-pricing models. If expectations are uncertain, the difference between the current price and the expected price covers not only carrying costs, but also a risk premium. According to Kaldor (1939), the premium varies with the degree of uncertainty, i.e., the dispersion of expectations around the mean or the own price variance, and increases proportionally to the original cash outlay. Since commodity owners free themselves from price uncertainty by selling forward, the forward price falls short of the expected price by the risk premium. Hence, the forward price becomes a biased estimator of the expected future cash price. Under the assumption of uncertainty, as defined by Kaldor, the difference between the expected cash price and the current cash price is determined by the risk-free interest rate, net carrying costs, and the risk premium (Hernandez and Torero 2010).

$$E_t[S_{t+T}] - S_t = S_t r_{f,T} + (w_{t,T} - \varphi_{t,T}) + \rho_{t,T} S_t \tag{2.3}$$

with $\rho_{t,T}$ being the risk premium, which is a function of the variation of expectations on the future cash price. When substituting for the net storage costs[17], from Equation 2.2 and 2.3 it follows:

$$F_{t,T} = E_t[S_{t+T}] - S_t \rho_{t,T} \tag{2.4}$$

Kaldor (1939) argues that if speculative stocks are zero, the convenience yield compensates for the carry costs proper, the interest rate and the risk premium[18], and the expected future cash price equals the current cash price, which follows from Equation 2.3. Hence, in this particular case, the forward price falls short of the cash price by the risk premium: $F_{t,T} = S_t(1 - \rho_{t,T})$. This is a situation of backwardation. If the convenience yield outweighs the carry cost proper, interest rate and risk premium, the cash price exceeds the expected cash price by more than the risk premium[19]. If speculative stocks are abundant, the convenience yield approaches zero, and the current cash price is the expected cash price minus storage costs proper and interest rate. The cash price is thus lower than the forward price, and the

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[17] $(w_{t,T} - \varphi_{t,T}) = F_{t,T} - S_t(r_{f,T} + 1)$.

[18] So that: $S_t(r_{f,T} + \rho_{t,T}) + w_{t,T} = \varphi_{t,T}$ and thus, $S_t(r_{f,T} + \rho_{t,T}) + w_{t,T} - \varphi_{t,T} = 0$.

[19] If $S_t(r_{f,T} + \rho_{t,T}) + w_{t,T} - \varphi_{t,T} < 0$, then $S_t > E_t[S_{t+T}] > F_{t,T}$.

forward price falls short of the expected price by the risk premium[20]. This is a situation of contango.

Departing from Kaldor (1939), Dusak (1973) links the risk premium not to the own price risk (idiosyncratic risk), but to the joint price risk of the asset with a wider market portfolio (systematic risk). She is the first to apply a capital asset-pricing model (CAPM) to the commodity futures market and to show that the expected excess return which accrues to the holder of a commodity futures contract[21] is equal to the excess market return[22] multiplied by the market beta[23], as a measure for systematic risk. Hence, in contrast to Kaldor's approach, the size of the risk premium depends on the covariance with a perfectly diversified market portfolio instead of the own price variance. This reasoning is grounded in the conviction that idiosyncratic risk can be diversified away, and thus, should not be priced. Only variance that is correlated with the overall market variation, and hence, systematic, should be reflected in the risk premium. According to Dusak (1973), commodity excess returns can be written as:

$$E_t[R_{C,T}] - r_{f,t,T} = [E_t[R_{M,T}] - r_{f,t,T}]\beta_C \tag{2.5}$$

with $E_t[R_{C,T}]$ being the expected return on a long commodity futures position, $E_t[R_{M,T}]$ the expected return on a diversified portfolio or an investor's total wealth and β_C the market beta. The expected risk premium is hence proportional to the market beta. After rearranging, Equation 2.5 can be rewritten as[24]:

$$F_{t,T} = E_t[S_T] - S_t\rho_{t,T} \tag{2.6}$$

with $\rho_{t,T} = \beta_C(E_t[R_{M,T}] - r_{f,t,T})$ being the risk premium according to Dusak's (1973) model. Hence, the current futures price is defined as the expected cash price minus the risk premium multiplied by the original cash outlay.

This expression looks identical to Kaldor's (1939) derivation of the risk premium in Equation 2.4. Again, the futures price becomes a (downward) biased estimate of the future

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20 $S_t < F_{t,T} < E_t[S_{t+T}]$.

21 The return to a commodity futures long position minus the risk-free rate of return.

22 Excess return on a fully diversified portfolio.

23 Defined in Equation 2.5 as $\beta_C = \frac{Cov(R_M,R_C)}{\sigma^2(R_M)}$.

24 After substituting and rearranging, $S_t(1 + r_{f,t,T}) = E_t[S_T] - S_t\beta_C(E_t[R_{M,T}] - r_{f,t,T})$. If returns are expressed in terms of prices, so that $E_t[R_{C,T}] = \frac{E_t[P_T]-P_t}{P_t}$, the current cash price can be written as: $P_t(1 + r_{f,t,T}) = E_t[P_T] - P_t\beta_C(E_t[R_{M,T}] - r_{f,t,T})$. Following Dusak (1973), one can interpret $P_t(1 + r_{f,t,T})$ as the current futures price for delivery and payment in period T and $E_t[P_T]$ as the cash price expected to prevail at time T, which leads to Equation 2.6.

cash price. Dusak (1973) is criticised by Carter, Rausser, and Schmitz (1983) firstly, for only considering the case of long traders, and secondly, for arguing against Keynes's risk premium by assuming it away[25]. They correct for these shortcomings and find evidence for both systematic and idiosyncratic risk for three agricultural commodity markets.

Although all risk premium models reviewed reach a similar conclusion in that the futures price is a biased estimator of the future cash price, the bias is derived differently among the models. Keynes links the premium to hedgers' demand, relative to speculators' willingness to enter into futures contracts. Kaldor understands the risk premium in terms of the own price variation, and Dusak and later authors derive the premium from the systematic risk component. Alongside theories which link the risk premium to own and cross-price variation, another theoretical strand developed, the so-called hedging pressure theories, which are, arguably, closer to Keynes's original idea.

Hedging pressure models are commonly derived from a general equilibrium framework in which rational agents maximise their utility over future consumption with respect to their optimal investment choices, regarding their positions on futures and other (commonly, stock) markets. The risk premium is derived as a function of commercial traders' demand for hedging positions. Due to the problems associated with incorporating an excess demand framework into neoclassical theories, market frictions are introduced to make such a framework consistent (Hirshleifer 1988; 1990; Bessembinder 1992; Chang 1985). Without market friction, hedging demand would always meet liquidity supplied by speculators, and no price effect would arise. Under the assumption of market frictions – that is, under the assumption that the supply of contrarians to hedging positions is not perfectly elastic – hedging pressure models link the size of the basis over a contract's life cycle to the hedgers' demand as compared to speculators' willingness to enter the market.

Hirshleifer (1988), in his model, distinguishes between two trader types—producers (hedgers) and outside investors (speculators)—and assumes that the latter type faces transaction costs, due to fixed set-up costs or effective informational barriers. As a result, future consumption functions of speculators who chose to participate in futures markets differ from those who decide against futures market participation. A trader's optimal choice of positions regarding future consumption depends on the size of the transaction cost that governs speculators' participatory choices. The number of traders in the exchange is thus endogenously defined by the size of the transaction cost. Hirshleifer (1988) shows that in such a setting the risk premium entails a systematic risk component, which depends

[25] They also criticise her for including only common stocks, which leads to downward-biased market betas.

on the market beta, and a residual risk component, which rises with transaction costs and hence, the number of non-commercial speculators participating in the market. In the tradition of Keynes's risk premium, Hirschleifer (1988) argues that the residual risk premium exists to compensate speculators for their costs. In a later model, he corrects for only considering short hedgers by assuming fixed set-up costs for long hedgers and risk-averse speculators (Hirshleifer 1990). If both long and short hedgers are free of transaction costs, every short hedger would meet a long hedger, and no hedging pressure would build up. The non-participation choice of some consumers, driven by a fixed set-up cost, thus restores the claim of hedging pressure made in his earlier model. When short hedgers are in excess of long hedgers, the futures price exhibits a downward bias, which means the market is in backwardation.

Hirschleifer (1988; 1990) justifies his assumption of transaction costs incurred by speculators and/or consumers, but not producers, by the size of their businesses. He links set-up costs to scale economies and argues that consumers and speculators often run smaller businesses than commodity producers. However, this might not necessarily be the case, considering that the commodity processing and manufacturing sector is often as concentrated as the commodity production/extraction sector (see Chapter 7). The commodity industries' structures might reveal an alternative explanation. Consumers, especially in the agricultural and soft commodity sectors often manage their risk outside the financial futures exchange via forward transactions. Further, the supply of speculative liquidity could be restrained, since speculators are disadvantaged against hedgers. The disadvantage arises because speculators lack the infrastructure for handling physical commodities, which means that they are constrained in their trading strategies and cannot exit the market by taking delivery.

Acharya, Lochstoer, and Ramadorai (2013) suggest an interesting variation of Hirshleifer's (1988; 1990) hedging pressure model by synthesising it with Deaton and Laroque's (1992) optimal inventory management model. They show that with the assumption of market friction, hedging pressure not only impacts futures prices, but also cash market prices through inventory adjustments. According to their model, which assumes that short hedgers dominate in the market, the premium paid to speculators suppresses prices of longer-dated futures contracts relative to shorter-dated ones. Consequently, the costs for short hedgers increase due to the supressed carry[26]. Producers might seek to avoid cost through the release of inventories, which then results in suppressed cash prices[27].

Bessembinder (1992), similar to Hirshleifer (1988), combines the CAPM framework with the hedging pressure hypothesis and links the market basis to systematic risk and hedgers' demand. He finds evidence that after controlling for systematic risk, hedging pressure is significant for foreign currency and agricultural futures. De Roon, Nijman, and Veld (2000) further show that the risk premium also depends on hedging pressure from other markets, due to what they call 'cross-hedging pressure'. Further, Basu and Miffre (2013) find evidence that hedging pressure is a systematic factor in determining commodity futures risk premiums.

In contrast to previously reviewed theories of convenience yield and risk premium, the theory of hedging pressure accounts firstly, for the difference in traders active in the physical and derivatives markets in the form of non-commercial speculators, and secondly, for the possibility of traders executing price pressure in the futures market, which causes a deviation of the futures price from the underlying physical market price.

However, despite these important insights, the theory of hedging pressure—like related theories which are based on the no-arbitrage condition between cash and futures markets—seems to suggest that price discovery takes place in the physical market (Stein 1981; Chang 1985). Deviations from the no-arbitrage condition are explained by competing theories, which account for the 'residual' price variation, i.e., the variation that is not explained by the cash price and carry variables (Hayes 2006). However, the direction of causation of price formation between cash and futures markets does not logically follow from the no-arbitrage condition.

Therefore, it is sensible to assume price formation mechanisms to be present in both the physical and the futures markets. This insight opens possibilities for bi-directional feedback mechanisms between those two markets, as shall be elaborated further in Section 2.4. Before considering dynamics in both markets jointly, another strand of literature is reviewed, which provides theories on price formation in asset markets.

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[26] The market carry refers to the level difference between the nearest-to-expiration and the next-nearest-to-expiration contract price, i.e., the return one can earn carrying the physical commodity until the end of the next-nearest-to-expiration contract maturity.

[27] The same rationale applies to long hedgers dominating the market and is analogous to the argument that index traders caused excess demand for long positions, and as such, pushed futures and physical prices upward.

2.3 Theories on Price Formation in Asset Markets

Neither the theory of storage, nor the theory of risk premium, leaves scope for an analysis of price formation in commodity futures markets. These theories are predominantly concerned with an arbitrage relationship between the cash and the futures markets, and the interplay between those two markets and the inventory market. A theory that is concerned with price formation processes in derivatives markets is the efficient market hypothesis, first formulated by Fama (1965).

Although the efficient market hypothesis can be applied to commodity futures markets, its stringent assumptions linked to the neoclassical rational expectations framework have been doomed as unrealistic. Alternative theories emerged from this debate, including bounded rationality, rational herding and the Post-Keynesian theory of fundamental uncertainty. Those theoretical strands are discussed in the following sub-sections.

It is argued that if the stringent assumptions of the efficient market hypothesis are eased, an analytical framework can be derived that is more appropriate for explaining price dynamics observed in asset markets and, by implication, price dynamics in commodity futures markets.

2.3.1 Efficient Market Hypothesis

In contrast to theories discussed previously, the efficient market hypothesis concerns itself with the translation of information into prices. It thus provides a theoretical framework for price formation in futures markets beyond no-arbitrage relationships with the physical market. According to this hypothesis, commodity futures prices reflect nothing but information on market fundamentals. This conjecture is based on the rationale that the value of a futures contract is determined by the *consensus expectations* on the market's future fundamental value. Each rational trader is assumed to base her trading decision on a subset $[\Omega_{i,t}]$ of the total information set of market fundamentals $[\bar{\Omega}]$. Consequently, each position taken by a trader will add to the market information density. With perfect foresight, the probability of the future price of the commodity would be certain, so that: $P[S_{t+1}|\bar{\Omega}] = 1$, and hence: $F_{t,T} = E_t[S_T|\bar{\Omega}] = S_T$. Since traders' expectations directly translate into prices via their positions taken, the more market participants, the closer the futures price approaches its 'true' fundamental value.

Under this premise, price deviations away from market fundamentals would introduce riskless arbitrage opportunities, which are instantaneously exploited by arbitrage traders, who know the market fundamental value and bring the price back into equilibrium. Financial derivative instruments are assumed crucial for 'market completeness', in the sense that they provide arbitrageurs with the necessary flexibility to fully exploit arbitrage opportunities (C. P. Jones 2007; Deville, Gresse and Séverac 2014).

The logic of the efficient market hypothesis critically depends on the assumption that key market participants evaluate assets on the basis of market fundamentals only, act fully rationally, base their actions on publicly available information or their own private sources and do so independently of each other. From this assumption, it follows that traders' price expectations are identically and independently distributed around the fundamental value of the commodity (M. Carter 1991). Even if irrational 'noise' traders, who are defined as traders that do not base their information on market fundamentals, existed in the market, their behaviour is assumed to be uncorrelated, which implies that their positions cancel out.

However, Fama (1965) argues that the efficient market hypothesis does not hinge on the absence of correlation between noise traders as long as arbitrage is possible. As long as enough sophisticated traders are active in the market, they would take advantage of the price deviation if unconstrained in their resources.

It is important to note that Fama's (1965) arbitrage mechanism differs from what is implied by the no-arbitrage condition suggested by the theories of storage and risk premium. Fama (1965) considers arbitrage possibilities for the price level and not the relative prices (e.g., of cash and futures) as done by the theories reviewed earlier. These two forms of arbitrage, often used interchangeably, have to be distinguished since their implications for market dynamics differ, a fact that is overlooked in the literature. In the following, I will differentiate between *fundamental arbitrage* and *spatial arbitrage*. In the case of fundamental arbitrage, to which Fama (1965) refers, arbitrage is exploited if prices deviate from their fundamental value (the price level is misspecified). In the case of spatial arbitrage, arbitrage is exploited if cash or any other close substitute and futures prices deviate (relative prices are misspecified).

Regarding fundamental arbitrage, informed traders, based on their expectations of a commodity's latent fundamental value, are assumed to go short if they think the commodity is overvalued or to go long if the commodity is undervalued, thus arbitraging away the misalignment. In contrast, if arbitrage opportunities of the spatial kind arise, traders are predicted to profit from buying in one market and selling in the other, thereby forcing the two markets to realign.

By implication, spatial arbitrage only enforces a close relationship between two related markets, but it does not necessarily link an asset to its fundamental value. An adjustment of an asset towards its fundamental value through spatial arbitrage only occurs if, firstly, the close substitute, with which the arbitrage trade is made, is priced according to its fundamental value and, secondly, if the asset price adjusts towards the price of its close substitute and not the reverse. Fundamental arbitrage, in contrast, only corrects for an over- or under-valuation of an asset, but not for relative prices. As shall be elaborated more in Section 2.4, the differentiation between fundamental and spatial arbitrage and their different implications for price formation processes are cornerstones of the financialisation hypothesis outlined in this thesis (see Figure 2.5).

Not only do implications for price dynamics differ for the two types of arbitrage, but also underlying assumptions. Regarding fundamental arbitrage, two assumptions are made. Firstly, informed traders believe in the efficient market hypothesis—that is, they believe that the market will revert to its fundamental value[28]. Secondly, a probabilistic guess can be made about the fundamental value of the commodity on the basis of available information.

As shall be elaborated in Section 2.3.2, the first assumption is questionable if trading decisions by noise traders are correlated. If this is the case, prices can systematically deviate from the fundamental value, which implies arbitrage traders lose on their positions, at least in the short-run. The profitability of an arbitrage position, then, depends on the relative market weight and resources of fundamental arbitrage traders relative to other uninformed speculators.

The second assumption is based on the ability of rational individuals to quantify uncertainty, i.e., the assumption of ergodic systems. The literature, which questions the existence of such systems, shall be reviewed in Section 2.3.3. However, even if ergodicity is retained and only uncertainty—in the sense that traders face cognitive limitations in predicting the future with certainty—is assumed, fundamental arbitrage is not riskless even for sophisticated traders.

The possibility of spatial arbitrage critically depends on the availability of an 'essentially similar' asset (Shleifer 2000, 3-5). If two assets are not close substitutes, the arbitrage is not riskless (Harris and Gurel 1986). For commodity futures, the close substitute for one

[28] This assumption is logically inconsistent. Traders who believe in the efficient market hypothesis would have no motivation to trade, since they cannot expect any excess returns from a fully efficient market. A variation of this argument is made by Grossman (1976) and Grossman and Stiglitz (1980), who stress that it is nonsensical in such an environment to entertain costly information gathering if no return can be expected, and hence, the optimal choice of each trader would be to trade uninformed, if at all.

futures contract could be (1) a longer or shorter-dated futures contract of the same commodity at the same futures exchange; (2) a futures contract of the same commodity at different futures exchanges (e.g., cocoa is traded on the London and New York exchanges); or (3) a futures contract and the underlying physical good. Any difficulties in trading one asset against the other, like transaction costs, exchange rate risk and timing mismatch, impose limits to spatial arbitrage.

The validity of the efficient market hypothesis, and also Fama's (1965) argument, ultimately depends on the effectiveness of fundamental arbitrage (Shleifer 2000, 13). If arbitrage is not riskless, traders may refrain from arbitraging and market inefficiencies could arise. The assumptions necessary for effective fundamental arbitrage have been questioned on various grounds. One is the observation that traders are heterogeneous in trading motives and strategies beyond the informed–uninformed or arbitrageur–noise trader dichotomy. The financialisation hypothesis is essentially based on literature, which suggests a wide variety of trader behaviour.

The assumption of different trading motives and strategies applied by heterogeneous traders provides a more realistic account of asset markets, in general, and commodity futures markets, in particular, and builds a strong argument against the view of market dynamics drawn from the efficient market hypothesis (Nissanke 2012a). If market participants are heterogeneous in their investment motives and trading strategies, not every investor's position necessarily adds to the overall information set regarding market fundamentals (Hayes 2006; Adam and Marcet 2010b). Since market fundamentals might be less reflected in futures prices with the entry of new speculators, liquidity can be destabilizing (Stein 1981).

This consideration sharply contradicts the conventional wisdom that the more liquid the market is, the more efficient and the more tranquil it is. This is because liquidity is often mistakenly equated with information content. This assertion is problematic, even if one ignores the possibility that traders might base their investment decisions on information about non-fundamental factors. An increase in liquidity does not necessarily imply a larger sample of opinions on the future fundamental value, i.e., there is not necessarily higher information content (Davidson 1998). The size of the sample of opinions on the market's future fundamental value, and hence, the precision of the estimate—i.e., the futures price—depend on the number of traders and the diversity of independent information on market fundamentals they hold (Jones and Seguin 1997). This is not guaranteed by liquidity. If market efficiency is defined as the speed with which new, not exclusively fundamental-based information is incorporated into prices, liquidity might foster market efficiency, but not necessarily price stability and price discovery (Hirshleifer 2001). By allowing for the heterogeneity in traders' investment strategies and investment motives, liquidity does not necessarily increase the precision with which prices mirror market fundamentals, liquidity also does not necessarily lower the amplitude of price movements (O'Hara 1997, 216-7).

Furthermore, liquidity is understood as an indicator for the magnitude of the price impact of a single trader. Since the relative weight of an investor is smaller when the market is more liquid, liquidity is assumed to guarantee only a marginal price impact from each investor. The validity of this assertion depends on the assumption that traders act independently. If this assumption is violated, positions taken by only few traders might trigger a systematic response by others. Hence, a few traders can exert a significant 'weight-of-market' impact (Nissanke 2012a).

The assumption of heterogeneous market participants is not peculiar to the commodity market. It was introduced as a hypothesis to explain certain anomalies—especially in the stock and foreign exchange markets—which essentially contradict the efficient market hypothesis. Approaches seeking more consistency with neoclassical theories introduce either market frictions or bounded rationality in order to ease the assumption of fully rational agents and perfect foresight. This allows for the introduction of limits to arbitrage and hence, limits to market efficiency. From these approaches, behavioural finance and market microstructure theories evolved. Behavioural finance derives implications for price formation from behavioural traits of market actors, while microstructure theories additionally consider the institutional environment in which prices form (O'Hara 1997, 6). Both strands of literature show that speculative bubbles are possible, with the acknowledgement of heterogeneity of traders in their motives and strategies.

Another approach acknowledging the possibility of speculative bubbles, but less compatible with neoclassical theorising, is followed by Post-Keynesians. These authors argue that market actors are confronted with fundamental uncertainty. In such an uncertain environment, economic agents interact diversely and strategically.

These different schools of thoughts shall be revisited next, before an alternative view on price formation in commodity markets is composed and presented in Section 2.4.

2.3.2 Bounded Rationality and Rational Herding

The bounded rationality and the rational herding literatures are motivated by the need to explain anomalies like frequent deviations of asset prices from their hypothetical fundamental value, fat tails of return distributions, and volatility in excess of market fundamentals in stock and in foreign exchange markets. The *bounded rationality* perspective is closely linked to behavioural finance, which moves away from the assumption of fully rational agents and takes a more eclectic approach to understanding agents' behaviour. Theories are informed by cognitive science, human psychology, evolutionary biology and sociology (Baddeley 2010). The *rational herding* perspective introduces market frictions and is closely associated with market microstructure theories, which take the institutional environment and its links to the price formation process into consideration. Both strands of literature tend to divide financial market participants into two categories: informed fundamental arbitrage traders and uninformed systematic noise traders[29]. Noise traders are assumed to be systematic so that their trades correlate and introduce noisy price signals (Black 1986).

The assumption of correlated noise traders is in contrast to the efficient market hypothesis reviewed previously. Hence, if one takes the efficient market hypothesis at face value, two questions arise (O'Hara 1997, 96-8). Firstly, noise traders supposedly lose money because they trade on the 'wrong side' of the market and, therefore, are eventually driven out of the market. The assumption of a continual flow of loss-making traders into and out of the market, despite the persistent evidence that they have the wrong strategy, demands an explanation. Secondly, if noise traders do not follow market fundamentals, then what constitutes the common factor driving their positions? Both bounded rationality and rational herding theories provide answers to these questions.

Regarding the latter question, noise traders' apply extrapolative strategies, which build upon technical indicators generated by models without an anchor in market fundamentals. Although, the models are highly sophisticated, they are based on the same trading signals derived from common data and indicators, and hence, noise traders' positions can be correlated—see De Long, et al. (1990). Further, noise traders apply herding strategies by which they deliberately follow other seemingly informed traders—see Banerjee (1992). Although McAleer and Radalj (2013) insist that herding necessitates the deliberate mimicking of other agents, Devenow and Welch (1996) understand herding more broadly as a phenomenon that is driven by some coordination mechanism, such as a widely spread trading rule (extrapolative strategy) or the ability to observe other agents (herding strategy). Strategies of herding and extrapolation clearly overlap. Nevertheless, the distinction is

[29] The Post-Keynesian approach does not rely on such a distinction, because with fundamental uncertainty, the future is unpredictable. Hence, rational behaviour, as defined by neoclassical economists, is a logical impossibility, which makes the distinction between rational and irrational behaviour obsolete (Davidson 2002, 56).

important, as it is useful to differentiate between the motives underlying those strategies, which are association with either the bounded rationality or rational herding literature.

The bounded rationality school, in its endeavour to explain price volatility and movements of asset prices away from their fundamental value, introduces noise traders that do not act rationally in the neoclassical sense of fully informed, utility-maximising agents. However, the conceptualisation of non-rational behaviour has changed as the literature developed. While earlier studies understand noise traders as non-rational insofar as their demand for risky assets is affected by beliefs and sentiments (Shleifer and Summers 1990), later studies focus on the cognitive limitations of optimising agents, which apply trial-and-error strategies in an evolutionary manner (De Grauwe and Grimaldi 2006; Hirshleifer 2001; Lo 2004).

Despite the differences, both manifestations of the bounded rationality literature come to the same conclusion that information on past prices and traders' positions is not redundant, but contains valuable indications regarding how other traders behave under uncertainty (Adam and Marcet 2010a). Historical price and position data hence reveal important information about latent behavioural tendencies of other traders, which induce certain stochastic price processes.

The early bounded rationality literature is strongly intertwined with empirical psychology. The term bounded rationality was originally coined by Simon (1957; 1959; 1955), who argues that individuals are unable to act as assumed in the neoclassical optimisation process. For example, Tversky and Kahneman (1974) show in experimental settings that people rely on simple heuristics when assessing probabilities and that cognitive biases are systematic[30]. In this tradition, Shleifer and Summers (1990) and Shleifer (2000, 113-6) base their models on two phenomena documented by the cognitive science literature—'conservatism' and 'representativeness'. Investors, showing these behavioural traits, do not incorporate information immediately, but over time, and tend to become overly optimistic after receiving a series of 'good news'. Similarly, De Long, et al. (1990) argue that for the estimation of probabilities, individuals employ heuristics that can lead to non-random biases that are correlated across subjects. As a result, markets overreact or underreact to information, showing empirical patterns such as fat-tailed return distributions, excessive volatility and bubbles.

[30] Almost a decade later, the authors co-edited a book under the same title with a collection of papers that summarised similar experiments (Kahneman, Slovic and Tversky 1982).

More recent bounded rationality models suggest successively adjusted strategies as a foundation for explaining traders' behaviours. De Grauwe and Grimaldi (2006) introduce transactions costs, which leads the researchers to assume that rationally informed traders only trade if the asset, in this case the exchange rate, is outside the 'transaction cost band'—that they only trade if the arbitrage position compensates for the transaction costs. Noise traders, or 'chartists', are assumed to compute the moving average of past exchange rates and extrapolate these into the future[31]. As the future becomes more uncertain, rational traders switch to trial-and-error strategies, including technical indicators. Such behaviour of market participants results in multiple equilibria. Hirshleifer (2001) also proposes a trial-and-error approach to trader behaviour and explicitly links such behaviour to evolutionary processes. He argues that rule-of-thumb trading strategies are correlated across traders, since people share similar heuristics, ones that have worked well in humanity's evolutionary past. He envisions the subordination of the purely rational paradigm as a special case under a broader psychological paradigm.

Lo (2004) claims to have developed such a new paradigm, which he terms the 'adaptive market hypothesis'. In a similar manner to Hirshleifer (2001) and other bounded rationality scholars, he links traders' behaviour to psychological processes. His approach builds on evolutionary psychology by applying the principles of evolution to financial interaction (Lo 2005). Optimisation of behaviour is understood as a trial-and-error process of applying different heuristics, including technical indicators, which, if challenges remain stable, adapt to deliver the optimal result. Suboptimal outcomes are not unlikely in the interim, although behaviour is never considered to be irrational, rather 'maladaptive' (Lo 2004). Distinct groups of market participants are understood as species that compete for scarce resources that are profit opportunities. Investment strategies undergo cycles of profit and loss, with Schumpeterian rents accruing to innovative strategies. With these cycles of profitability, Lo (2012) is able to address the puzzle posed by Grossman and Stiglitz (1980) and explain various financial anomalies.

In contrast to the bounded rationality school, the rational herding literature shows that herding strategies can be rational in the presence of market frictions. Devenow and Welch (1996) distinguish between three different causes for the occurrence of rational herding which are (1) payoff externalities, (2) principal-agent problems, and (3) informational learning. The first friction includes, for instance, bank runs where the payoff to one agent

[31] Certainly, chartists use far more sophisticated statistical models than simple moving averages, which can, at best, be only an approximation. However, these extrapolative models could similarly result in positive feedback trading, since even sophisticated algorithms are based on the same data and indicators available.

adopting a certain strategy increases as other agents adopt the same strategy. The second friction arises from strategic human interaction. Asset managers might prefer to 'hide in the herd', since a mistake is less damaging to a manager's reputation if the same mistake is made by many (ibid.). This is a realistic assumption, because asset managers' performances are usually measured against each other and not in absolute return terms. The third friction arises when partially informed agents discard their own information in the light of information inferred from the observed actions of other agents.

Regarding the third cause for rational herding, Welch (1992) coined the term 'information cascades' and introduced an informational learning model in which, under uncertainty, herding becomes the rational strategy. In his model, agents make decisions sequentially and update their beliefs in a Bayesian probability model, given the information about previous agents' decisions. Similarly, Banerjee (1992) builds a sequential decision model in which agents can observe previous decisions made by other agents without knowing whether the persons making the prior decisions were knowledgeable. He shows that even if an agent knows with a certain probability that her information is wrong, she does what she observes others are doing, even if this means discarding her own information. The model is built upon the assumption that all agents are rational in the Bayesian sense, i.e., they base their decisions on estimated probabilities using Bayes' law.

Bikhchandani, Hirshleifer and Welch (1992) stress the fragility of such systems in the presence of external disturbances. They distinguish between 'previous-action-observable' regimes and 'previous-signal-observable' regimes. In the former case the information cascade continues, while in the latter case the information cascade breaks if a long enough series of opposing signals occurs. Under the latter regime, it is assumed that the decision-maker's signal or knowledge is made available to everyone after the decision is made, regardless of whether the trader followed or ignored her own signal. The former case is arguably a better reflection of reality, as position data on futures exchanges are publicly available, although with a delay, while traders' information is undisclosed.

Adam and Marcet (2010a) also assume Bayesian optimisation under imperfect knowledge. They provide a micro foundation for models of adaptive learning where agents are 'internally rational', which means that they maximise discounted expected utility under uncertainty, however, with consistent subjective beliefs about the future. Agents might not be 'externally rational', which means that they might not know the true stochastic process for variables beyond their control, like market outcomes and fundamentals. By relaxing the external rationality assumption, Adam and Marcet (2010a) formally show that the equilibrium market price is equal to the marginal investor's expected sum of total payoff in the next period, rather than the sum of all future payoffs. In a later paper, they show how their learning model could give rise to low-frequency boom and bust cycles in asset prices (Adam and Marcet 2010b).

Another strand of literature focuses on principal–agent problems, arguing that it is rational for agents to follow the pack in order to protect their reputation, client base, or 'to be on the safe side' (Devenow and Welch 1996). Scharfenstein and Stein (1990) suggest that agents tend to imitate others, because they perceive a mistake to be more reputationally damaging if it is made by one person alone, whereas it becomes excusable if it is made by many. De Brouwer (2001, 156-7) adapts this argument to explain the performance of traders in the Asian financial crisis of 1997–98. Since macro hedge funds were commonly perceived as having the best market knowledge, smaller traders were strongly incentivised to mimic those funds. These behavioural assumptions are also demonstrated by Lütje and Menkhoff (2000), through a survey conducted among German fund managers.

Another field of theories is based on externalities and game theoretical considerations in which presumably irrational behaviour, like herding, becomes rational in the presence of negative externalities. This literature mostly focuses on second- and third-generation currency crisis models. In such models, it has been shown that it is rational for an individual trader to pull out of a market if she believes that others might do so as well (e.g., bank runs, or the risk of a currency devaluation). In order not to be caught at the bottom, a trader tries to be among the first ones pulling out (Obstfeld 1986; 1996). Although in the first-generation currency crisis models—e.g., Krugman (1979)—changes in fundamentals are believed to precede the crisis, it is acknowledged in later models that fundamentals can fulfil expectations ex-post and that a crisis can evolve in a self-fulfilling manner. Jeanne (2000) distinguishes between 'speculative attack' and 'escape-close' models. The latter type, associated with second- and third-generation models, emphasises the self-fulfilling element of speculation, as market fundamentals are endogenised with mutual feedback mechanisms between speculative expectations and market fundamentals.

Both bounded rationality and rational herding theories come to the conclusion that positions taken by noise traders can be strongly correlated and lead to aggregate demand shifts, which impact prices if the noise traders' momentum in the market is large enough. These theories clearly break with the efficient market hypothesis, which assumes that noise traders' positions are independently distributed, so that the aggregated impact is zero. Although, as pointed out before, the efficient market hypothesis does not hinge on the assumption of uncorrelated noise traders as long as fundamental arbitrage is efficient, various reasons have been put forward in the literature for why arbitrage is generally risky, and hence, systematic limits to fundamental arbitrage exist.

The conjecture that arbitrage is generally risky departs from four properties of financial markets: (1) the presence of 'noise trader risk', (2) market imperfections and transaction costs, (3) agency problems, and (4) information asymmetry.

In the presence of noise traders, rational arbitrage traders face two types of risk, fundamental risk and the risk that the mispricing worsens. The second type of risk is aggravated by the presence of noise traders and coined 'noise trader risk' by De Long, et al. (1990). If mispricing worsens, fundamental arbitrage traders are required to put more money on the trade. If capital is constrained or costly, the trader might be forced out of the market before her arbitrage trade pays off due to margin calls and interest rates on borrowed capital. Even without the presence of noise traders, fundamental arbitrage is not riskless, since traders do not have perfect knowledge about the fundamental value. If arbitrage traders are risk-averse and trade with a finite horizon, their willingness to trade against mispricing is limited (Shleifer and Summers 1990).

Further, the fact that arbitrage involves capital introduces various agency problems. If an arbitrage trader is trading on behalf of a client while losing money, it might be difficult and costly for her to acquire further capital to continue the trade.

Shleifer and Vishny (1997) argue that since arbitrage requires deep and specialised knowledge about the market, only a tiny group of traders has this knowledge. Hence, their market weight might be too small, and prices might move against them in the short-run, forcing them to liquidate their positions and act unwillingly as positive feedback traders, i.e., they would act as trend-following traders, thus aggravating the existing price trend.

Last but not least, informed arbitrage traders might even purposely turn into positive feedback traders as argued by Shleifer (2000, 156). If arbitrage traders are aware of noise traders employing extrapolative strategies, arbitrageurs are tempted to bid up the price higher than warranted by fundamentals in order to stimulate noise traders into acting as positive feedback traders to, in turn, bid up the price even further.

Shleifer (2000, 156) concludes that in the presence of extrapolative traders, 'arbitrage can be destabilizing' and extrapolative traders, although losing in the long-run, might gain significantly in the short-run. In the same spirit, Shleifer and Summers (1990) explain the continuing entrance of noise traders into the market by arguing that less risk-averse noise traders are more aggressive in their trading than arbitrageurs. If risk is rewarded, those traders earn higher average returns than arbitrage traders. Such trading strategies come at a greater volatility, so that most traders become poor and only a few, very rich. De Long, et al. (1990) show that most noise traders fail, but noise traders as a group come to dominate the market. Although most noise traders are eventually driven out of the market, the high reward, which accrues to some, motivates others to follow. Hence, noise traders, if their weight in the market is large enough, create their own space in which their price bets are rewarded in a self-fulfilling manner (Shleifer, 2000, 52).

Although both areas of literatures differ in their underlying assumptions—bounded rationality assumes partially rational agents, while rational herding assumes market frictions—they similarly conclude that trend-following and herding tendencies arise, which result in limits to fundamental arbitrage. In such scenarios, bubbles and price movements away from a market's fundamental value are likely to arise.

2.3.3 Fundamental Uncertainty and the Keynesian Tradition

The Post-Keynesian literature, although coming to a similar conclusion on traders' behaviour and the possibility of speculative bubbles, as the previously reviewed literature, starts from a different understanding of uncertainty. In neoclassical models, uncertainty is equated with 'probabilistic risk', but the Post-Keynesian authors argue that 'true' uncertainty is not quantifiable (Davidson 2002, 39-40). It is argued that if the future is risky, these risks are measurable, and by applying probability theory, the future is knowable.

In contrast, if the future is uncertain, it cannot be reliably forecasted. Thus, an uncertain future is unknowable and must consequently be restricted to non-quantitative terms. This leads to the postulate of a non-ergodic system in which the future cannot be calculated on the basis of past and present data. This entails an important distinction from the bounded rationality literature, which has as its underlying assumption that while the future is knowable, it is unknown by traders due to cognitive limitations (Lawson 1985). For the bounded rationality school, uncertainty is an epistemological problem, whereas it is an ontological one for Post-Keynesians (Dunn 2001).

Ergodicity, the necessary assumption for the existence of a predictable future, is rejected on the basis of the transmutable nature of the future resulting in 'fundamental uncertainty (Dunn 2001; 2008, 96-8). If the system is permanently changed, the past is not representative of the future (Davidson 2002, 47). Elapsing time does not change the sample size, but the sample itself. To put it differently, by looking into the past for a prediction of the future, a greater sample—which would make a more representative data set from the same population—is not drawn, but a sample that provides a systematically different data set from a different population is drawn. Expectations based on statistical estimators are therefore misleading. In contrast, rational expectation models require the existence of an ergodic system where today's knowledge is projectable onto the future (Davidson 2002, 51). Not only is ergodicity rejected, but it is also assumed that people are aware that they cannot foresee future events, that is, they are aware of true uncertainty (Hicks 1977, vii; Davidson 1991).

If the future is unknown, a commodity's fundamental value cannot be known by market practitioners, and no such thing as the efficient equilibrium price exists (Bernstein 1999). Further, if market practitioners are aware of the unknowability of the future, portfolio protection through diversification against changes in financial markets is an important activity (Davidson 2002, 188). So, too, is speculation over the psychological state of other market practitioners (Carabelli 2002). The insight that expectations translate into prices, then, produces behaviour, as in Keynes's famous example of people betting on the winner of a beauty contest based on how they think other people will evaluate beauty and not on their own judgements.

Keynes's own writing about uncertainty and the ability to know the future is not as explicit as suggested, and slightly different interpretations are proposed by Post-Keynesian scholars (Rosser Jr. 2001). For instance, Lawson (1985) stresses that Keynes does not reject the existence of knowledge *per se*. Lawson (1985) distinguishes between three cases, which are knowledge of, knowledge about, and the unknowable. 'Knowledge about' is knowledge about the probability proposition of something (secondary proposition), but not the 'knowledge of' something (primary proposition). Knowledge of a secondary proposition then leads to a 'rational belief of the appropriate degree' in the primary proposition. He distinguishes between cases where the probability is unknown due to lack of skills—close to the bounded rationality literature—and cases where the probability is immeasurable or indeterminate. Only in the latter case does true uncertainty exist, under which people fall back on conventions. For Lawson (1985), conventions fulfil an important role of making behaviour predictable, at least in the short-run. Interestingly, what he seems to argue is that conventions make knowledge *about* the future possible to some degree, but not *of* the future.

For Lawson (1985), trader heterogeneity exists, since trading motives are conditioned on knowledge and the interpretation of knowledge that is obtained by each individual trader through practice. Different societies or forms of societies will bring about different trading motives, and hence, behaviour. Similarly, Bibow, Lewis, and Runde (2005) refer to Beckert (1996) and argue that reliance on peoples' 'social devices' makes action more predictable. Mimicking then arises from the attempt to conform to the majority. Shiller (2014) combines economic sociology with human psychology and Keynes's remarks on conventions. He borrows from Durkheim's notion of 'collective consciousness' in arguing that price formation is a convention, but maintains the ergodicity assumption, and thus, is closer to the bounded rationality school.

Comparing the bounded rationality literature reviewed earlier with Post-Keynesian approaches, the distinction comes down to the question of whether the world is predetermined or open to choice – that is, whether we live in an ergodic or non-ergodic system, or what Lawson (1977) terms a closed (immutable) or an open (transmutable) system. The break with the efficient market hypothesis is necessarily stronger for Post-Keynesians, since future market fundamentals are indeterminate (i.e., no stable market fundamentals can exist), while for the bounded rationality school, the fundamentals are determinate, (i.e., stable market fundamentals exist), but only the agents' abilities to fully grasp market fundamentals are questioned.

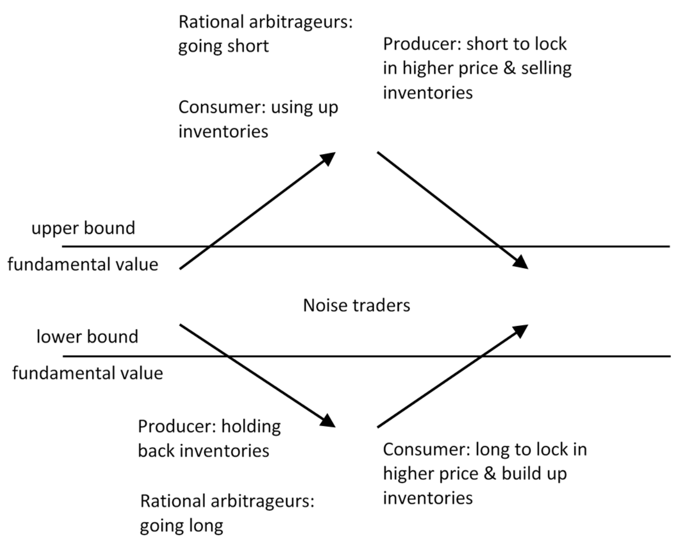
While the distinction is vital, it is useful to conclude that the consequences for the behaviour of agents derived from both theories are similar. For both schools of thought, the past only offers limited guidance for predicting future events, either because it cannot be fully comprehended or because it is substantially different from the future. In such a setting, maximisation, or optimisation, is not possible, and agents return to rules of thumb and conventions (Dunn 2001).

Hedging pressure theories, reviewed in Section 2.2.2, describe how the interplay between hedgers and speculators in commodity futures markets affects the relationship between the physical and the derivatives market price. Theories on price formation in asset markets, reviewed in this section, further differentiate between informed and uninformed speculators and show that uninformed speculators, or noise traders, can systematically impact asset prices, which results in speculative bubbles and excessive volatility. The combination of both theories, amended by another trader category of index traders, provides the theoretical foundation for the financialisation hypothesis proposed in this thesis. Further, theories of convenience yield and risk premium enable the identification of implications of the financialisation hypothesis for the complex interplay between futures, cash and storage markets. These considerations are set forth in Section 2.4.

2.4 A Synthesis: Uncertainty and Heterogeneous Traders

The combination of the efficient market hypothesis with no-arbitrage theories provides the neoclassical foundation for a theory on price formation in commodity futures markets. Two types of players are assumed to be active in commodity futures markets: hedgers, who are consumers and producers, and speculators, who act as rational fundamental arbitrage traders (Masters and White 2008). Hedgers aim to reduce their price risk exposure in the physical market, while rational arbitrage traders aim to maximise profits by exploiting arbitrage opportunities. Arbitrage traders base their investment decision on information—private or public—about market fundamentals and thereby add to market information density. Although it is acknowledged that traders might err in their expectations on future market fundamentals, their errors are assumed to be random, and hence, likely to cancel out.

Figure 2.1: Market Dynamics under Fundamental Arbitrage



Source: Adapted from Tokic (2011).

Under such conditions, consumers and producers in the market go long or short according to their hedging needs, the inventory level and expectations on market fundamentals. If prices temporally rise beyond the upper bound of a range within which informed commercial traders locate the fundamental value[32], producers, expecting prices to decline in the future, take advantage of the favourable price level by selling speculative inventories. In

[32] It appears realistic to assume that even informed traders disagree about the fundamental value, since economic data never fully corresponds to theoretical concepts and economic theory disagrees on the exact model formalisation.

addition, consumers, as well as rational arbitrage traders, go short in the futures market to lock in temporarily high prices. Meanwhile, consumers, likewise expecting a future decline in prices, deplete their inventories with the intention of postponing buying. As a result, the demand for short contracts increases along with the supply on the physical market, which puts downward pressure on both futures and cash prices, and prices are realigned with the expected fundamental value. With greater availability of storage, the convenient yield declines and the carry strengthens, compensating for inventory holding. The increasing carry eventually curbs inventory sales. The inverse case applies if prices are temporarily below the expected fundamental value (Figure 2.1).

Hedgers, in this framework, fulfil a dual arbitrage role. While informed, non-commercial speculators align prices with the fundamental value, commercial hedgers fulfil the task of aligning not only prices with market fundamentals but also the physical and the futures markets through spatial arbitrage. Noise traders, as discussed previously, are arguably left without any price impact, since informed traders arbitrage away any price inconsistencies. Uninformed noise traders are, then, valuable liquidity providers who serve as counterparties for hedgers (Tokic 2011).

One of the most striking developments over the last decade, which has attracted wide attention among academics and policymakers alike, is the relatively sudden influx of liquidity associated with index investment into commodity derivatives markets. Index traders invest in a basket of commodity futures and allocate investments into the respective markets, in accordance with the composition of the index they are seeking to replicate (Heidorn, et al. 2014). Such investment instruments are novel for commodities, but have a long history in other financial markets[33].

In this context, the binary division between informed and uninformed[34] traders is amended by a third category to capture index traders. Index traders are categorised as 'passive' noise traders, in the sense that their investments are unrelated to market-specific traits, whilst 'active' informed and uninformed traders base their investment decisions actively on market-specific dynamics (Nissanke 2012a). Further, for commodity markets, the active, informed trader category is subdivided into commercial hedgers and non-commercial arbitrageurs. It is important to note that the active uninformed trader category here corresponds to the uninformed noise trader category, as defined in the previously reviewed

[33] The impact of portfolio insurance strategies, such as index trading, on market performance was already acknowledged in the late 1980s for security markets (Black 1986).

[34] Accepting the notion of uncertainty as either an epistemological or ontological reality suggests using 'informed' instead of 'rational' and 'uninformed' rather than 'irrational'.

bounded rationality literature. Hence, in this section the noise trader category is defined differently than before, or to be more precise, the noise trader category is split into the passive (index trader) and the active (uninformed speculator) noise traders.

Index traders, subsumed under the passive noise trader category, commonly invest with the aim of portfolio diversification (Masters and White 2008). Since index investors do not attempt to time or arbitrage the market, their trading behaviour is largely detached from the respective market's fundamental information set. Instead, positions taken are arguably correlated with overall market sentiments and global liquidity cycles, as index traders' investment decisions are based on portfolio considerations. Further, unlike uninformed speculators, who take positions on both sides of the market (going long and short), traders who seek passive exposure to commodity prices are overwhelmingly long. As a result of their particular trading strategies, index traders' positions are correlated as to the timing of their entry in the market, driven by global liquidity cycles, as well as their repositioning by rolling over long positions.

Following the bounded rationality and rational herding literature, index traders are likely to have a systematic impact on prices, and index traders' effects can be amplified by other traders, who employ extrapolative and herding strategies. Either under the assumption of market frictions (non-perfect elasticity of supply), or by acknowledging demand-driven price dynamics in the Keynesian tradition, long-only positions by index traders induce upward pressure on futures prices. These conjectured price dynamics are reminiscent of the hedging pressure hypothesis by which various authors have shown that short hedgers induce a bias to futures prices as an insurance premium to speculators (see Section 2.2.2). Therefore, index traders' demand for long positions, like hedgers' demand for short positions, is expected to have a decisive impact on futures prices. Since index traders take long-only positions, this price impact results in a positive premium on the futures price over the cash market price. In the following, I will refer to this price pressure effect induced by index traders as *index pressure*[35].

Since the presence of index traders in commodity futures markets is a relatively recent phenomenon, only a few studies provide a microstructure model for commodity futures markets that explicitly accounts for the presence of index traders. Among those studies, Brunetti and Reiffen (2014) suggest an equilibrium model, which includes index traders, speculators and hedgers. Their model predicts that the spread between two contracts is

[35]A more general version of this hypothesis is brought forward by Harris and Gurel (1986) as the 'price pressure hypothesis'. They argue that with a shift in demand, investors who accommodate the demand shifts need to be compensated for their services.

enlarged by index traders rolling over contracts, and that the spread is correlated across commodities listed in the same index. A larger spread implies a decrease in the hedging costs. Their insights are based on the hedging pressure and risk premium approach in that they argue that index traders provide the liquidity to hedgers, so that the risk premium and, hence, hedging costs decline. However, their model is incomplete, as it only assumes short hedgers—hedging costs for long hedgers would increase with the presence of index traders—and it does not consider the relationship between the futures and the cash markets.

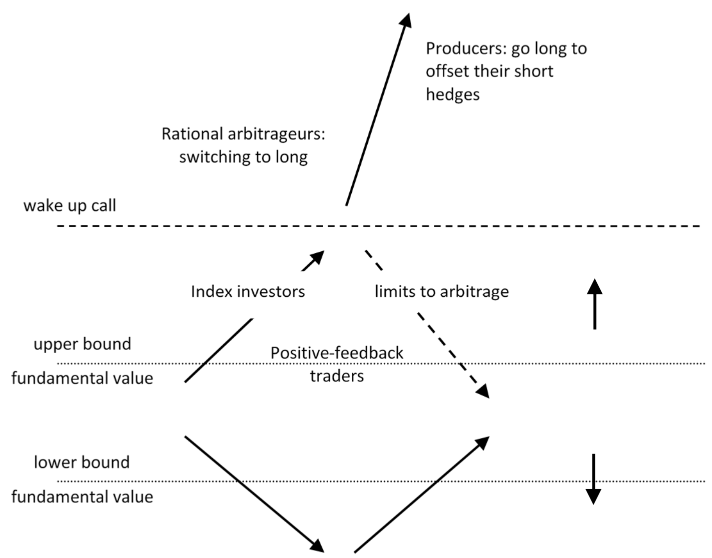
Basak and Pavlova (2013) propose another structural model, which faces similar problems as the Brunetti and Reiffen (2014) model. They suggest a dual trader division in which they contrast hedgers and index traders. Different from Brunetti and Reiffen (2014), Basak and Pavlova (2013) do not make reference to the hedging pressure literature, but locate their model within a wider empirical and theoretical literature dealing with the effect of index traders on stock markets and price pressure hypotheses. Although they are able to derive many of the empirically observed anomalies and claims made by the financialisation hypothesis, like speculative bubbles, excessive co-movement, excessive volatility and various spillover effects across indexed and non-indexed commodity markets, they are also unable to extend the model to the physical market beyond a mechanical no-arbitrage condition. This shortcoming is explicitly acknowledged by the authors. By using the no-arbitrage condition for an extension to the cash market, they simply substitute the futures price with the cash price plus carry.

This crude way of dealing with the problem reveals a key difficulty with price discovery models for commodity markets. While the early models locate price discovery in the physical market in a general equilibrium framework, the later market microstructure models locate price discovery in the futures market. The former models derive the futures price as a mirror of the cash price, while the latter models derive the cash prices as a mirror of the futures price. Either way, price discovery on one of the two markets is removed from consideration with assumptions of the no-arbitrage conditions that equate one market price with the other. As a result, these theories are *unable to fully reflect the dynamic interplay between both markets*.

Furthermore, the role of speculation in commodity markets is conceptualised differently in no-arbitrage and asset-pricing theories. For the former theories, speculation enters as a determining factor only through hoarding in the inventory market. For the latter theories, speculation is included only through bounded rationality and rational herding in the futures market. The problems with these conflicting theories are addressed further here, after first reviewing the effect of index and speculative traders on dynamics in the futures market.

Possible scenarios for the emergence of speculative bubbles in the presence of index traders can be derived based on the bounded rationality and rational herding theories. If the weight of passive index positions magnified by extrapolative traders outweighs the weight of positions of informed arbitrageurs and hedgers, the efficient market hypothesis is likely to fail, even in liquid markets (Hull 2011, 531-3). With increasing uncertainty, traders employing extrapolative strategies are rewarded for the risk they take on, and these strategies could eventually become more profitable than arbitrage trading (Gromb and Vayanos 2010). If uncertainty is high, extrapolative traders engaging in positive feedback trading are likely to prevail. This may prompt arbitrageurs to close their short positions by going long, as margin calls pose increasing costs[36] and trend-following behaviour becomes profitable (Kilian and Taylor 2001; De Long, et al. 1990). Further, with increasing uncertainty, the bounds within which informed traders locate the fundamental value move apart. This delays price reversion further (Figure 2.2)[37].

Figure 2.2: Market Dynamics under Speculative Bubbles



Source: Adapted from Tokic (2011).

[36] The same argument was made by Tokic (2011) for commercial hedgers in the oil market and reported by the CFTC (2010) for the case of cotton in March 2008.

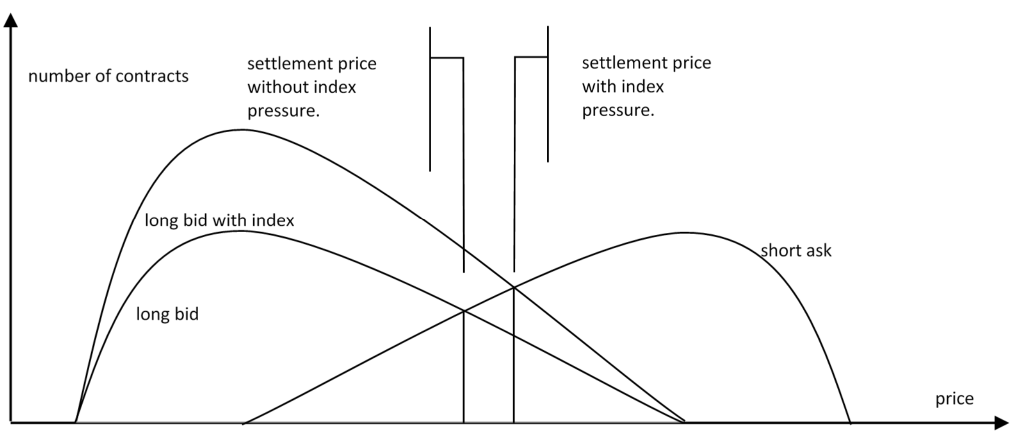
[37] This contradicts De Grauwe and Grimaldi (2006). The reason for this is that they relate the fundamental price band to transaction costs while we argue for uncertainty, in line with Kilian and Taylor's (2001) argument.

If the scenario as outlined above proves well founded, price deviations from market fundamentals can be explained by the changing composition and strategic interaction of different trader types exerting weight-of-market power. The market then oscillates between 'fundamental equilibrium' and 'bubble equilibrium' states. At a certain 'tipping point', the market becomes excessively speculative, and arbitrage traders switch to simple trading heuristics rather than providing balanced liquidity (Nissanke 2012a).

Upward price dynamics can be exaggerated similarly to downward price dynamics. If traders in times of financial distress face borrowing constraints or other pressures to liquidate their assets, the upward price trend will be reversed (M. Carter 1991). With index investors seeking diversification of their portfolios and increasingly contributing to the liquidity in commodity futures markets, a shock in the 'central' market, such as stock markets, could lead to the massive exit of traders from 'satellite' markets, such as commodity markets, causing cross-market contagion (Gromb and Vayanos 2010). Importantly, this development suggests a close relationship between financial and commodity markets and explains the double crisis in 2008–09 (Lagi, et al. 2011).

Speculative bubbles in commodity markets are not new phenomena (Maizels 1987; 1994; Amin 1995), and bubble scenarios for stock and foreign exchange markets have been examined within the informed–uninformed trader dichotomy, as discussed in Section 2.3. The 2002–08 price surge in commodity markets, therefore, cannot be ascribed solely to the presence of index traders.

Figure 2.3: Book Effect of Index Traders



Source: Author.

However, this thesis argues that index traders' characteristic investment patterns have decisively contributed to the persistence of such phenomena. Considering the trading book at a particular point in time, as depicted in Figure 2.3, a sudden influx of index traders shifts the settlement price upwards. Index traders push prices upwards, since their demand for long positions is price inelastic. Since index traders allocate a certain investment amount across commodity markets, index traders are insensitive to price changes in any particular commodity market and only change positions if changing total index exposure or if reweighting the index.

This conjectured price impact of index traders is strengthened by earlier findings on stock price behaviour and index inclusion, which show that an inclusion of a company in one of the major indices is accompanied by a substantial and relatively permanent rise in returns (Harris und Gurel 1986; Shleifer 1986). Grossman (1988), as well as Brennan and Schwartz (1989), point out that with the presence of portfolio insurance traders (that is, index traders), the information content of the market is reduced and price volatility increases significantly.

Such studies are also related to the literature on excess co-movements of indexed stocks due to common demand shifts, as suggested by Pindyck and Rotemberg (1990). Shleifer (2000, 37–39) shows in a structural dynamic model that co-movement of securities might not be caused by common fundamentals but by speculative investments. This conjecture is further empirically supported by studies undertaken by, *inter alia,* Greenwood (2005) and Barberis, Wurgler and Shleifer (2005), who confirm that the degree of co-movement between stocks included in the Nikkei 225 and S&P 500, respectively, are related to price-pressures exerted by correlated investors' demand.

What follows from the stock market literature is that passive index traders, who trade in a unidirectional manner, have a significant impact on the prevailing price level and price dynamics in commodity futures markets. Such a price impact is a potential candidate for shifting the price beyond the upper bound of the fundamental value, as depicted in Figure 2.2. If information density is low, the price impact might conflict with an information signal, and extrapolative traders are likely to amplify the more newly introduced trend.

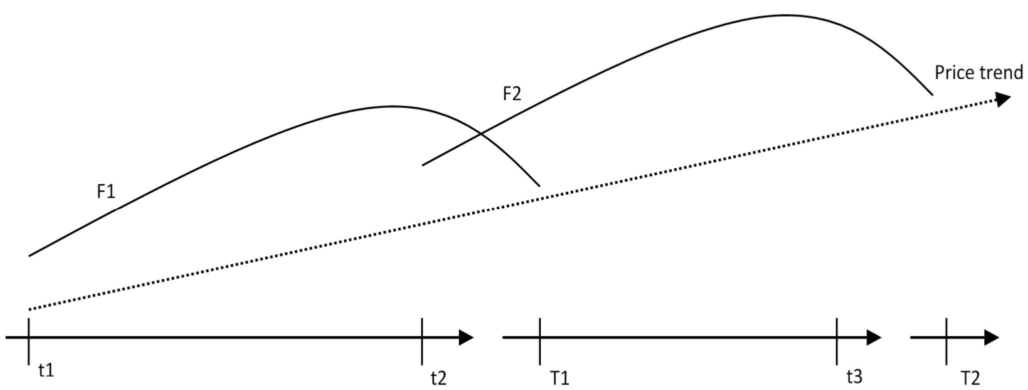
This situation is even more likely in commodity markets, where information asymmetry is an inherent feature. Commercial traders have a known information advantage on inventory levels, as well as future production and consumption. Therefore, since the identity of a trader is not disclosed, the activity of a large inflow of index traders could easily be confused with a trade placed by an informed hedger. Further, following the price-pressure and hedging-pressure hypotheses, it has been shown that in the presence of market frictions and transaction costs, the supply of contrarian traders is not perfectly elastic. Considering margin calls, trading fees and various capital constraints, a large inflow of long-only index traders is likely to have a substantial price impact.

On the basis of no-arbitrage theories reviewed in Section 2.2, the analysis can be extended to the relationship between cash and futures markets and futures contracts with different maturity dates. This allows me to draw implications of the financialisation of commodity derivatives markets on the physical market and the commodity markets' specific interplay between storage, cash and futures markets.

Index trading might not only impact the price level, but also the term structure, which is the price difference between futures contracts with different maturities. Since the term structure entails important information for actors in the physical market, commercial traders' decisions could be affected, which would then result in potential spillover effects to physical commodity markets.

As illustrated in Figure 2.4, if the entry of passive index traders puts price pressure on the contract they are in, denoted as [F1], the contract's price increases as long as index traders enter the market between t_1 and t_2. This trend is further magnified by the presence of extrapolative traders. When index traders rollover their contracts at maturity between t_2 and T_1, they execute upward price pressure on the deferred contract [F2] and downward price pressure on the maturing contract [F1]. This implies that, firstly, due to the presence of extrapolative traders, contracts are inflated more over their life cycle than they are deflated by the exit of index traders, and that, secondly, the carry of the market is increased.

Figure 2.4: Index Rollover Effect in a Normal Market



Source: Author.

This effect of index traders on the futures market's term structure has been theoretically and empirically confirmed by Brunetti and Reiffen (2014), who find that the spread between contracts with different maturity dates increases with the rollover of index traders. The suggestion that index investment either turns the market into a strong carry or strengthens an existing carry is consistent with the index pressure hypothesis outlined previously.

For markets of storable commodities, a carry is considered 'normal' in order to compensate for the storage costs. The market would only become 'inverted', that is, deferred contracts would trade at a lower price than closer-to-maturity contracts, if the convenience yield rises to the extent where it completely offsets the storage costs—which might occur when inventories are low. However, if index investment strengthens, so does the carry and hence, the costs to carry inventories over into the next period declines. If a high percentage of full carry[38] coincides with price volatility, owners of the physical commodity might be reluctant to sell due to (1) the implicit option value of stock holdings (Pindyck 2001; Irwin and Sanders 2012); or (2) the utility gained from precautionary holdings in times of high market uncertainty (Bozic and Fortenbery 2011; Pirrong 2011); or (3) the expectation of higher prices in the future, given a positive underlying price trend (Deaton and Laroque 1992; Singleton 2014).

Because of the limits to spatial arbitrage imposed by physical traders' reluctance to sell into the storage market, futures and cash market prices might fail to converge at the end of a futures contract's maturity. Moreover, high price volatility alone might impose limits to both spatial and fundamental arbitrage, as arbitrage trading becomes risky. As argued by Lyons (2001), arbitrage is only profitable if the returns to the arbitrage trade reach a certain threshold conventionally measured by the 'Sharpe ratio'. This is a relative measure of the returns on an arbitrage strategy with respect to the variance of the returns on such strategy. Thus, high price volatility and larger carry situations might impose limits to spatial arbitrage, and hence, cause non-convergence between the cash and futures market. The extent of non-convergence could be further increased by the index traders' roll effect.

The efficient market hypothesis assumes that the full-information value, i.e., the market-clearing price in the futures market under perfect foresight, equals the fundamental value, i.e., the market-clearing price in general equilibrium in the physical market, as depicted in

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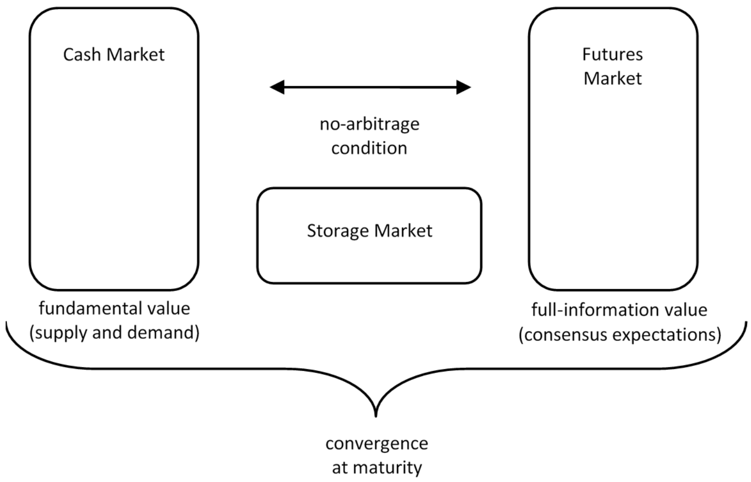
[38] The percent of full carry is estimated as the percentage of the storage plus interest compensated for by the carry $\left[\frac{F2_t - F1_t}{C_t^S + I_t}\right] * 100$, with C_t^S being the cost of storage, I_t the foregone interest rate and $F1_t$ and $F2_t$, the prices of the nearest and next-nearest contract to maturity, respectively (Irwin, et al. 2011).

Figure 2.5. However, considering the differences in trader composition and market structure between physical and derivatives markets, clearing prices on both markets may diverge (O'Hara 1997, 227). If traders' expectations do not coincide with fundamentals of the physical market, or if traders do not base their investment choices (only) on these fundamental factors, the market-clearing price of the commodity futures market does not necessarily equate the fundamental value of the commodity underlying the futures.

Figure 2.5: The Different Theories on Commodity Price Formation



Source: Author.

This argument is not new and was already considered by Working (1948), who notes that "the question whether cash and future markets are equivalent apart from the time element includes the question whether cash and futures prices may differ because they reflect the opinion of substantially different groups of traders". He also notes that a deviation between the two markets "requires the supposition that arbitrage between the cash and future price may be inefficient", which is when limits to spatial arbitrage exist. Although Working (1948) discards the idea to treat the two markets separately, he acknowledges that if hedgers are scarce—he appears to assume that only hedgers are true arbitrageurs—the relationship between cash and futures markets may break down. Considering that spatial arbitrage is only riskless at a futures contract's maturity (Yang, Bessler and Leatham 2001), prices might deviate substantially over a contract's life cycle.

Furthermore, mispricing in one market might spill over to the other market. As outlined before, there is no logical reason for the ex-ante belief that the direction of causation would only go from the cash to the futures market. Distortions in the futures market might not only have a direct impact on physical prices via spatial arbitrage trades, but also due to the fact that cash prices often consist of the futures prices and an agreed premium accounting for quality considerations (see Chapter 7). If the responsiveness of demand with respect to prices is low, i.e., if the price elasticity of demand is close to zero in the short-run, the cash market price might follow the futures price for some time. This is particularly true if there is uncertainty about market fundamentals and the overall amount of supply available. The reversal of such a speculative price trend might also be delayed, as producers' and consumers' financial planning timeframes allow demand and supply in the cash market to react to price changes only after a significant lag. Lagi et al. (2011), with reference to interviews they conducted, point out that the delay with which prices enter planning decisions might be up to 12 months. And further, even if inventories start to adjust, information on such changes will enter the futures markets with an additional time lag. Recalling the work of Acharya, Lochstoer and Ramadorai's (2013) on the impact of hedging pressure on cash market prices, the dominance of long index positions in the market would lead to a large carry, which, in turn, motivates inventory accumulation, and so would lead to an increase in the cash market price.

If a market's fundamental value is understood as a latent price, which is determined by structural factors behind market-clearing conditions in equilibrium, then the hypothetical framework outlined implies that if cash and futures markets differ systematically in the factors driving demand and supply (and price) in these markets, their market fundamental values differ as well. This occurs because demand and supply by speculative investors and index traders in the futures market and the factors driving such demand and supply enter the underlying price trend, and thus, become a market fundamental for the respective market (Gilbert 2008a).

The potential inconsistency between equilibrium conditions in the physical and the futures market causes contrary price signals spilling over from one market to the other, creating uncertainty and price volatility and abrupt market adjustments at maturity dates. With high volatility and a strengthened carry, it has been shown that spatial arbitrage is limited, which further disconnects the two markets. Furthermore, misleading information signals about storage levels can be transmitted through a term structure, which is not solely driven by physical market fundamentals. This can lead to various spillover effects from futures to cash markets.

The presence of uncertainty, whether in an epistemological or ontological sense, contradicts the rationality assumptions of the efficient market hypothesis, and trader behaviour—as suggested by bounded rationality, rational herding and Post-Keynesian scholars—provides a more accurate description of market realities. Against this background, fundamental arbitrage is limited, and futures prices can be in excess—regarding level, volatility and co-movement—of demand and supply conditions prevalent in physical commodity markets. Although physical and futures markets might not be linked through fundamental arbitrage, they are linked though spatial arbitrage, which results in spillover effects of price dynamics from futures to cash markets and high market volatility caused by inconsistent price signals in both markets.

If, however, limits to spatial arbitrage exist, these differences in driving factors underlying price dynamics in the physical and the futures markets, including demand by index traders and uninformed speculators, are revealed in non-convergence between cash and futures markets and the extent of the market basis at maturity. Similarly, variations in index and uninformed speculative investments across futures contracts with different maturities are revealed in the shape of the market's term structure.

Long-established theories considering heterogeneity among traders are applicable, with few amendments, to commodity markets and build the foundation of what could be termed financialisation with respect to commodity futures markets. These theories build on the assumption of uncertainty as an epistemological or ontological reality, which results in certain behavioural tendencies of financial traders and heterogeneity regarding their investment motives and strategies. Under these assumptions, index and uninformed speculative traders' investments can affect price formation mechanisms in commodity futures markets. Implications of the financialisation hypothesis for the relationship between physical and futures markets and futures contracts with different maturity dates can be derived on the basis of no-arbitrage theories.

However, the strength of the financialisation effect, which is linked to the relative market weight of traders and the degree of uncertainty, has to be determined empirically. This leads to the Section 2.5, which provides a review of the empirical literature on the financialisation of commodity markets.

2.5 Empirical Evidence

Empirical investigations into the financialisation of commodity markets fall into two different, although linked, fields. By far the most popular field of research investigates the impact of traders' investment positions on price level and price volatility. The second field focuses on the synchronisation of price dynamics across commodity futures markets and between commodity and equity markets.

Various papers provide reviews and assessments of evidence presented by the empirical literature—e.g., Irwin and Sanders (2010), Tollens (2011), Hailu and Weersink (2011). The aim of the following literature review is to provide an overview of methodologies used in existing empirical studies and to reveal potential flaws. Appendix 2.3 summarises studies published on the latest commodity price developments. It can safely be said that the evidence regarding the effect of speculative and index investments on price formation in commodity futures markets is, so far, inconclusive.

Methodologies employed by studies focusing on price level, change and volatility include:

- Simulations run with structural models that are derived from market microstructure theory and the literature on heterogeneous agents, the results of which are then compared to observed prices;
- Simple regression analysis between returns (and/or price volatility) and changes in traders' positions (and in some studies, fundamental factors are included);
- Granger or rolling Granger non-causality tests between traders' positions and commodity returns (and/or price volatility);
- Vector autoregressive (VAR) models combined with impulse response analyses;
- Rolling unit root tests that identify explosive growth in prices as evidence for extrapolative trading strategies;
- Error correction models (ECM), which investigate the speed of adjustment towards market fundamentals;
- Smooth transition functions, Markov-switching models and other non-linear and non-parametric models.

Methodologies employed by studies focusing on co-movement include:

- Simple correlation, rolling correlation, dynamic conditional correlation and other variations;
- Panel regression analysis;
- Non-parametric methods like common factor analysis;
- Network analysis and clustering.

In the following sub-section, these two fields of empirical studies are reviewed critically.

2.5.1 Trader Composition and Price Level and Volatility

By far, the most influential papers discussed in the early debate are a study published by Masters and White (2008) and an Organisation for Economic Co-operation and Development (OECD) study that was authored by Irwin and Sanders (2010). The former study presents descriptive evidence for index traders' investment inflow coinciding with rising commodity prices. By contrast, Irwin and Sanders (2010) argue with econometric tests that little evidence for a causal relationship between index trading activities and commodity futures price dynamics exists. Irwin and Sanders (2010) run several Granger non-causality tests to investigate the impact of index traders' net-long positions (long minus short positions) on commodity futures returns, as well as swap dealers[39] net-long positions on price volatility for 12 agricultural commodities. Most coefficients are insignificant.

Irwin and Sanders' (2010) approach was subject to criticism for several reasons. One of the most substantial, because it also applies to many other empirical papers—e.g., Stoll and Whaley (2011), Lehecka (2013)—is that Granger non-causality tests have low power in identifying lead–lag relationships between commodity prices and trading positions, because published position data are only available in weekly frequency. As it is assumed that expectations are translated into prices almost instantaneously, data in weekly frequency are inappropriate for analysing a timewise causal relationship. Further, financial market data, like commodity futures prices, are known for their large noise component, which obscures underlying signals and hampers inference in a Granger non-causality framework (Frenk 2011).

In addition to limitations in the data, Irwin and Sanders (2010), ex ante, preclude any amplifying collinear effects between index traders and other speculators, since they omit the latter trader type. The same criticism applies to their later paper, Irwin and Sanders (2012). Moreover, due to the difficulties associated with non-stationary time series, they chose commodity returns as the response variable. This choice limits the scope of investigations to weekly changes in commodity prices. Any potential long-run or cumulative impact of index investors' positions on commodity prices cannot be revealed in such test[40].

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[39] Swap dealers are a particular trader category that is heavily involved in index trading, and hence, was used as a proxy for index traders in several studies (see Chapter 3 for more detail).

[40] Unless a great amount of lags is included, which is not the case.

Gilbert (2008a; 2010a; 2010b) also runs Granger non-causality tests, taking commodity returns as the regressant. In contrast to Irwin and Sanders (2010), he firstly allows for amplifying effects between index investors and other non-commercial traders by including both trader types (Gilbert 2008a; 2010a) and, secondly, he controls for market fundamentals and endogeneity problems between prices, open interest and market fundamentals in a three-stage least squares regression (Gilbert 2010b). He finds that index investments have a persistent impact on oil, metal and soybean prices. Findings for other agricultural commodities are insignificant. These results are confirmed by Mayer (2009), who conducts Granger non-causality tests, investigating the lagged correlation between the share of index traders and other non-commercial traders with commodity returns. He finds evidence for changes in index investments Granger-causing changes in price for five out of eight commodity markets. Robles, Torero and von Braun (2009) use rolling Granger non-causality tests to control for parameter instability. They assess the impact of past values of various speculation indicators (similar to Working's T-index) on price changes for wheat, maize, soybeans and rice. Their results show that past values of the chosen indicators are significantly and positively associated with price changes over several time periods.

VAR models, combined with impulse response analyses, are suggested by Timmer (2009) and, in a more sophisticated way, by Juvenal and Petrella (2011). Timmer (2009) assess the impact of various factors including oil prices, exchange rate movements and dynamics in other commodity markets on rice, wheat and corn returns. He concludes that speculative demand in the futures market had a short-run impact on wheat and corn prices. Juvenal and Petrella (2011) follow a suggestion by Bernanke, Boivin and Eliasz (2004) and augment their structural VAR by a small set of principal components. Their factor-augmented VAR (FAVAR) has the advantage of capturing unobservable factors inferred from a large amount of information from observable economic variables. Juvenal and Petrella (2011) analyse the impact of shocks from oil supply, global demand, speculative oil inventory demand and financial speculative demand. Informed by Hamilton's (2009) structural model for speculation in oil markets, they derive restrictions on the signs of the parameters estimated. Global demand shocks are found to be the strongest driver behind price fluctuations and co-movement across commodities. The second strongest driver is found to be financial investments. Financial investment is especially significant between 2004 and 2008. Since VAR models are basically systems of Granger non-causality tests (Qin 2013, 43), the same criticism concerning the data frequency, noisiness of the data and exclusion of the long-run component applies.

Gilbert (2010b), Amanor-Boadu and Zereyesus (2009), Irwin and Sanders (2012), Stoll and Whaley (2011), and Singleton (2014) conduct contemporaneous regression analyses in addition to or instead of Granger non-causality tests. Amanor-Boudu and Zereyesus (2009) regress contemporaneous changes in non-commercial traders' positions on returns in an autoregressive integrated moving average (ARIMA) framework for corn, wheat and soybeans. They find that the relationship is insignificant.

Irwin and Sanders (2012) conduct a cross-sectional data analysis and employ a new data set, which supposedly captures the positions of index traders more precisely. The inclusion of contemporaneous and lagged values of these data provides no evidence for index traders' impact on prices over the sample period late-2007 to 2011. However, the index position data taken from the larger trader reporting system of the CFTC used by Irwin and Sanders (2012) are reported quarterly and hence, come at even lower frequency than the alternative CFTC weekly reports used by other studies. Because of the low data frequency and the limited time period for which the data are available—a time period that is known to have experienced a decrease in index positions across commodity markets—results have to be viewed with caution.

Stoll and Whaley (2011) include contemporaneous values of index and other speculative investment flows in dollar terms in their regression. They find that investments by other speculators are significantly and positively related to commodity returns. The coefficient on index investment is insignificant. The use of investment data in US dollar units rather than the number of open contracts, as used in most studies, is questionable, given the way position data increase with both additional open interest and the dollar price level. Further, only contemporaneous positions and no lagged values for index and other speculative demand are considered, which restricts the model to static correlation between traders' positions and commodity returns.

In a more comprehensive analysis, Singleton (2014) includes index traders' positions, managed-money spread positions[41] and aggregated open interest, as well as various indicators to control for traders' expectations on market fundamentals and overall market sentiments, in a linear regression model on crude oil futures returns. In contrast to previous studies, he finds that changes in index and managed-money spread positions have the largest impact on crude oil futures returns during the price peak in 2008. This evidence is significant for contracts with different maturities. Interestingly, Singleton (2014) uses 13

[41] A particular group of speculative traders that does not engage in index trading (see Chapter 3 for more detail).

weeks of changes[42] in index and managed-money spread positions instead of weekly changes.

Bos and van der Molen (2012) use a similarly comprehensive data set to account for fundamental factors, as well as index positions. In their study of global coffee markets, they employ nonparametric estimation methods that do not presuppose any underlying distribution of the data. They argue that the impact of index investors on price formation might be negligible, on average, but substantial and significant in short time periods. This 'spiky' impact cannot be captured by models relying on mean-variance estimation methods. By using nonparametric models, they find significant evidence that in times of market inefficiencies, index investments have a significant and positive impact on coffee prices.

Many of the studies investigating the impact of financial investments on commodity futures returns also conduct analyses on the impact of such investments on price volatility. One of the earliest studies in this regard is published by Holt and Irwin (2000), who find that the positions of large hedge funds are positively correlated with price volatility. They argue that such volatility is not caused by hedge funds acting as noise traders, because this would have presupposed that these had to make losses, which they cannot find in the data. This argument can be refuted, since, according to the bounded rationality and rational herding hypotheses, noise trading can be highly profitable. Irwin and Sander (2010; 2012) assess the impact of index traders on implied and realised volatility in a Granger non-causality framework. They find either no significant relationship between volatility and index investment or a significant negative relationship for a few markets.

Further, Brunetti, Buyuksahin and Harris (2010) find that the activities of hedge funds and swap dealers reduce volatility. Although they employ Granger non-causality tests, their methodology might not be subject to the same criticism as previously applied, as non-public daily position data are used. The higher frequency of the data partly rebuts the criticism of Granger non-causality tests. However, such tests remain problematic due to the large noise component. Moreover, the authors take swap traders' positions as a proxy for index investments, which is found to be imprecise (Irwin and Sanders 2012).

Power and Turvey (2011) overcome the noisiness of the data by filtering aggregate volume data from January 1998 to December 2006 by wavelet transformations. Herein, they extract variation in trade volume with a time horizon beyond one month. Their method is

[42] Herein he aims to assess the intermediate impact of traders' positions on price formation. Short-run (over a few days) lead–lag relationships are, according to Singleton (2014), of limited use for assessing the long-run price pressure effect of investment flows.

motivated by the observation that index traders invest on a long-term horizon only. Low frequency variation in volume can thus be attributed to index traders. After applying the filter, they employ two-stage least squares models, regressing price volatility on index positions. Their approach is problematic firstly, because commercial hedgers also tend to follow a long-term investment approach and, secondly, because they exclude the time period after 2006 by arguing that important structural changes, which drove prices independently from index positions, had occurred. However, the validity of this assertion is at the core of the financialisation debate.

Position data disaggregated by trader type are made publicly available by the CFTC for US futures markets and used by the majority of studies investigating the effect of financialisation on commodity markets, including the studies reviewed so far. However, several limitations have been identified with this data (see also Chapter 3). Firstly, positions data are published weekly. Secondly, positions in a particular commodity exchange are aggregated across all traded futures contracts. Thirdly, disaggregation is done according to the commercial background of each trader. While this poses difficulties in itself, since distinctions between commercial backgrounds are often not clearcut, the commercial affiliation does not necessarily imply a certain trading behaviour. Given these limitations in the data, some researchers suggest identifying price patterns, which are associated with a certain trading behaviour, instead.

For instance, Gilbert's (2008a; 2010a; 2010b) test for extrapolative trading is based on the argument that a root of a price series slightly greater than 1 indicates that past price trends are exaggerated in the preceding time periods, which is evidence for extrapolation. He finds many time periods in which explosive growth of metal prices is significant (Gilbert 2008a). These results are supported by a later study on agricultural commodities (Gilbert 2010a). In order to solve the somewhat arbitrary choice of the sample periods tested, he proposes a recursive unit-root test in his later paper (Gilbert 2010b). Results confirm his previous findings.

Liao-Etienne, Irwin and Garcia (2012) combine the search for explosive bubble behaviour with Granger non-causality tests. They employ a forward and backward recursive procedure developed by Phillips, Shi and Yu (2012) [43] to test for unit roots in price series based on the standard Augmented Dickey-Fuller (ADF) test. For corn, soybean and wheat futures, they identify explosive periods between late-2007 and mid-2008, as well as in the second half of 2010. In a second step, they develop dummy variables for the explosive

[43] Gilbert employs a similar method developed by Phillips, Wu and Yu (2011).

growth periods and apply a Granger non-causality test to investigate the relationship between commodity index positions and changes in futures prices. Granger non-causality test results are insignificant for all but the CBOT wheat market, where changes in index net-long positions are significantly related to returns in bubble and non-bubble periods. In a later study, Liao-Etienne, Irwin and Garcia (2014) apply the same unit root test to single futures contracts to avoid the noise that is introduced when rolling over futures contracts at maturity dates[44]. For all 12 agricultural markets included in their analysis, various bubble periods are identified between 1970 and 2011. However, bubble episodes are of short duration, with 80–90 per cent lasting fewer than 10 days, and representing a maximum of 2 per cent of price behaviour.

The same test for explosive price behaviour is used by Coakley, Kellard and Tsvetanov (2015) for the crude oil market. They use continuous futures price series of all simultaneously traded contracts, that is, the continuous time series of the closest, the second-closest, and the third-closest, etc., contract to maturity[45]. Their analysis spans the time period 1995–2012. Results indicate that all series exhibit periods of bubble behaviour that ends in late 2008. Moreover, they find that bubbles in longer-dated contracts start much earlier and are longer lasting than bubbles in the shorter-dated contracts.

Also, Cifarelli and Paladino (2010), Lagi, et al. (2011), and Vansteenkiste (2011) seek evidence for extrapolative feedback trading in the price data itself. They develop structural models, which explicitly allow for heterogeneous agents, as suggested by market microstructure theory.

For instance, Cifarelli and Paladino (2010) incorporate positive feedback trading into a multivariate CAPM on crude oil prices. They find evidence for the conjecture that, in recent time periods, extrapolative trading strategies have caused considerable departure of the crude oil futures price from its fundamental value. Lagi, et al. (2011) construct a dynamic structural model derived from the theory of storage and heterogeneous agent models. They find that most of the food price dynamics observed from 2004 onwards can be ascribed to ethanol convergence and speculation. Vansteenkiste (2011) assumes two market regimes, a 'fundamental-based' and a 'chartist-based' regime. While the former is described by the theory of storage, the latter is described by a model derived from the market microstructure theory that accounts for heterogeneous agents and positive-

[44] The noise is particularly strong if first differences are used, since then positive/negative changes can be due to price changes as well as backwardation/contango in the market (Liao-Etienne, Irwin and Garcia 2014).
[45] They avoid the calendar effect by rolling over at maturity with the closing price of the last business day of each month.

feedback trading. A Markov regime switching function, conditioned on Working's T-index, determines the market's dynamic switching between these two regimes. She finds significant evidence that an increase in speculative activity increases the probability of the market remaining in the 'chartist regime'. And, further, that the probability of being in the 'chartist regime' has significantly increased from 2004 onwards.

However, no direct inference from traders' behaviour on price dynamics can be drawn from models focusing on price patterns, which is a major shortcoming. Hence, other explanations for explosive price behaviour might be equally valid. An exception might be made for Liao-Etienne, Irwin and Garcia (2012), however, they are confronted with the problems identified with Ganger non-causality tests.

Further interesting approaches to the question of how to assess the impact of financialisation on commodity futures prices are suggested by Schulmeister (2009), Basu, Oomen and Stremme (2010), Mou (2011), and Brunetti and Reiffen (2014). These authors model the profitability of investment strategies, which explicitly accounts for noise trading.

Schulmeister (2009) investigates the profitability of over 1,000 popular technical trading strategies and finds that strategies are profitable and that exit and entry points are largely synchronized. Mou (2011) shows that a strategy of front-running the roll of large commodity indices offers prolonged arbitrage opportunities. This finding implies that index traders have a significant price impact and that limits to spatial arbitrage exist. Basu, Oomen and Stremme (2010) compare the performance of trading algorithms, including information on positions of different trader types with those who exclude such information. They find that, in retrospect, algorithms including position information yield returns 12 times higher than their restricted alternatives. Hence, information on positions by different trader types entails predictive power on future price developments. Brunetti and Reiffen (2014) investigate the impact of index traders on the cost of hedging. They find that the roll of index traders increases the spread between the maturing and next-to-maturity contracts. However, since they approximate index traders' position with swap traders' open interest, their results are problematic.

ECMs, which incorporate long-run and short-run effects, were suggested by Maurice and Davis (2011), Kaufmann (2011), Redrado, et al. (2009), and Beckmann, Belke and Czudaj (2014).

Maurice and Davis (2011) use an ECM to test for the efficiency of the futures market, by analysing the speed of adjustment between futures and cash prices for cocoa and coffee markets. Since they find an adjustment parameter above 0.5 and co-integration between cash and futures prices for all markets over the time period 1990 to 2011, they conclude that futures markets of those commodities are efficient despite financial investments. The validity of this argument is questionable both because it is not investigated whether or not the co-integrating relationship breaks and because the cash price might be influenced by financial investments if spatial arbitrage is effective.

Kaufmann (2011) takes a more reliable approach. He suggests an ECM to assess the adjustment process of the West Texas Intermediate (WTI) crude oil futures prices towards its physical market fundamentals. He defines factors considered to be market fundamentals and formulates an ECM based on the co-integrating relationship between these variables. He finds that the co-integrating relationship between crude oil futures and their fundamental variables breaks down between 2007 and 2008.

Redrado, et al. (2009) account for market fundamentals and, in addition, non-linearity in the market adjustment process and regime switching via transition functions conditioned on the price misalignment between the current and the fundamental value. Instead of single commodities, aggregates for metal and food commodities are used. Given the heterogeneity of commodities within, as well as between, the aggregates, the fundamental value is almost certainly erroneous. Moreover, the transition function, which drives changes in the speed of adjustment, is conditioned only on the size of the misalignment. No information on the presence of speculative investments is included. Although the authors suggest that the existence of small misalignments over a prolonged time period might be caused by market sentiment, their model does not provide support for this conjecture.

Beckmann, Belke and Czudaj (2014) analyse the short-run and long-run effect of global liquidity on commodity prices in a Markov switching vector ECM. They approximate global liquidity with the first principal component of money supply time series of the US and various other European countries. They find a significant long-run relationship between global liquidity and commodity prices.

2.5.2 Trader Composition and Co-movement

In addition to explosive bubbles and excessive volatility, empirical studies focus on excessive co-movement in the price dynamics between different commodities, as well as between commodities and equities.

Tang and Xiong (2012) were first to test for excessive co-movement in the context of the latest commodity crisis. They employ simple linear regressions to assess the correlation of different non-energy commodities included and excluded in the major commodity indices, before and after 2004 with oil prices. They regress commodity futures returns on oil returns, as well as on control variables, capturing market fundamentals. In that way, they seek to test if, firstly, the correlation between oil prices and prices of other commodities has increased after 2004 and, secondly, whether this effect is significantly stronger for commodities included in the major commodity indices as would be expected if index investment drove price dynamics. They find that correlation between non-energy commodities and oil increased significantly, and that this development is more pronounced for indexed commodities than for off-index commodities.

However, their methodology has to be criticised on several grounds. Firstly, oil prices have to be considered as a fundamental factor for some commodities. Secondly, no control variable for ethanol conversion—one of the major forces repeatedly suggested as being behind a strengthened correlation between oil prices and agricultural commodity prices—is added. Thirdly, a comparison between off-index and indexed commodities is biased because of the potential differences in market characteristics other than index inclusion or exclusion such as, liquidity and market completeness. Last but not least, simple changes in the correlation between oil and other commodity returns do not allow a direct inference to be made on the factors causing these changes. Nevertheless, Tang and Xiong (2012) attribute the causes to index investment.

Buyuksahin and Robe (2011; 2014) provide tests on the impact of financial investors on the co-movement between commodity and equity prices by employing non-public daily position data in an autoregressive distributed lag (ARDL) model. In their analysis on changes in cross-market linkages between energy commodity and equity markets between 2000 and 2010, they find that it is not index traders, but hedge funds, which are active in both equity and commodity markets, have contributed to an increase in correlation.

Silvennoinen and Thorp (2013) choose a non-linear modelling strategy by using double smooth transition conditional correlation functions. They condition the transition function on expected stock volatility and the participation of speculators. The model thus allows for shifts between different market states, conditioned on speculators' weight-of-market and expected volatility. They find that transition indicators are significant and that commodities listed in the major commodity indices show a higher degree of co-movement than commodities excluded from major indices.

Bicchetti and Mayestre (2013) analyse the potential impact of high frequency traders on co-movement between commodity futures and the US stock market. Such analysis is made possible by using the recently available Thomson Reuters Tick History database. They compute rolling correlations at three different frequencies—1 hour, 5 minutes, 10 seconds—between returns in the most liquid US commodity markets and the S&P 500 futures contracts over the time period, 1997 to 2011. They find a synchronized structural break, which starts during 2008 and continues afterwards, and conclude that this is consistent with the conjecture that recent financial innovations in commodity futures exchanges have a positive impact on commodity–equity co-movement.

Ncube, Tessa and Gurara (2014) account for market fundamentals before analysing the monthly time-varying, pairwise co-movement between two groups of soft and grain commodities with crude oil during the time period, 1980 to 2014. They use a multivariate Generalized Autoregressive Conditional Heteroskedasticity (GARCH) model and find no particular evidence for excessive co-movement, but note that during an economic downturn co-movement increases. They explain this by precautionary inventory hoarding during these time periods, synchronised across markets.

Gomez, et al. (2014) analyse co-movement across a wide range of different commodities by network analysis between 1992 and 2010. They use a correlation matrix ordered according to the vicinity of its elements and construct a hierarchical network from it. In this way they are able to depict an accurate typology and hierarchy of the overall co-movement involved in commodity price dynamics. Their network analysis reveals that while there is no persistent increase in co-movement from mid-2008 to late 2009, co-movement almost doubled when compared to the average correlation. The authors link this phenomenon to speculation and uncertainty in the market. However, as with Tang and Xiong (2012) and Ncube, Tessa and Gurara (2014), no testable link is established between trader behaviour and variations in co-movement.

2.6 Concluding Remarks

In the previous discussion this thesis has shown that, under the assumption of uncertainty and information asymmetry, traders are likely to engage in extrapolation, herding and portfolio insurance strategies. These trading strategies have been demonstrated to lead potentially to price developments away from what is considered to be market fundamentals. Under the uncertainty assumption, either in the epistemological or ontological sense, fundamental arbitrage is limited. The relationship between markets supposedly driven by the same market fundamentals, then, hinges on the possibility of spatial arbitrage. However, price formation theories based on spatial arbitrage neither suggest a direction of the effect of arbitrage trade, nor do they suggest arbitrage to be linked to market fundamentals. Hence, price dynamics introduced by index traders and other uninformed speculators can spill over to physical commodity markets through spatial arbitrage, changes in traders' expectations and commercial traders' reaction to changes in the market term structure.

Most of the empirical studies reviewed face the difficulty that the methodology employed does not fully correspond to the dynamic processes outlined as the financialisation of commodity markets hypothesis in this thesis. Either market fundamentals or positions by traders other than index traders are omitted. Since these factors are suggested as correlated with index positions, the coefficients estimated are likely to be subject to omitted variable bias. Further, given concerns over non-stationarity, most models are estimated in first differences. This confines the analysis to weekly changes, which are not expected to reveal any effect.

While the majority of the empirical literature focuses on testing price levels and volatility, the relative price between cash and futures market and simultaneously traded futures might be more revealing. This is because fundamental factors are notoriously difficult to quantify (Black 1986). It is close to impossible to make a full assessment of the extent to which price dynamics are related to market fundamentals or to uninformed speculators' and index traders' demand, since either data on identified market fundamentals are missing or conflicting theories on what constitutes market fundamentals exist.

A way around the question of market fundamentals is to look at market basis and term structure effects. If two price series are supposedly driven by the same market fundamentals, their difference can only be explained, apart from the time factor (carry variables), by the difference in traders active in the different markets or contracts under investigation. For this reason, price differentials between cash and futures markets, as well as between contracts with distinct maturity dates, might serve as a more fertile ground for analysing the effect of different trader types on price formation processes. Further, such an analysis has arguably higher relevance for market practitioners, since potential spillover effects between derivatives markets and physical markets are taken into consideration.

However, before such analyses can be conducted, assumptions made by the financialisation hypothesis on the behavioural traits of traders should be carefully tested. This will be done in the following Chapter 3.

Chapter 3 Traders' Behaviour under Uncertainty

3.1 Introduction

Chapter 2 outlined how the interplay of different trader types could affect commodity markets' price level, volatility, markets' term structures and market basis. Various assumptions about traders' behaviour under uncertainty underlie these considerations. These assumptions, as shall be elaborated more in the following, can be summarised in three hypotheses: (1) uninformed speculators employ extrapolative trading strategies, (2) uninformed speculators engage in herding strategies, and (3) traders are heterogeneous in their trading strategies and motives.

However, the empirical literature, which investigates these assumptions with respect to commodity futures markets, is thin. The great majority of empirical studies on the financialisation of commodity markets directly jumps to test the impact of traders' positions on price dynamics (see Chapter 2: Section 2.5), without an assessment of whether assumptions about traders' behaviour hold or the data used adequately reflect traders' behaviour.

Therefore, this Chapter 3 is dedicated to systematically test assumptions about traders' behaviour under uncertainty as outlined in Chapter 2: Section 2.4, and to carefully assess the adequacy of the data available.

The introduction aside, this chapter is divided into four sections. Section 2 builds on the trader categorisation which has been introduced in Chapter 2: Section 2.4 and suggests a formalisation of the behavioural assumptions made. Against the background of the abstract trader categorisation proposed in the previous section, Section 3 discusses data availability and limitations. The discussion is followed by a descriptive analysis of trader-position data for the cocoa, coffee and wheat markets, which serve as case studies in this and the following empirical chapters. Section 4 presents an econometric analysis of trading motives and strategies. The analysis commences with a review of methodologies used for similar empirical investigations. Several shortcomings in the existing literature are identified. On the basis of this critique, I develop alternative empirical frameworks for testing the three hypotheses outlined above. The last Section 5 discusses the insights gained.

3.2 Heterogeneity and the Financialisation Hypothesis

Four stylised trader categories have been identified: informed hedgers, informed speculators, uninformed speculators, and noise traders. The first three categories are considered to be active traders, in so far as their investment decisions are made on the basis of market-specific considerations. The index trader category is considered to be passive, since index traders' investment decisions are thought to be unrelated to developments in the market they are investing in. Further, the first two trader categories are informed, that is, they are knowledgeable about market fundamentals and take those into consideration when investing. The latter two categories belong to the uninformed trader group. Their investment decisions are not based on a thorough assessment of market fundamentals. Instead these traders base their investment decisions on past price and volume patterns or considerations about market developments outside the particular market they are investing in, like portfolio diversification.

The hedger or commercial trader category comprises all traders, whose core business is related to activities in the physical market. It is commonly assumed that their main trading motive is hedging their physical exposure. For this purpose, they offset their long (storage, production) or short (future purchasing) physical position by a short or long position in futures. However, they are known to engage in strategic hedging in order to minimise their risk by simultaneously maximising their revenue (CFTC 2008). This means that they potentially over- or under-hedge depending on their view of future market developments. Due to their engagement in the physical market, they are thought to be informed and base their trading decisions on their expectations regarding future market fundamentals. Since they are active in both the financial and physical side, they are able to execute not only fundamental but also spatial arbitrage where it arises, and thus enforce a close relationship between cash and futures markets.

The demand function of the i^{th} commercial hedger in the futures exchange can be described as[46]:

$$D_{i,CP} = \alpha_i \left[E\left(P_{i,F} \middle| \Omega_{i,F} \right) - P_t \right] \tag{3.1}$$

α_i is a factor for risk aversion. $E\left(P_{i,F} \middle| \Omega_{i,F}\right)$ is the expected fundamental value of the commodity futures (that is the expected cash price at time F) conditioned on $\Omega_{i,F}$, which is the i^{th} commercial hedger's information set on market fundamentals. P_t is the current price of the commodity. Under perfect foresight: $\Omega_{i,F} = \overline{\Omega}_F$ and $D_{CP} = [P_F - P_t]$ for all commercial traders.

[46] The notation used is partly adapted from Tokic (2011).

Non-commercial informed arbitrage traders are assumed to base their decisions on expected futures prices, given hedging demand that drives the risk premium, and their knowledge about market fundamentals.

$$D_{j,IA} = \alpha_j \left[E\left(P_{j,t+1} \middle| \sum D_{i,CP}, \Omega_{j,F} \right) - P_t \right] \tag{3.2}$$

$E\left(P_{j,t+1} \middle| \sum D_{i,CP}, \Omega_{j,F}\right)$ is the expected price for one period ahead given hedgers demand and information about market fundamentals. If assuming perfect foresight and frictionless markets and that only rational arbitrage traders and hedgers are in the market, Equation 3.2 becomes $D_{IA} = [P_F - P_t]$ for all arbitrage traders.

Under the efficient market hypothesis, the presence of uninformed traders is not precluded, but these are assumed to be white noise, with equally positive and negative feedback traders in the market.

$$D_{k,UF} = \mp \beta_k [P_{t-1} - P_{t-2}] \tag{3.3}$$

with β_k being the sensitivity of the kth feedback trader's demand to price changes over the previous time period. Trading dynamics as depicted in Figure 2.1 would prevail if the behavioural assumptions of Equations 3.1–3 held.

As discussed previously, index traders have become increasingly active in commodity futures markets. Because of their distinctive investment behaviour, they have to be modelled as a separate trader category:

$$D_{l,IX} = \alpha_l \left[E\left(P_{l,P} \middle| \Omega_{l,M} \right) - \mathrm{P_t} \right] \tag{3.4}$$

$E\left(P_{l,P} \middle| \Omega_{l,M}\right)$ is the expectation on price dynamics with respect to information about overall market conditions affecting index traders' investment portfolio. Their position-taking is hence linked to systemic market factors rather than idiosyncratic market fundamentals. The presence of index traders changes the overall demand taken into account by informed arbitrage traders. Equation 3.2 has to be amended accordingly:

$$D_{j,IA} = \alpha_j \left[E\left(P_{j,t+1} \middle| \sum D_{i,CP} + \sum D_{l,IX}, \Omega_{j,F} \right) - P_t \right] \tag{3.5}$$

Under perfect foresight, informed arbitrage traders are able to differentiate between $D_{i,CP}$ and $D_{l,IX}$, and consequently discard index traders' demand as noise, which would yield

Equation 3.2. However, if relaxing the assumptions of the efficient market hypothesis, so that:

(1) There is uncertainty about market fundamentals among traders;
(2) There is known informational asymmetry among traders;
(3) Traders interact strategically and hence not independently of each other.

The third assumption follows from the first and the second. If there is uncertainty about future market fundamentals and awareness about information asymmetry, additional demand from index traders is likely to enter arbitrage traders' expectations.

Since large commercial traders have a known information advantage, it is rational, especially for smaller traders, to follow large orders. This information advantage arises from an opaque storage market, a high market concentration and high costs associated with information gathering. Against this background, herding and extrapolative strategies are rational, especially for smaller traders. The systematic exploitation of data on past prices and other traders' investment choices is likely to result in a prevalence of positive feedback traders in Equation 3.3. The presence of index traders is not a necessary condition for such situation to evolve, but given trader anonymity and the conformity of index traders' positions, these are likely candidates for inducing price pressure.

3.3 How to Quantify Speculative Demand?

In reality, it is difficult to maintain the stylised trader categories as presented, and the distinction between trader types according to their investment behaviour is not as explicit as suggested (Heumesser and Starlitz 2013). Further, the categories, although useful, are too narrow to reflect the full behavioural spectrum. For instance, it is suggested that traders can be distinguished according to how knowledgeable they are about market fundamentals and how sensitive they are regarding idiosyncratic market factors. Other traits, like investment horizon, are neglected. High frequency traders employ different trading strategies and have a different price effect than lower frequency traders, although they might be equally well informed or sensitive to idiosyncratic market factors.

Another neglected strategy is market manipulation. Since most strategies categorised as market manipulation require the manipulator to hold a high market weight and the ability to store the physical product, large commercial traders, as well as large non-commercial traders, who acquired storage space, are likely candidates (Heidorn, et al. 2014)[47]. Market

[47] This insight motivated Gilbert (2010b) to regard traders' positions as endogenous.

manipulation can be regarded as the purposeful exploitation of power in order to create price pressure[48]. Commodity futures markets are particularly prone to such incidences for several reasons. Firstly, markets are often extremely centralised. Secondly, information asymmetry between hedgers and non-commercial traders is structural. Trading on private information is an important aspect of a hedger's usual business. Cases of market abuse or manipulation are, however, incidental and not continuous. They can hence only be studied on a case-by-case basis.

Further, there are some practical difficulties with categorising traders. Categorisation is only feasible on the basis of observable and time invariant properties. However, trading strategies are neither observable nor static. There is arguably a circular relationship between investment strategies and their price impact, as the performance of investment strategies is reviewed regularly and adapted constantly (Lo 2004). Trading strategies are *per se* unobservable. Therefore, trader-position data, distinguished by the particular industry in which the respective trader is predominantly engaged in, are used as an approximation for behaviour. This again poses serious empirical challenges. Traders' strategies within a particular industry are not necessarily homogeneous. Not only are industry groups heterogeneous, but trading strategies are often not linked to just one particular industry group, and there is a known overlap of strategies that are used across industries.

While the categorisation suggested in the literature is useful, it is neither complete nor easily linkable to observable traits. In order to quantitatively assess the impact of various trading strategies on the price formation mechanism in commodity futures markets, available data used to quantify such strategies has to be carefully assessed before employing it in a regression-type analysis.

3.3.1 Data Availability and Limitations

Most commodity exchanges provide daily volume and open interest data for each traded futures contract. Volume counts the number of contracts traded over each trading day. Open interest counts the number of outstanding contracts at the end of each trading day (Lucia and Pardo 2010). Conventionally, daily volume is regarded as short-term investment and taken as a proxy for speculative activity, while open interest is regarded as long-term investment and ascribed to hedgers. Although the empirical literature confirms that volume

[48] A definition of market manipulation is difficult, since the term is juristically defined and hence changes under the respective jurisdiction. Further, the abuse of a position of power can be regarded unfair but not necessarily unlawful. For the following the above definition should suffice.

is largely speculative while positions measured by open interest tend to be dominated by hedgers (ibid.), no further disaggregation of volume by trader type is possible.

Open interest data disaggregated by different trader types is available for US-based futures markets through the CFTC Commitments of Traders (COT) reports. These data sources have been widely used in the empirical literature on commodity markets. The CFTC provides a breakdown of each Tuesday's open interest by different trader types for US futures exchanges in three major flagship reports, which suggest different categorisations regarding the traders' commercial backgrounds. The COT report is the earliest data publication, which dates back to the 1980s for some commodity markets, and distinguishes between commercial (hedgers) and non-commercial (speculators) traders. In 2008, the CFTC commenced the publication of the Commodity Index Trader Supplement (CIT), which adds index traders as a separate category and is available from the beginning of 2006. The third major report is the Disaggregated Commitment of Traders Report (DCOT), which distinguishes between producers and consumers, money managers, other non-commercial traders and swap dealers, and provides data starting from mid-2006. Additionally to the three main reports, the Index Investment Data Report (IID) is published on a monthly frequency.

The IID report captures index traders' positions more precisely than the weekly CIT report. Data collection is based on a special call for traders classified as index traders. In the CIT report, all positions by an index trader are enumerated as index positions, but the special call allows for a differentiation between the index-based and non-index-based positions of a trader who is predominantly engaged in index trading. The IID data are often used as a benchmark to assess the extent to which other categories reflect index investment. Among the weekly reports, the CIT index trader category is found to reflect index positions most accurately (Irwin and Sanders 2012).

The CIT supplement was produced on recommendation of a CFTC staff report in 2008 which identified various shortcomings with the earlier COT data (CFTC 2008). One shortcoming arises from a controversy over the definition of commercial hedgers. Firstly, the institutional structure of US commodity exchanges provides strong incentives for traders to register under the commercial category, since position limits are less stringent for traders in this category. This incentive leads to overestimation of traders in the commercial category (Sanders, Boris and Manfredo 2004). This conjecture is supported by Ederington and Lee (2002), who analyse non-public position data for the heating oil market. The data enable them to identify the line of business of each individual trader. They conclude that commercial traders cannot easily be regarded as hedgers, because many firms with no obvious physical business are also contained in this group. Secondly, the classification of swap traders poses various challenges. Swap dealers provide tailored derivative products to a wide customer base on an OTC-basis. They usually net their exposure internally and hedge their residual price risk at the more standardised exchange. Since they engage in futures trading for hedging of risk that results from their commercial business, swap traders were categorised as commercial traders (CFTC 2008). The report recommends redefining the commercial trader category and creating a separate category for swap traders. These recommendations resulted in the publication of the CIT and DCOT reports.

The DCOT report started publication shortly after the CIT report in September 2009. The report provides more detailed classifications of non-commercial traders into swap dealers, managed money and other non-commercial traders than the CIT report. Money managers are either commodity trading advisors or commodity pool operators[49] or any other fund (CFTC 2009). Other non-commercial traders are all reportable traders, who are neither swap dealers nor funds. These are mainly institutional investors and investment banks. Clients, who seek exposure to commodity indices, operate through swap dealers. Hence, there is some similarity between the CIT index trader category and the DCOT swap trader category. However, there are also important differences, since swap dealers also include non-index based swap traders' positions, while the index trader category—in addition to swap dealers—includes large investment funds which engage in index trading directly at the exchange (CFTC 2009). The CIT category captures index investment more precisely, but the DCOT money manager category is an interesting addition as it captures funds known to engage particularly often in extrapolative trading strategies. Further, the producer merchant category in the DCOT report reflects hedging demand more accurately than the commercial trader category of the CIT supplement report, due to the remaining non-index swap traders in the latter.

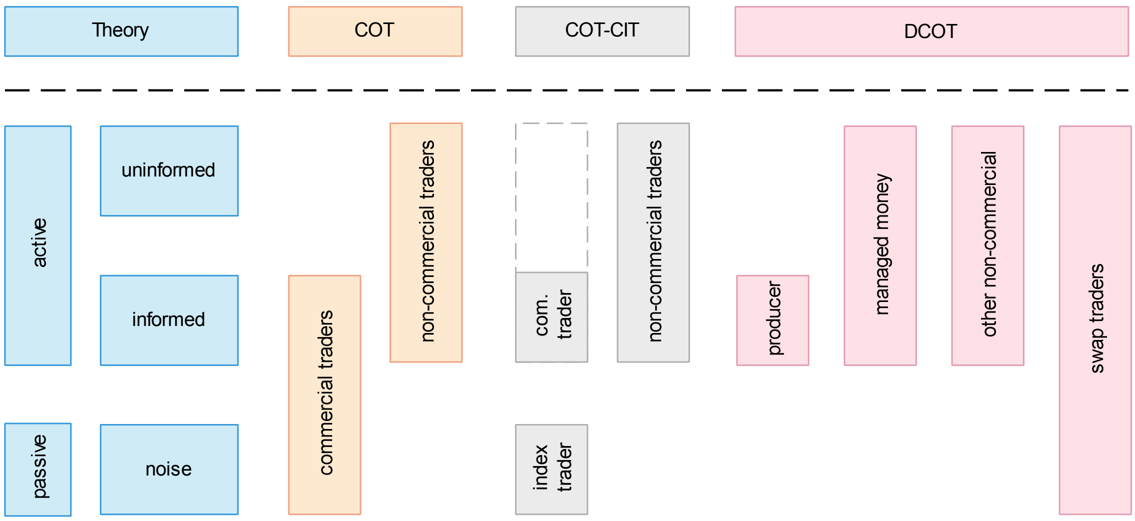
Despite the carefully defined trader categories, it is often not clear into which category a particular market participant might fall. Brokers, in particular, operate for a variety of clients with diverse investment interests and industry backgrounds, so brokers' positions should ideally be disaggregated by client. Further, traders often engage in multiple commercial businesses—for instance, commercial traders use hedge funds (see Chapter 7),

[49] A commodity pool acts similar to an investment trust or a syndicate and solicits or accepts funds, securities, or property for the purpose of trading commodity futures contracts or options. The commodity pool operator makes trading decisions on behalf of the pool or engages a commodity trading advisor to do so. Managers at hedge funds or their advisors are often registered with the CFTC as commodity pool operators (CFTC 2015).

index traders invest for non-index purposes, etc. The disaggregation of such positions is tedious and the categorisation often relies, to a certain extent, on the judgment of the person doing the categorising.

Most importantly, one has to keep in mind that the CFTC can only observe the trader but not the trading activity executed. If trading activities are diverse in one particular trader category, the category is inadequate for capturing investment strategies. Given that the classification of traders is based on commercial categories and not trading strategies, the categorisation suggested by the CFTC is not one-to-one translatable into the stylised theoretical categories proposed. The typology in Figure 3.1 is an attempt, nevertheless, to link the theoretical classifications to the industry groups as suggested by the CFTC reports. Appendix 3.1 provides a more detailed account.

Figure 3.1: Traders Typology after CFTC Reports



Source: Author.

The active and uninformed category corresponds to extrapolative and herding strategies associated with uninformed speculators. The active and informed category corresponds to arbitrage strategies associated with informed hedgers or informed speculators, who engage in fundamental and spatial arbitrage trades. The passive noise trader category corresponds to portfolio diversification strategies and is associated with index traders.

Besides concerns over the degree of precision with which commercial categories reflect trading strategies, the data frequency is problematic, since CFTC reports are published weekly. Further, intra-day traders are excluded from the open interest data. This leads to an underestimation of the impact of traders engaging in short-term investment strategies, especially found among the money managers and other non-commercial trader categories.

In the following section, observed trader-position data are carefully analysed for three commodity markets—wheat, coffee and cocoa—before conducting econometric tests.

3.3.2 Trader Heterogeneity in Commodity Markets

Wheat, cocoa and coffee experienced similar price surges and high levels of volatility from the early 2000s onwards. Prices peaked in mid-2008 and experienced a sharp decline until the beginning of 2009 (Figure 3.2). While wheat, concurrently with the overall commodity price index, reached another slightly lower price peak in early 2011, cocoa prices already surpassed the 2008 peak in early 2010. Coffee prices reached a level almost twice the previous peak in early 2011.

Figure 3.2: Commodity Price Indices
(index 2010=100, monthly, Jan. 2004–Jul. 2014)

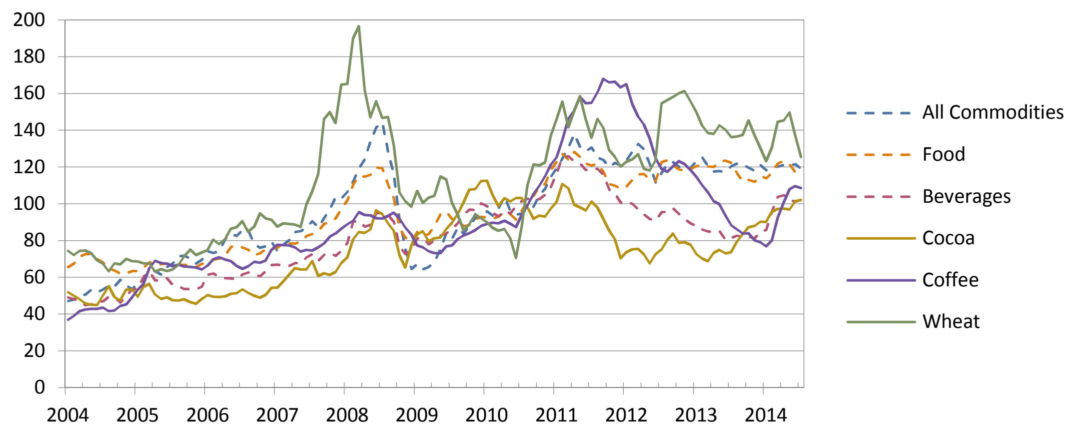
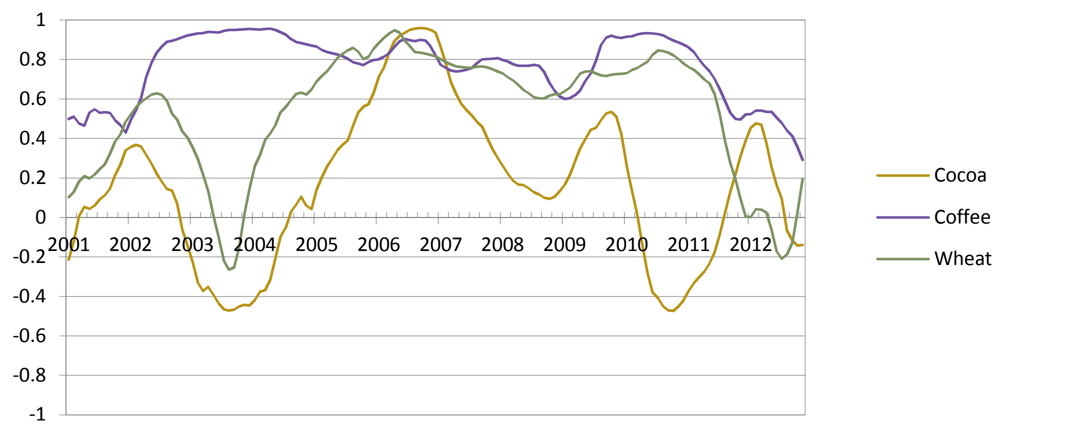


Figure 3.3: Covariance Between Commodity Index and Single Commodity
(three-year monthly centred moving covariance, Jun. 2011–Apr. 2013)

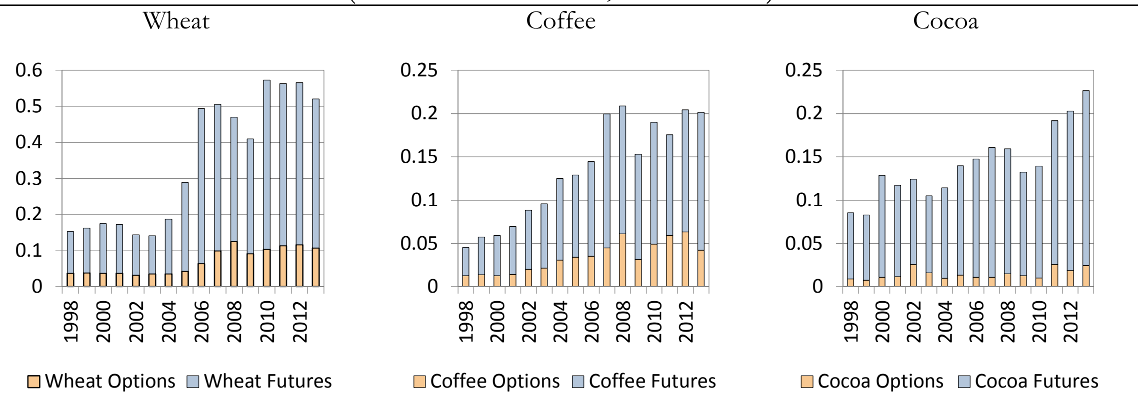


Source: IMF, IFS: Commodity Prices (author's calculation).

Coffee and wheat show a high degree of co-movement with the overall commodity price index since 2002 and 2004 respectively, while cocoa is the least strongly correlated (Figure 3.3). However, since mid-2011 the degree of co-movement with the overall commodity index for both, wheat and coffee, declined. This coincides with a decline in oil prices and index investment in these markets.

All three commodities—again cocoa to the least extent—experienced an unprecedented inflow of liquidity, revealed in rising open interest over the last decade (Figure 3.4). In 2006, open interest in the wheat market had jumped to a level 2.5 times as high as in 2004. For cocoa and coffee, the rise was more steady, but clearly visible as well. The extent of liquidity inflow can at least partly be linked to index investment. Wheat is included in all major basket commodity indices and is cited as the second most affected US market by index investment between 1992 and 2008, only after crude oil (CFTC 2008). Although coffee and cocoa are included in commodity indices as well, these are given smaller weights than wheat, which results in less index investment.

Figure 3.4: Annual Average Open Interest
(contracts in millions, 1996 - 2014)

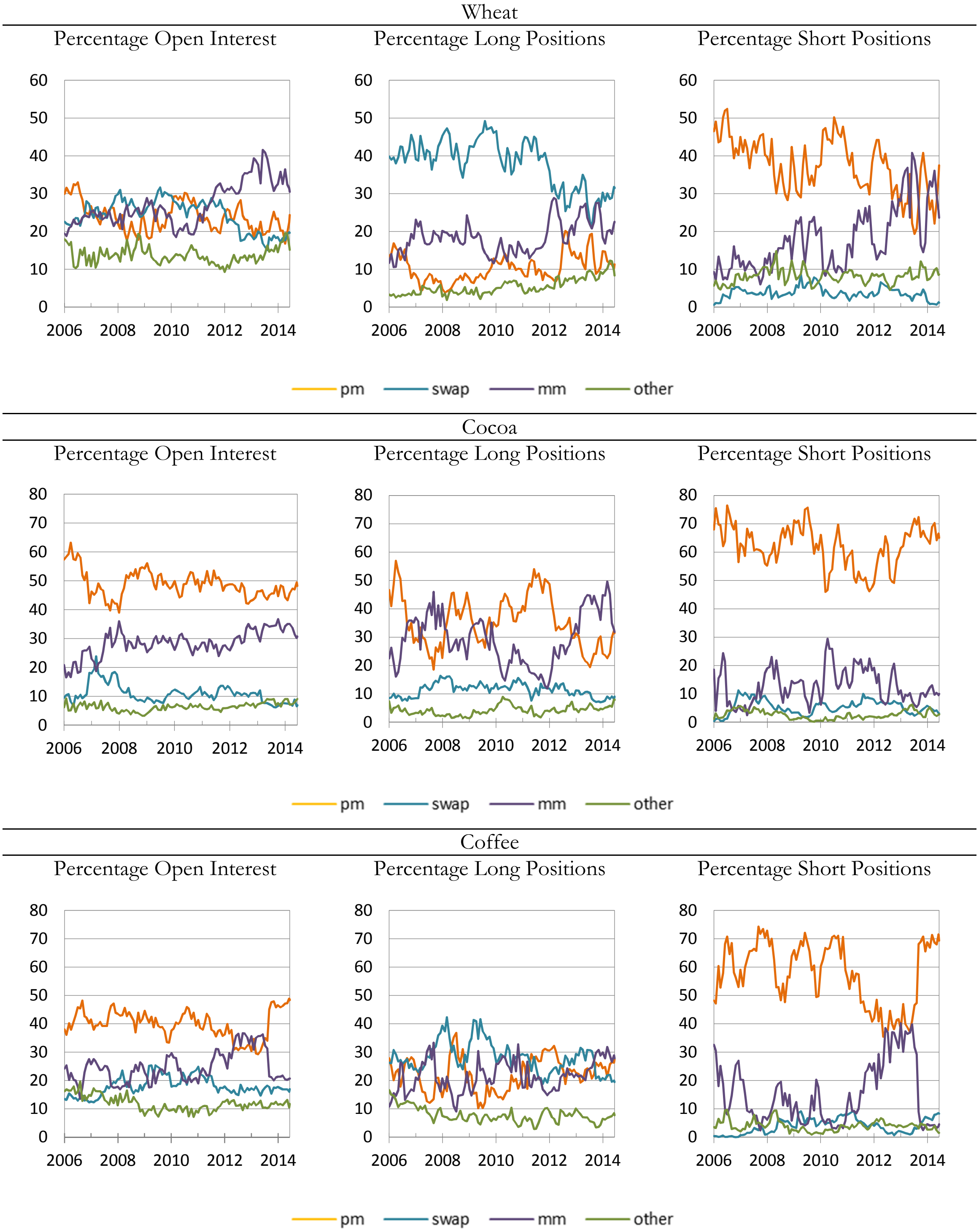


Source: CFTC, COT.

The difference in trader composition in these three markets is revealed by the shares of trader types in total open interest (Figure 3.5). While money managers and swap traders dominate the wheat market, cocoa and coffee are still dominated by commercial traders. The disaggregation into short and long positions provides evidence for the predominant strategy employed by different trader types. Commercial traders are overwhelmingly short, in support of Keynes's normal backwardation theory. Index traders, here approximated by swap traders, are predominantly long, as suggested by the financialisation hypothesis.

Although index traders provide liquidity to commercial hedgers, their positions, especially in the wheat market, seem to exceed commercial hedgers' demand for trading counterparties, so that money managers and other non-commercial traders step in to fulfil the counterparty role for index traders (see Chapter 4).

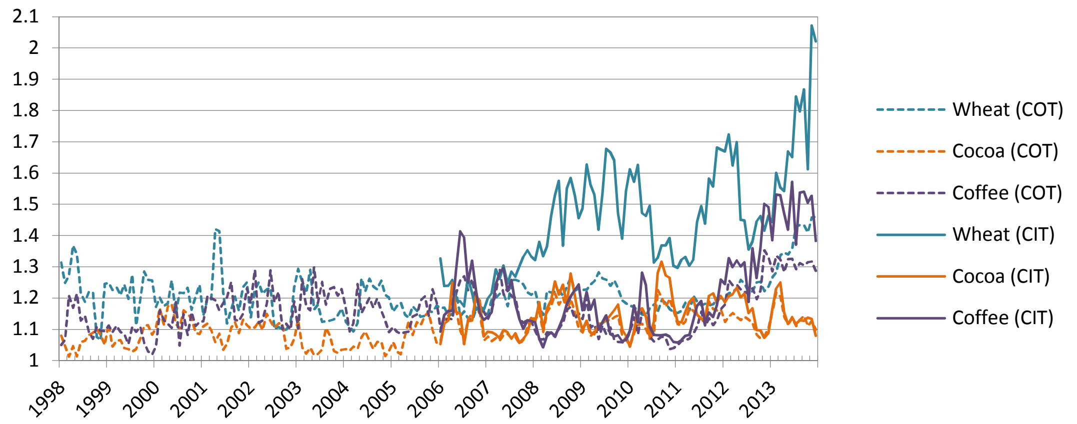
Figure 3.5: Trader-composition in Total Open Interest
(end of month % share, Jun. 2006–Dec. 2014)



Notes: *pm* stands for Producer and Merchant, *swap* for Swap Dealers, *mm* for Money Managers, and *other* for Other Reportables. Source: CFTC, DCOT (author's calculation).

Early researchers into commodity markets attempted to measure this 'excess' of speculative liquidity. The most prominent indicator to evaluate the degree of speculation is Woking's T-index, which estimates the ratio between hedgers' demand and the supply of speculative positions (Working 1960). However, since estimation is commonly based on the COT commercial and non-commercial categories, the T-index tends to underestimate the degree of speculation, due to the misclassification of swap traders. This bias is clearly visible in Figure 3.6. For the wheat market, Working's T-index, estimated by COT data, does not exceed 1.4 until 2013, but, estimated by CIT data, the index reaches values up to 1.7 over the same time period. The difference reveals the extent of index trading, that is categorised as commercial positions in the COT data set. Moreover, intra-day positions are excluded, which adds to the bias.

Figure 3.6: Working's T-Index with COT and CIT Data
(end of month, Jan. 1998–Dec. 2013)

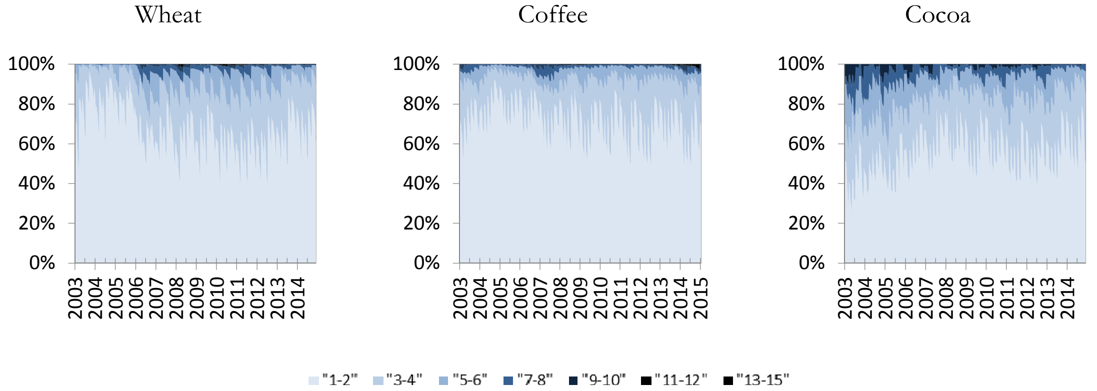


Source: CFTC, COT and CIT (author's calculation).

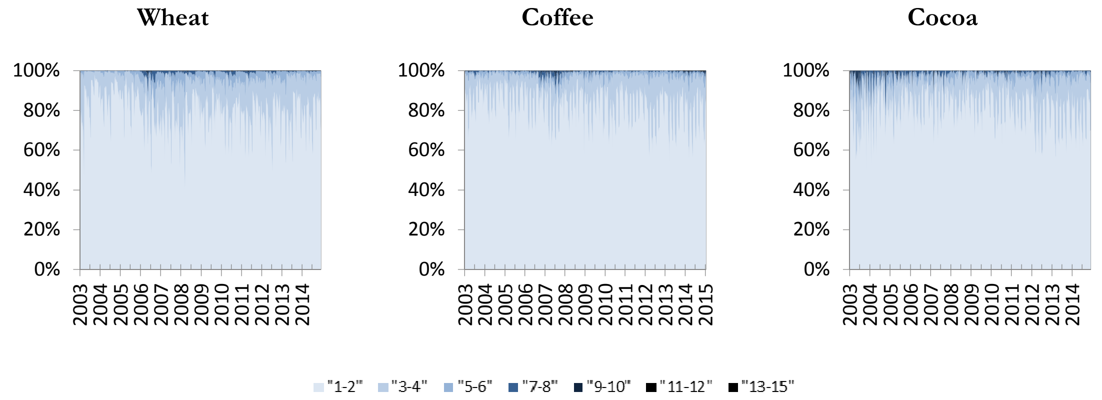
Although no disaggregation of open interest or volume by different trader types is available for *individual* commodity contracts, changes in the allocation of open interest and volume across simultaneously traded contracts still provide insights into changes in trading strategies associated with particular trader types (see Chapter 5). For the wheat market, that has been most affected by index investment, a clear shift towards longer-dated contracts in both open interest and volume is visible (Figure 3.7). Both hedgers and index traders use longer-dated contracts. However, the increase coincides with an increase in index investment, but not hedging positions, and can hence be linked to the former.

Figure 3.7: Open Interest and Volume Across Contracts

Open Interest (in %, 2003–2015)



Volume (in %, 2003–2015)

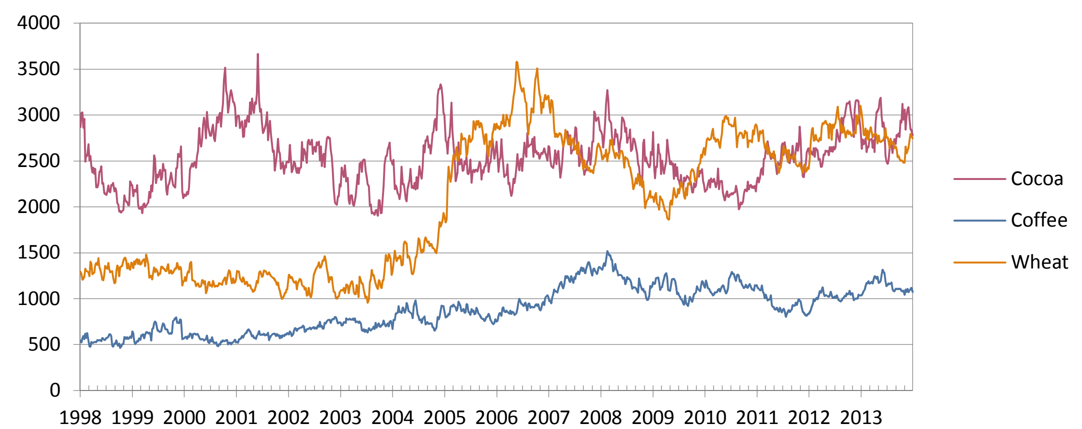


Note: *"1-2"* indicates aggregated volume of the next-to-maturity and second next-to-maturity contract, etc. Source: Datastream (author's calculation).

For the cocoa market, that has seen the least index investment, open interest shifted towards the short-dated contracts, at least until 2008 and again from 2012 onward. These dynamics roughly coincide with the cocoa price cycle (Figure 3.2) and are probably linked to speculators, who seek short-term exposure in order to benefit from a price rise. Interestingly, for both wheat and coffee, there is an increase of volume in deferred contracts during the 2008 price peak. This effect might be due to hedgers and index traders being forced to close out their positions during those volatile times.

Wheat, coffee and cocoa do not only differ in the composition of open interest and volume, but also in the degree of market concentration. One measure of concentration in the futures market is the average number of contracts held per trader. This can be calculated from the CFTC reports. As shown in Figure 3.8, market concentration is high for the cocoa market and has been high historically compared to the coffee and wheat markets.

Figure 3.8: Market Concentration
(long and short reporting traders, end of month, Jan. 1998–Dec. 2013)



Source: CFTC, COT (author's calculation).

For the wheat market, concentration increased between 2004 and 2005 to a level as high as for cocoa. This might be linked to the entry of swap traders with a large client base or large institutional investors and investment banks.

Due to its small size and few players on the physical side, the cocoa market has always been prone to market manipulation. The latest incident occurred in mid-2010 at the London cocoa exchange. Oversight is less stringent in London than in New York and the market is more opaque—no position data disaggregated by trader type is made public—so that London is more exposed to manipulation. A single hedge fund, associated with one of the largest cocoa trading houses, squeezed the market by taking large-scale long positions in the July 2010 contract and eventually forced short traders into delivery according to a report by the International Cocoa Organization (ICCO 2010). Those unable to deliver had to settle in cash with the long trader, who could then bid up the settlement price. The physical position, which gained value through the forced delivery, was subsequently hedged at the exchange in order to lock in temporarily high prices. Thereby, the trader is believed to have profited twice from the squeeze. Market manipulation of this kind is only possible by large traders that are strong both in the physical and in the derivatives market. The structure of the industry hence plays a key part in determining whether these manipulations are likely to occur (see Chapter 7).

While cases of market manipulation are incidental, behavioural traits like herding, extrapolating and passivity regarding market fundamentals are systematic. The following empirical investigation tests whether there is evidence for those systematic behavioural tendencies in wheat, coffee and cocoa.

3.4 Empirical Analysis of Traders' Behaviour

The key elements of the financialisation hypothesis outlined in Chapter 2 are assumptions about traders' behaviour under uncertainty. Various suggestions have been made for the behavioural traits of different traders in commodity futures markets that could potentially lead to speculative bubbles, excessive volatility and other market inefficiencies. These can be summarised in three testable hypotheses:

(1) Traders engage in extrapolation;
(2) Traders engage in herding;
(3) Traders are heterogeneous in their trading motives.

The first two hypotheses are linked to the bounded rationality, rational herding and fundamental uncertainty literature. The last hypothesis reflects the heterogeneity assumptions made and the particular traits attributed to different trader types. These hypotheses will be tested consecutively.

Despite the fact that many theories on speculative bubbles build on behavioural assumptions, empirical investigation of trader behaviour is generally thin for commodity futures markets (Devenow and Welch 1996). Studies can be divided into three broad areas. One area is concerned with price patterns, which arise as a consequence of certain behaviour—e.g., Gleason, Lee and Mathur (2003), Christie and Huang (1995). These studies provide indirect tests for trader behaviour, which, however, only hold if there is a single path of causality between latent behaviour and observed price patterns (*price pattern* literature). Another strand analyses data on traders' positions and investigates traders' investment motives and strategies (*position taking* literature). The most prominent strand of literature looks into the question of whether traders' positions or traders' sentiments predict future returns (*forecastability* literature)—e.g., Tornell and Yuan (2009), Rouwenhorst and Tang (2012); and Wang (2001), Sanders, Boris and Manfredo (2004) for an overview. The most interesting area for market practitioners is the latter one, which explains the many publications in this area.

Although more prominent, the *forecastability* literature is less useful in testing behavioural assumptions. Since this is the intention of this Chapter 3, the focus is on the *position taking* literature. The few empirical papers that have taken this route will be discussed next. Appendix 3.2 provides a technical summary, complementing this review. Some of the studies will be familiar already, since they have previously been mentioned in Chapter 2: Section 2.5. However, the previous review focused on the link between trader behaviour and price dynamics[50]. The elements of the literature that were dedicated to testing behavioural assumptions were hence ignored.

One way of analysing traders' behavioural traits is by psychological profiling, as for instance done by Canoles, et al. (1998). The authors survey 25 commodity brokers and their 114 clients in Alabama and find that commodity speculators have the 'psychological profile of habitual gamblers'. Similar insights are given by Schwager (1992; 1989). He conducted numerous interviews with commodity traders, which reveal insights into trading strategies that are not based on market fundamentals. A more recent study by Barclays Capital (BC 2012), based on interviews with traders, similarly finds that most traders do not cite market

[50] Here the focus is on the reverse impact of price dynamics on traders' positions.

fundamentals as the main motive for position changes. No less than 45 per cent of the traders interviewed reduced their commodity exposure in 2011 due to the general desire to reduce risky assets, rather than due to commodity-specific concerns. An additional 25 per cent cited other non-commodity related factors, such as the need to reduce the dollar exposure of their portfolios.

Ederington and Lee (2002) provide valuable insights into the diversity of traders. They use non-public CFTC data with information about each trader's line of business. They find that especially traders in the speculator category differ in their holding strategies. Commodity pool operators and hedge funds speculate on price fluctuations in the short-term with most of their positions being taken in the nearby contracts, while floor traders[51] are more involved in trading longer-dated contracts. Commercial traders tend to hold their short positions significantly longer than their long positions. This indicates that those hedge with a long-term focus and speculate with a short-term horizon[52]. Producers and intermediaries use the futures market as temporary hedge until their forward/OTC contract can be matched. Commodity pool operators take only long or only short positions, and rarely the spread positions[53] that are characteristic for other speculative traders like investment banks. Commodity trading advisors hold more spread positions and position themselves in the medium-term. These findings do not only reveal the extent of trader heterogeneity but also expose the inherent difficulties with the publicly available CFTC data sets, which are unable to reflect this diversity.

An attempt to formally test for extrapolative strategies employed by traders is made by Sanders, Boris and Manfredo (2004). The authors suggest two variables for capturing traders' behaviour based on the COT report. Firstly, weekly percentage of total open interest held by each trader category and secondly, with reference to De Roon, Nijman and Veld's (2000) measure for hedging pressure, the weekly percentage net-long position. The first variable captures the relative market weight of each trader category and the second provides the normalised size of the net-positions by trader type. The authors employ Granger non-causality tests to examine the lead–lag relationship between net-long positions and commodity futures returns for several energy commodity markets between October 1992 and December 1999. For non-commercial traders they find that net-long positions are

[51] Floor traders are brokers which either execute trades on behalf of others or execute their own trades (CFTC 2015).

[52] If accepting the assumption that most commercial traders are short hedgers, that is, producers rather than consumers.

[53] Spread trading is the simultaneous sale and purchase of different futures contracts with different delivery months or futures contracts of different commodities. A spread position takes advantage of changes in relative prices.

significant positively related to returns, while this effect is significantly negative for commercial traders. They argue that their results suggest positive feedback trading by non-commercial traders.

However, these findings are problematic for two main reasons. Firstly, the adding up constraint—if non-reporting traders' positions are minimal—implies that the commercial and non-commercial trader categories are counter images: commercial traders being net-short implies that non-commercial traders must be net-long. Results for one category have to be the inverse of the other (Wang 2003). Secondly, the COT categories are misleading.

Similar pitfalls are found in a study by Wang (2003), although he explicitly acknowledges these limitations. He analyses trader behaviour for eight different commodity markets using COT commercial and non-commercial categories and additionally controls for various other trading motives by a trading sentiment index. This index is significantly positively related to changes in non-commercial traders' positions. In contrast to Sanders, Boris and Manfredo (2004), he finds that commercial traders engage in positive feedback trading, which he explains by hedging practices involving synthetic options.

Rouwenhorst and Tang (2012) apply data by all three major CFTC reports and analyse both the contemporaneous and lagged-Granger relationship between changes in net-long positions normalised by total open interest, excess returns and market basis for 28 individual commodity markets. In line with Sanders, Boris and Manfredo (2004), they find that commercial positions are strongly negatively related while non-commercial positions are strongly positively related to returns. In contrast, swap dealer positions and, even more so, index traders' positions are found to only marginally co-vary with returns. These findings support the hypothesis that swap dealers and index traders are passive in the market. Further, the authors find that positive feedback strategies employed by non-commercial traders are largely driven by managed money positions.

A test for herding is proposed by McAleer and Radalj (2013), who utilise the COT data in order to analyse the extent of herding activity in gold, oil—for which they find no evidence for herding—and other, non-commodity, futures. They assume that small traders employ herding strategies to mimic larger traders' position taking. In order to test for this conjecture, they approximate small traders with non-reporting traders and large traders with non-commercial reporting traders. Two assumptions underlie this choice of variables. Firstly, reporting non-commercial traders are assumed to be informed traders. Secondly, non-reporting traders are assumed to be uninformed traders. This is problematic as both the motives and commercial background of non-reporting trades is unknown. Further, other studies suggest that the non-commercial trader category is heterogeneous and does comprise of informed and uninformed traders (Ederington and Lee 2002). Finally, while the argument that non-reporting traders are less informed is reasonable, since information gathering is costly and large traders are more likely to have the financial resources to engage in such activity, earlier deliberations suggest that small traders would rather follow commercial than non-commercial traders. This is because commercial traders, due to their engagement in the physical market, have a known information advantage over inventory data and future supply and demand.

Domanski and Heath (2007) explicitly tested for the heterogeneity assumptions regarding trader behaviour underlying the financialisation literature. They base their analysis on the COT report for the crude oil, natural gas, gold and copper markets. The dependent variable is the share of non-commercial traders' net-long open interest in total open interest. Explanatory variables are informed by considerations about speculators' trading motives and include returns, roll returns, volatility, opportunity costs (short-term interest rate) and diversification benefits, like correlation with equity price indices and expected inflation. The model is estimated for 1998-2001 and 2002-2006, and it is tested whether coefficients change significantly between the two time periods. Results suggest that short-term factors, such as returns and the short-run interest rate, have become more important in recent years, while diversification benefits have declined in importance.

Mayer (2009) extends the analysis by Domanski and Heath (2007) to other commodity market. He employs similar explanatory variables linked to return and diversification considerations as in Domanski and Heath (2007). However, instead of only looking at non-commercial traders' motivations, he analyses the behavioural tendencies of both index and other non-commercial speculators by using CIT index traders' position data. This unfortunately restricts the data set that includes index traders to 29 oberservations in the period from January 2006 to June 2008. However, estimations based on COT non-commercial traders' positions are estimated for a larger sample including the three consecutive time periods 1999-2001, 2002-2004 and 2005-2008.

Mayer (2009) finds that index traders, as well as non-commercial traders' positions are strongly driven by return considerations. For index traders, roll returns have a significant influence on position-taking, but for non-commercial traders the main drivers are spot returns. These findings reveal the different trading strategies employed. For index traders, who pursue long-only investments, rolling over the position from one contract to another is an essential characteristic of their strategy. Coefficients for variables that capture diversification benefits are less significant for the later time periods for non-commercial traders. Mayer (2009) suggests that speculative motives have gained importance over diversification benefits. However, results can also be explained by the fact that only post-2005 index traders are accounted for in a separate category. In prior years, some of the index traders are categorised as non-commercial traders[54]. In a later paper, Mayer (2012) adjusts the definition of the explanatory variables slightly, but results remain largely similar.

There are several shortcomings in the existing empirical literature, besides those stemming from limitations in the data available.

Regarding the estimation of *extrapolative strategies*, studies consider return data only. However, most traders base their investment decisions on more complex technical indicators. Further, technical traders are known to often trade intra-day. Considering only open interest data results in an underestimation of the extent of extrapolation present in the market.

Regarding tests for *herding*, while non-reporting traders are the best proxy for small uninformed traders available, large non-commercial traders are not the optimal choice as a proxy for informed traders. Moreover, reportable commercial and non-commercial traders' positions are not necessarily large enough to trigger herding behaviour by smaller traders. Theoretical considerations also suggest that traders are more likely to engage in herding in the presence of uncertainty, which is not accounted for in existing studies.

Finally, regarding tests for *heterogeneity* in trader behaviour, parameter variance is not analysed beyond periodisation of the available time span. Further, existing studies exclude the behaviour of non-index non-commercial and commercial traders from their analysis.

Therefore, the following section addresses these shortcomings and proposes alternative methods to empirically test for trader behaviour, which circumvent the shortcomings identified in the reviewed literature. In the succeeding Section 3.4.2 I will conduct my own empirical analysis and discuss results in the context of the hypotheses outlined in Chapters 1 and 2.

3.4.1 Data and Methodology

Three hypotheses on traders' behaviour were proposed: (1) traders engage in extrapolative strategies, (2) traders engage in herding, especially under uncertainty, and (3) traders are

[54] Mayer (2009; 2012) refutes this as unlikely as the share of index traders is small and between 10 to 15 per cent. However, for some markets, like wheat, the share of index traders' position in the COT commercial category greatly exceeds 15 per cent.

heterogeneous and follow different investment strategies that may or may not be linked to market-specific considerations.

Various shortcomings in the empirical literature, which seeks to test these hypotheses, have been identified. The next sub-section develops alternative methodologies, which overcome these shortcomings, before empirical results for extrapolation, herding and heterogeneity are presented in the last sub-section.

3.4.1.1 Extrapolation

Chartism, stop-loss trading, momentum trading and more sophisticated trading algorithms are common extrapolative strategies, well-known and discussed in the empirical finance literature (Shleifer and Summers 1990). These strategies are used for detecting patterns in price and position data that could give an indication of future price developments. Some of the most prominent extrapolative indicators are used in order to test the extent to which such strategies have been employed in commodity futures markets.

Two models are estimated in order to test for the significance of extrapolative trading strategies employed by short-term intra-day traders. Using intra-day positions has the advantage that long-term traders, like hedgers, are filtered out. Hence intra-day positions closely represent short-term speculative trading motives. Intra-day volume Q_t is estimated as the daily volume less the change in open interest. For estimation, all days without any trading activity, i.e., zero volume, are excluded. Since Q_t has, par definition, to be strictly positive at all times, the data are filtered for non-positive values and where these occur due to data anomalies[55], intra-day volume is replaced by total volume at the particular trading day. The first model, specified in Equation 3.6, tests whether traders respond to technical trading indicators in an autoregressive regression equation of order k, AR(k):

$$\Delta Q_t = \alpha_0 + \sum_{i=1}^{k} \alpha_i \Delta Q_{t-i} + \beta_1 E_t + \beta_2 R_t + \varepsilon_t \tag{3.6}$$

The lag length is determined by downwards testing from a maximum lag length of 20 trading days and Akaike Information Criteria (AIC). E_t is the extrapolative trading signal and R_t is market returns estimated as the difference between current and last period's commodity price of the next-to-maturity contract in logarithms. E_t is estimated as the sum of buy-signals, sell-signals and support signals by different prominent technical trading indicators: relative strength index, moving average convergence divergence, open interest

[55] A maximum of five cases have been detected per market.

momentum, and volume oscillator. Those indicators are described in greater detail in Appendix 3.3. Since E_t comprises two extrapolative indicators and two support indicators: $E_t \in [0; 4]$. The null hypothesis that traders do not engage in extrapolative trading is tested using t-tests. The alternative hypothesis is that traders follow extrapolative trading signals:

$H_0: \beta_1 = 0$

$H_a: \beta_1 \neq 0$

In order to identify potential asymmetries in traders' reaction to buy- and sell-signals, another model differentiates between bullish and bearish signals as specified in Equation 3.7. If traders are risk-averse, the reaction to a sell-signal should be greater than to a buy-signal.

$$\Delta Q_t = \alpha_0 + \sum_{i=1}^{k} \alpha_i \Delta Q_{t-i} + \beta_1 E_t^B + \beta_2 E_t^S + \beta_3 R_t + \varepsilon_t \qquad (3.7)$$

The null hypothesis is that traders are risk neutral, which means they react equally to buy and sell-signals. The alternative hypothesis is that traders are risk-averse[56], which means that they react more strongly to sell-signals than to buy-signals.

$H_0: \beta_1 = \beta_2$

$H_a: \beta_1 \neq \beta_2$

The hypotheses are tested using Wald test for general restrictions based on Chi-squared. Since the test is not invariant to how the null hypothesis is formulated, both formulations $\beta_1 = \beta_2$ and $\beta_2 = \beta_1$ are tested.

Daily closing price data are used together with daily volume and open interest obtained from Thomson Reuters Datastream. Continuous time series are created by taking the next-to-maturity contract and rolling over into the second next-to-maturity contract at the day the next-to-maturity contract ceases trading.

3.4.1.2 Herding

In order to test for herding behaviour, I take the model proposed by McAleer and Radalji (2013) as a baseline and amend it by three variations towards a more appropriate definition

[56] Two alternative hypotheses exist: risk-averse ($\beta_1 < \beta_2$) and risk-loving ($\beta_1 > \beta_2$).

of large traders' positions. Firstly, the net-positions of the four largest traders active in the market are taken as an explanatory variable. Secondly, as an alternative explanatory variable, commercial traders' net-positions are used as a proxy for large informed traders. Thirdly, index traders, approximated by swap traders[57], are used in order to test whether small traders mistake large index traders' positions for informed hedgers' positions.

The test is repeated for long and short positions separately. A difference in coefficients for long and short positions can arise due to risk aversion. Small traders might be more inclined to follow large sell positions than buy positions. Last but not least, uncertainty is controlled for by including market volatility. These considerations regarding risk aversion and uncertainty have been omitted from McAller and Radalji's (2013) study.

Only the COT and DCOT reports provide information on the share held by the largest four traders in total long and total short positions. With this information and knowledge about the total number of open contracts in the market, the total amount of contracts held short and long by the four largest traders is recovered. This information is used to build a proxy for large traders' positions. Further, the correlation coefficients between the large traders' positions and the positions of different trader classifications are estimated in order to identify the trader category within which these large traders predominantly fall. Given hedging exemptions for hedgers and swap traders, it is expected that large traders fall into these two categories.

In line with the analysis by McAller and Radalji (2013), I include contemporaneous and lagged returns to control for herding-like behaviour, which is caused by trend-following (see Chapter 2: Section 2.3.2). Thereby, the extent of unidirectional trading can be clearly assigned to either extrapolative trading or herding. The regression equation is specified as

$$\begin{aligned}\Delta ST_{t,i} &= \alpha_0 + \alpha_1 \Delta LT_{i,t-1} + \alpha_2 R_t + \alpha_3 R_{t-1} + \alpha_4 \Delta VOL_t \\ &\quad + \sum_{j=1}^{k} \beta_j \Delta ST_{t-j,i} + u_t\end{aligned} \tag{3.8}$$

with i = {net-long, long, short}, VOL_t is the past week's daily volatility (Tuesday to Tuesday variance) as a proxy for market distress, $\Delta ST_{t,i}$ is the change of small traders' i position over time period t-1 to t, and $\Delta LT_{t,i}$ is the change of large traders' i position over

[57] DCOT swap traders' positions have to be used since the CIT report does not provide position data for the four largest traders.

the same time period. The null hypothesis is that small traders do not herd and the alternative is that they herd.

$H_o: \alpha_1 \leq 0$

$H_a: \alpha_1 > 0.$

If $\hat{\alpha}_1$ is significantly smaller than zero, small traders act as counterparties for large traders. If the coefficient is significantly greater than zero, evidence for small traders engaging in herding is found. Further, a significantly positive return coefficient indicates extrapolative behaviour. Lastly, the larger the lag length, decided by downward testing and AIC, the greater is the persistence, or the more long-term the small traders' investment horizon.

Data on market returns and volatility are estimated based on the continuous next-to-maturity contract, which is obtained from Thomson Reuters Datastream. Returns are estimated Tuesday to Tuesday. This is weekly data, taking every Tuesday's entry point, determined by the availability of the COT reports.

3.4.1.3 Heterogeneity

Finally, the heterogeneity assumptions underlying the financialisation hypothesis are tested. A lagged regression equation in monthly frequency is chosen.

$$NL_{i,t} = \alpha_0 + \sum_{j=1}^{k} \alpha_j \Omega_{j,t-1} + \beta_1 R_{t-1} + \beta_2 NL_{i,t-1} + \varepsilon_t \qquad (3.9)$$

For the i[th] trader type, with i = {com, ncom, index, pm, mm, swap, other}[58]. $NL_{i,t}$ are net-long positions divided by total open interest, $\sum \Omega_{j,t-1}$ is the sum of relevant market information for the particular trader, and R_{t-1} are returns lagged one period. The regression analysis is conducted in several steps focusing in turn on index traders i = {index, swap}, other non-commercial traders i = {ncom, mm, other}, and hedgers i = {com, pm}.

Firstly, regression results obtained by Mayer (2009, 2012) are replicated for comparative reasons and amended in several ways. A longer time period is chosen, data from additional trader-position reports are considered, and the information set $\sum \Omega_{j,t-1}$ is altered by redefining some of the explanatory variables as listed in Table 3.2. Secondly, the analysis is

[58] These categories refer to those in Figure 3.1 in the following way: *com* – commercial trader, *ncom* – non-commercial trader, *index* – index trader, *pm* – producer, *mm* – money managed money, *swap* – swap trader, *other* – other non-commercial trader.

extended to non-index non-commercial traders. Thirdly, positions taken by commercial hedgers are analysed by adding variables that capture hedging effectiveness and hedging costs. This way, the analysis is extended to other non-commercial speculators and hedgers following previous theoretical deliberations summarised in Table 3.1. Moreover, recursive estimation methods are used throughout, in order to overcome the arbitrariness in the periodization of earlier studies.

Table 3.1: Trader Behaviour and Potential Market Information Variables

Trader Behaviour	Variables
Commercial hedgers $\sum[E(P_{i,F}\|\Omega_{i,F})]$	Fundamentals: • Calendar spread (carry), exchange rate. Hedging costs: • Basis size, hedging effectiveness, volatility.
Non-commercial traders (informed) $\sum[E(P_{j,t+1}\|\sum D_{i,CP}+\sum D_{l,IX},\Omega_{j,F})]$	Returns: • Returns, roll returns, volatility, interest rate. Hedging demand: • Hedging positions.
Non-commercial traders (uninformed) $\sum[P_{t-1}-P_{t-2}]$	Trading indicators: • Returns, technical indicators.
Passive index traders $\sum[E(P_{l,P}\|\Omega_{l,M})]$	Returns: • Returns, roll returns, volatility, interest rate. Diversification: • Market beta, expected inflation, exchange rate.

Table 3.1 lists the behavioural assumptions made regarding the information sets used in the regression analysis. The empirical literature has so far focused on $\Omega_{l,M}$, that is on market information thought to be relevant for index traders. In the following analysis, hypotheses made on other trader categories are tested as well.

Table 3.2 provides a list of all explanatory variables, definitions and data sources. Two variations from Mayer (2009; 2012) regarding variable definitions are suggested. Most index investment—at least in the early years—is motivated by the aim to replicate the main basket commodity indices. One of the most prominent indices is the S&P GSCI. All three commodities investigated here are included. However, the weight of these commodities in the index is relatively small. In 2014 cocoa had a weight of 0.23 per cent, coffee 0.58 per cent and Chicago wheat 3.45 per cent (Heidorn, et al. 2014). Since the highest weight in the S&P GSCI is put on energy commodities, the performance of those commodities is decisive for the overall performance of the index. Due to the small weight of the commodities analysed, the returns to the index will not be linked to the returns of the particular markets analysed.

Table 3.2: Market Information Variables, Definitions and Sources			
	Variable	**Definition**	**Source**
Fundamentals	Calendar Spread	The difference between the third-to-maturity and next-to-maturity futures settlement price as the last Tuesday of each month.	Thomson Reuters Datastream
	Basis Size	The difference between the underlying cash price and next-to-maturity futures' settlement price at the last Tuesday of each month.	Thomson Reuters Datastream
	Hedging effectiveness	One minus the twelve months backward looking variance of the market basis divided by the one month backward looking variance of the cash market prices.	Thomson Reuters Datastream
Returns	Returns	Percentage change of the logarithmic futures price taking the last Tuesday's settlement price of the current and previous month of the next to delivery contract.	Thomson Reuters Datastream
	Roll returns	The twelve month backward looking moving average of roll return defined as the difference between the last Tuesday's of the month closing price of the next-to-maturity and third next-to-maturity contract. Prices are in logarithms.	Thomson Reuters Datastream
	Volatility	Twelve month standard deviation (backward looking) of the returns on the third next-to-maturity contract.	Thomson Reuters Datastream
	Interest rate	Average of the three month deposit interest rates in US, UK, Japan, Canada, France, Germany, Netherlands, and Switzerland. The averages over the last Tuesday of each month are taken.	Thomson Reuters Datastream
	Technical indicators	See Appendix 3.2. Series are constructed from daily next-to-maturity contract settlement prices, open interest and volume data.	Thomson Reuters Datastream
Diversification	Market beta	Twelve month backward looking correlation of commodity returns (next-to-maturity) with Standard and Poor 500 equity index returns.	Thomson Reuters Datastream
	Expected inflation	Difference between inflation indexed and nominal market yield on Treasury security at 10-year constant maturity.	Federal Reserve, United States
	Exchange Rate	US-trade weighted value of US dollar against major currencies, index March 1973=100.	Federal Reserve, United States[1]
Note: [1] For details on the weights and estimation see Federal Reserve (FED) (2014)			

Looking at Mayer's (2012) results, index traders' behaviour for those commodities strongly represented in the basket indices, like crude oil, is found to be close to the predictions made, while this does not necessarily apply to index positions in other markets, which have a lower index share. A potential explanation is that the demand for index exposure is linked to the diversification benefits of the commodity index as a whole and not the particular commodity. Hence, I redefine returns and market beta variables as total returns of the S&P GSCI index and the twelve months backward-looking correlation between S&P GSCI total returns and S&P 500 equity returns as an alternative market beta. The passivity assumption for index traders is even stronger for these alternative variable definitions.

In order to capture the roll yield variable accurately, the data selection is informed by index traders' rolling date. Since for wheat, coffee and cocoa there are only five maturity months, the usual maturity day—about two to three weeks into the months—is taken and the data point eight calendar days before this day (the time of the roll) is chosen for every month. The same date is chosen in the construction of all other variables.

3.4.2 Extrapolation, Herding and Heterogeneity

Section 3.4 commenced with a critical review of methodologies employed in empirical studies on traders' behaviour. On the basis of the review, the previous sub-section presented alternative methodologies which overcome shortcomings identified in the existing literature. The following sub-section presents empirical results for the econometric tests conducted on extrapolative, herding and heterogeneous trading motives.

Several difficulties with the available data have been identified in Section 3.3. The most critical of which is the continuous alteration of trading strategies. For the tests conducted, an alteration in the trading strategy is revealed in the time variance of the coefficients estimates. In order to account for parameter instability, recursive and rolling window least-square estimations are conducted for most tests (Pollock 2003).

3.4.2.1 Results for Extrapolation

Regression Equation 3.6 is estimated for all three markets using contemporaneous and lagged explanatory variables over the time period January 1990 to December 2014 in daily frequency. For all three markets, $\hat{\beta}_1$, the coefficient on the trading signal indicator, is strongly significant and positive in both the contemporaneous and the lagged regression. The null hypothesis of no extrapolative trading can hence be rejected at the one per cent level in all cases. Further, $\hat{\beta}_2$, the coefficient on returns, is significantly negative in the contemporaneous regressions, except for the wheat market. This indicates that negative returns are associated with a higher trading activity than positive return, which is evidence for risk aversion. Throughout, a great amount of persistence is found in the volume data and autocorrelation is significant for a long lag length (Table 3.3).

Table 3.3: Estimation Results Extrapolative Trading
(1st Jan. 1990 – 9th Dec. 2014)

	Cocoa			Wheat			Coffee		
AR(i)	AR(18)			AR(19)			AR(18)		
	Coef	s.e.[1]	Partial r^2	Coef	s.e.[1]	Partial r^2	Coef	s.e.[1]	Partial r^2
Contemporaneous									
$\hat{\beta}_1$	544.184**	83.27	0.0069	1247.79**	258.9	0.0037	693.20**	94.79	0.0085
$\hat{\beta}_2$	-8470.41**	2524.	0.0018	-10883.7	10670	0.0002	-9962.2**	2449.	0.0026
Diagnos.	AR 1-2:	17.285 [0.0000]**		AR 1-2:	17.152 [0.0000]**		AR 1-2:	22.442 [0.0000]**	
	Normality:	1993.9 [0.0000]**		Normality:	2343.4 [0.0000]**		Normality:	3821.8 [0.0000]**	
	Hetero:	16.272 [0.0000]**		Hetero:	30.654 [0.0000]**		Hetero:	21.883 [0.0000]**	
	RESET:	2.4778 [0.1155]		RESET:	2.8438 [0.0918]		RESET:	98.458 [0.0000]**	
Lagged									
$\hat{\beta}_1$	362.158**	75.36	0.0037	1326.26**	238.4	0.0049	651.55**	106.1	0.0060
$\hat{\beta}_2$	-2679.96	2910.	0.0001	1106.41	11390	0.0000	-2058.60	2962.	0.0001
Diagnos.	AR 1-2:	2.7291 [0.0654]		AR 1-2:	9.3868 [0.0001]**		AR 1-2:	9.8781 [0.0001]**	
	Normality:	2076.2 [0.0000]**		Normality:	2401.2 [0.0000]**		Normality:	3750.5 [0.0000]**	
	Hetero:	16.605 [0.0000]**		Hetero:	28.981 [0.0000]**		Hetero:	18.080 [0.0000]**	
	RESET:	4.5475 [0.0330]*		RESET:	2.2443 [0.1342]		RESET:	104.64 [0.0000]**	

Note: [1] Newey West standard errors. * indicates significance at 5% and ** indicates significance at 1% level. All variables are in first differences (returns and indices) and found stationary at the 1 % significance level using ADF tests.

From the recursively estimated coefficients, one can see that the coefficient on returns in the cocoa market turned significantly negative in 2007, indicating a greater degree of risk aversion since then. For all three markets, the coefficient on the trading-signal index appears to have increased over recent years, in particular since 2004 and more visibly from 2008 onwards. This is probably due to a change in trader composition around this time that caused extrapolative trading strategies to gain in importance (Appendix 3.4, Figures 3.4.1–3).

Table 3.4 presents results from regression Equation 3.7 together with the Wald test statistics for asymmetry. For all three markets, the coefficient on sell-signals, $\hat{\beta}_1^S$, is larger than the coefficient on buy-signals, $\hat{\beta}_1^B$, as hypothesised. Sell-signals have a significantly positive effect on intra-day volume, both contemporaneously and lagged. In contrast, only contemporaneous buy-signals are significant at the five per cent level for all markets. Although the coefficient for sell-signals is larger than for buy-signals in all cases, the difference is only statistically significant for the coffee market.

Table 3.4: Estimation Results Extrapolative Trading Asymmetries
(1st Jan. 1990 – 9th Dec. 2014)

	Cocoa			Wheat			Coffee		
AR(i)	AR(18)			AR(19)			AR(18)		
	Coef	s.e.[1]	Part. r^2	Coef	s.e.[1]	Part. r^2	Coef	s.e.[1]	Part. r^2
Contemporaneous									
$\hat{\beta}_1^B$	459.374**	126.4	0.0021	1015.71*	396.1	0.0011	462.430**	168.5	0.0012
$\hat{\beta}_1^S$	602.353**	98.74	0.0060	1360.36**	301.2	0.0033	781.407**	116.1	0.0072
$H_0: \beta_1^B = \beta_1^S$ (3) $H_0: \beta_1^S = \beta_1^B$ (3)	Chi^2(1) = 1.3184 [0.2509] Chi^2(1) = 1.0065 [0.3157]			Chi^2(1) = 0.81948 [0.3653] Chi^2(1) = 0.54689 [0.4596]			Chi^2(1) = 5.1978 [0.0226]* Chi^2(1) = 2.3109 [0.1285]		
$\hat{\beta}_2$	-8455.5**	2521.	0.0018	-10358.4	10810	0.0001	-9799.84**	2370.	0.0027
Diagnostics	AR 1-2: Normality: Hetero: RESET:	11.509 [0.0000]** 1986.5 [0.0000]** 16.226 [0.0000]** 2.4571 [0.1170]		AR 1-2: Normality: Hetero: RESET:	18.140 [0.0000]** 2347.1 [0.0000]** 29.292 [0.0000]** 2.5021 [0.1137]		AR 1-2: Normality: Hetero: RESET:	27.316 [0.0000]** 3188.2 [0.0000]** 15.897 [0.0000]** 52.305 [0.0000]**	
Lagged									
$\hat{\beta}_1^B$	370.668**	127.7	0.0014	904.770*	400.8	0.0008	354.512	184.1	0.0006
$\hat{\beta}_1^S$	367.220**	89.94	0.0027	1542.75**	290.3	0.0045	739.98**	109.4	0.0073
$H_0: \beta_1^B = \beta_1^S$ (3) $H_0: \beta_1^S = \beta_1^B$ (3)	Chi^2(1) =0.00060032 [0.9805] Chi^2(1) =0.00053210 [0.9816]			Chi^2(1) = 2.2232 [0.1359] Chi^2(1) = 1.6684 [0.1965]			Chi^2(1) = 5.9221 [0.0150]* Chi^2(1) = 3.8284 [0.0504]		
$\hat{\beta}_2$	-2711.81	2916.	0.0001	2136.55	11520	0.0000	-1658.68	2908.	0.001
Diagnostics	AR 1-2: Normality: Hetero: RESET:	2.6199 [0.0729] 2076.2 [0.0000]** 15.925 [0.0000]** 4.5442 [0.0331]*		AR 1-2: Normality: Hetero: RESET:	9.8818 [0.0001]** 2405.5 [0.0000]** 26.829 [0.0000]** 2.0132 [0.1560]		AR 1-2: Normality: Hetero: RESET:	12.175 [0.0000]** 3159.1 [0.0000]** 14.380 [0.0000]** 55.828 [0.0000]**	

Note: (1) Newey West standard errors. (3) Testing for general restrictions using Newey West standard errors. * indicates significance at 5% and ** indicates significance at 1% level. All variables in first differences (returns and indices) and found stationary at the 1 % level using ADF tests.

Recursive coefficient estimates reveal that both buy- and sell-indicators gained prominence over the years. This is particularly visible for buy-signals in the coffee market since 2008 (Appendix 3.4, Figures 3.4.4–6). With the estimation of rolling windows over 500 days, sudden changes in the size of the coefficients are identified more clearly (Appendix 3.5, Figures 3.5.1–3). For the wheat market a significantly positive relationship between sell-signals and trading volume is found since the late 1990s. This relationship strengthens, however not continuously, from 2002 onwards. For cocoa and coffee, the sell-signal is found to be significant from the early 1990s and increases over recent years with a small kink during the price peak period in late 2008 for coffee. Interestingly, buy-signals are strongly significant and positively linked to trading volume from 2007 onwards with a visible drop in late 2008 coinciding with the commodity and financial crisis. While changes in returns do not appear to have been significantly related to trading volume for wheat and coffee, for the cocoa market the relationship is strongly negative between 2005 and 2010, which indicates risk aversion during these years.

Tests for changes in trading patterns, using Hansen's (1992a) parameter instability test, reveal that most of the parameter instability observed in recursive graphs is not statistically significant (Table 3.5). However, instability is confirmed for the contemporaneous relationship between trading signals and intra-day volume. By differentiating between buy- and sell-signals, this effect can be attributed to non-constancy in traders' reaction to sell-signals.

Table 3.5: Hansen Parameter Instability Tests

			Cocoa	Wheat	Coffee
Combined Indicator	Contemporaneous	$\hat{\beta}_1$	0.55080*	0.92540**	0.72205*
		$\hat{\beta}_2$	0.53412*	0.04006	0.12679
	Lagged	$\hat{\beta}_1$	0.14414	0.27370	0.18632
		$\hat{\beta}_2$	0.03882	0.27365	0.11667
Sell and Buy Indicators	Contemporaneous	$\hat{\beta}_1^B$	0.34231	0.34136	0.04534
		$\hat{\beta}_1^S$	0.28806	0.59619*	0.81335**
		$\hat{\beta}_2$	0.54051*	0.04025	0.11958
	Lagged	$\hat{\beta}_1^B$	0.21764	0.06575	0.06239
		$\hat{\beta}_1^S$	0.34564	0.40713	0.22130
		$\hat{\beta}_2$	0.03936	0.27550	0.12165

Notes: * indicates significance at the 5 per cent level and ** indicates significance at the 1 per cent level.

One reason for this is probably the reaction to sell-signals during the 2008 price slump. Traders reacted more strongly to those signals than before, since risk aversion increased amidst fears for the stability of the financial system as a whole. Another reason is the growth in computerised trading (Baffes 2011). In 2006, CBOT launched electronic futures trading, while ICE did so a year later. Computerised trading promoted technical strategies based on complex algorithms at high frequency. The introduction of these new trading platforms coincides with an increase in the trading-signal coefficients for all three markets.

However, low R-squares, parameter instability, as well as unfavourable residual diagnostics of estimated models suggest the omission of important variables, like changes in technology, as well as global market sentiments. This observation reveals the difficulty to approximate latent investment strategies with observed position data.

3.4.2.2 Results for Herding

Before estimating regression Equation 3.8, the correlation coefficients between net-long, long, and short positions of different COT and DCOT trader categories and the largest four and eight traders are estimated. Results are reported in Appendix 3.6, Tables 3.6.1–6.

Correlation coefficients for the wheat market clearly support the previous conjecture that the four largest traders' short positions can be attributed to commercial hedgers, while their long positions can be attributed to index traders. Table 3.6.1b shows an almost perfect correlation between the largest traders' and hedgers' short positions and the largest traders' and swap traders' long positions. Interestingly, using the COT data set, as shown in Table 3.6.4b, both the largest traders' short *and* long positions have a high correlation with the commercial hedger category. This, once again, shows the extent to which the COT commercial category captures index traders.

Results are not as distinct for the cocoa and coffee markets. For the cocoa market, the COT commercial trader-position data correlate with the four largest traders' positions (Table 3.6.5a-b). Further, the largest traders' long positions correlate with both swap traders' and hedgers' positions (Table 3.6.2b). This can be explained by the finding that index traders only make up a small percentage share of total open interest in the cocoa market so that commercial traders at least partly constitute both the four largest traders' long *and* short positions.

For the coffee market, the largest traders' long positions correlate with both long positions by commercial and long positions by non-commercial traders in the COT data set (Table 3.6.6b). The correlation table for the DCOT data reveals that the reason for this anomaly is that the largest traders' long positions are correlated with both swap traders' and money managers' positions (Table 3.6.3b). This is unexpected.

Results from regression Equation 3.8 for the wheat market provide little evidence for small traders mimicking the largest traders' positions. There is evidence, however, for small traders imitating hedgers' long and short positions. Further, there is strong evidence for small traders engaging in trend-following behaviour. All coefficients, but those for sell-positions on returns, are significant at the five per cent level and show the expected sign (Table 3.6).

Table 3.6: Estimation Results Herding for the Wheat Market												
	COT (Jan. 1993 – Dec. 2013)						**DCOT (Jun. 2006 – Dec. 2014)**					
	Net-long		**Short**		**Long**		**Net-long**		**Short**		**Long**	
AR(i)	AR(5)		AR(0)		AR(0)		AR(2)		AR(2)		AR(2)	
	Coef.	s.e.[1]	Coef.	s.e.	Coef.	s.e.	Coef.	s.e.[1]	Coef.	s.e.[1]	Coef.	s.e.[1]
$\hat{\alpha}_1$	-0.109**	0.032	0.003	0.025	-0.081*	0.040	-0.048*	0.024	-0.006	0.0291	0.014	0.053
$\hat{\alpha}_2$	10296.*	4277.	-1252.6	3732.	10246.*	4405.	8263.**	3017.	-2581.7	2737.0	5923.1*	2684.
$\hat{\alpha}_3$	14135.**	3159.	-6143.5	3780.	9732.1*	4464.	7960.**	2668.	-2564.1	3479.0	5367.3	3221.
$\hat{\alpha}_4$	-0.459	0.402	0.393	0.516	-0.234	0.608	-0.126	0.287	-0.172	0.207	-0.371	0.293
AR17	1.8575 [0.0732]		1.5883 [0.1349]		1.3427 [0.2265]		1.3188 [0.2396]		1.6489 [0.1200]		1.9517 [0.0603]	
Norm	850.32 [0.0000]		1303.8 [0.0000]		995.79 [0.0000]		102.64 [0.0000]		52.738 [0.0000]		45.454 [0.0000]	
Heter	5.3393 [0.0000]		0.2577 [0.9789]		0.2334 [0.9847]		2.8274 [0.0010]		5.2725 [0.0000]		2.0827 [0.0118]	
Reset	0.0320 [0.9686]		0.4963 [0.6089]		0.5172 [0.5963]		1.7406 [0.1767]		3.3324 [0.0366]		4.1821 [0.0159]	
$\hat{\alpha}_1^{com}$	-0.039	0.021	0.029*	0.015	-0.008	0.020	0.016	0.017	0.038*	0.016	0.072**	0.024
$\hat{\alpha}_1^{sw/nco}$	0.039	0.021	-0.029*	0.015	0.008	0.020	-0.050	0.028	0.048	0.071	0.009	0.032

Notes: (1) White standard errors. For the last two rows the same model as above is estimated but alternative variable definitions are used to estimate $\hat{\alpha}_1$. Diagnostics and remaining coefficients are not reported here to save space and because those differ only marginally.

Results for the cocoa market show significant mimicking of the largest traders' buy- and sell-positions by small traders. Evidence is also found for small traders following hedgers but not non-commercial traders. This finding supports the previous conjecture that small, uninformed traders are aware of the information advantage by large hedgers and hence inclined to follow those traders' positions. Again, small traders are found to engage in trend-following behaviour with all coefficients on returns being significant at the five per cent level and showing the expected sign (Table 3.7).

Table 3.7: Estimation Results Herding for the Cocoa Market												
	COT (Jan. 1993 – Dec. 2013)						**DCOT (Jun. 2006 – Dec. 2014)**					
	Net-long		**Short**		**Long**		**Net-long**		**Short**		**Long**	
AR(i)	AR(5)		AR(7)		AR(1)		AR(3)		AR(2)		AR(2)	
	Coef.	s.e.[1]	Coef.	s.e.[1]	Coef.	s.e.[2]	Coef.	s.e.[2]	Coef.	s.e.[2]	Coef.	s.e.
$\hat{\alpha}_1$	-0.01109	0.019	0.047**	0.017	0.0077	0.024	-0.0164	0.027	0.0362	0.024	0.0512*	0.025
$\hat{\alpha}_2$	4920.4**	983.7	-2125.*	880.6	3773.**	1122.	15069**	2051.	-5507**	1594.	9374.**	1350.
$\hat{\alpha}_3$	886.76	888.1	-1220.3	871.0	1310.5	1168.	3958.0*	1648.	-571.7	1774.	6668.**	1408.
$\hat{\alpha}_4$	-0.0029	0.015	0.0015	0.013	-0.0048	0.011	0.0053	0.020	-0.003	0.016	-0.004	0.013
AR17	1.0287 [0.4090]		1.4967 [0.1645]		2.5282 [0.0139]		3.1954 [0.0026]		2.5746 [0.0131]		1.8792 [0.0714]	
Norm	25.681 [0.0000]		116.57 [0.0000]		105.74 [0.0000]		37.045 [0.0000]		87.730 [0.0000]		78.535 [0.0000]	
Heter	4.2224 [0.0000]		3.8315 [0.0000]		3.0235 [0.0009]		5.4120 [0.0000]		4.6432 [0.0000]		0.8351 [0.6307]	
Reset	2.6698 [0.1026]		2.0424 [0.1533]		4.7908 [0.0288]		0.7749 [0.3792]		1.1289 [0.2886]		0.0003 [0.9852]	
$\hat{\alpha}_1^{com}$	-0.0189	0.012	0.024*	0.011	0.0122	0.014	-0.042*	0.018	0.0113	0.014	0.0393*	0.020
$\hat{\alpha}_1^{sw/nco}$	0.0189	0.012	-0.024*	0.011	-0.0122	0.014	0.0436	0.040	0.0930	0.072	0.0529	0.055

Notes: (1) White standard errors. For the last two rows the same model as above is estimated but alternative variable definitions are used to estimate $\hat{\alpha}_1$. Diagnostics and remaining coefficients are not reported here to save space and because those differ only marginally.

For the coffee market, evidence for herding is inconclusive. While herding in net-long positions is significant, the coefficient is negative, which indicates that small traders act as contrarians. However, the coefficient is significantly positive for the largest traders' and commercial hedgers' long positions in the COT data set, which indicates that small traders mimic the largest traders' and commercial hedgers' long positions. Evidence for trend-following behaviour by smaller traders is also weaker compared to the other two markets.

Significant coefficients on returns are only found for the later sub-period covered by the DCOT data set (Table 3.8).

Table 3.8: Estimation Results Herding for the Coffee Market

	COT (Jan. 1993 – Dec. 2013)						DCOT (Jun. 2006 – Dec. 2014)					
	Net-long		**Short**		**Long**		**Net-long**		**Short**		**Long**[2]	
AR(i)	AR(7)		AR(12)		AR(5)		AR(2)		AR(5)		AR(5)	
	Coef.	s.e.[1]	Coef.	s.e.	Coef.	s.e.[1]	Coef.	s.e.[3]	Coef.	s.e.[1]	Coef.	s.e.
$\hat{\alpha}_1$	-0.056**	0.019	0.0089	0.018	0.069**	0.026	-0.0417	0.023	-0.0043	0.027	0.0644	0.036
$\hat{\alpha}_2$	587.54	623.8	-342.53	741.5	21.670	719.7	6360.8**	1308.	-3194.*	1612.	2320.8	1659.
$\hat{\alpha}_3$	661.88	620.3	-1727.*	739.1	-514.82	711.5	1312.8	1009.	475.58	1187.	1859.1	1158.
$\hat{\alpha}_4$	0.0073	0.013	-0.0041	0.010	-0.0011	0.012	-0.0129	0.016	0.0222	0.013	0.0089	0.015
AR17	1.8780 [0.0698]		1.7813 [0.0874]		1.5926 [0.1336]		5.8095 [0.0000]		1.3415 [0.2290]		1.6297 [0.1252]	
Norm	162.64 [0.0000]		147.46 [0.0000]		110.06 [0.0000]		116.14 [0.0000]		49.260 [0.0000]		27.561 [0.0000]	
Heter	3.5253 [0.0000]		1.4386 [0.0508]		3.7254 [0.0000]		8.4041 [0.0000]		2.7791 [0.0003]		3.5595 [0.0000]	
Reset	12.664 [0.0004]		20.734 [0.0000]		8.0689 [0.0046]		4.4662 [0.0351]		4.4017 [0.0365]		2.6690 [0.1031]	
$\hat{\alpha}_1^{com}$	-0.03**	0.009	-0.0005	0.009	0.0314*	0.015	-0.042**	0.012	-0.0158	0.015	-0.0077	0.022
$\hat{\alpha}_1^{sw/nco}$	0.03**	0.009	0.0005	0.009	-0.031*	0.015	0.0278	0.039	0.0498	0.081	0.0436	0.056

Notes: (1) White standard errors. (2) One more lag for returns added in order to account for remaining auto correlation. (3) Newey-West standard errors. For the last two rows the same model as above is estimated but alternative variable definitions are used to estimate $\hat{\alpha}_1$. Diagnostics and remaining coefficients are not reported here to save space and because those differ only marginally.

Moreover, small traders' positions are found to be more persistent in coffee than in the other two markets with autoregressive lags being significant up to a lag length of 12 weeks. This indicates a longer trading horizon for small traders in the coffee market. One reason might be that for the coffee market some hedgers are small enough to be non-reporting traders so that some small coffee traders behave like hedgers instead of uninformed speculators.

3.4.2.3 Results for Heterogeneity

Mayer (2012) in reference to Domanski and Heath (2007) suggests that index traders' net-positions are positively related to return variables and negatively related to opportunity costs. Index positions are expected to correspond positively to diversification benefits, like expected inflation, depreciation of the dollar and low market beta. The coefficient for market volatility could be positive or negative, given that higher volatility is associated with higher returns as well as higher risk. Table 3.9 summarises the expected signs for the coefficients in reference to the definitions of the variables described in Table 3.2 and regression Equation 3.9.

Table 3.9: Expected Signs for Index Traders

	Return	Roll	Volatility	Interest	Correlation	Inflation	Ex.-rate
Index	+	+	+/–	–	–	+	–

Note: Expected signs as proposed by Mayer (2012).

Although previous authors have refrained from testing for non-stationarity, probably due to the small sample size available, which makes unit-root tests unreliable, an ADF test is conducted on trader-position variables, before proceeding with the regression analysis. Results are reported in Appendix 3.7, Table 3.7.1–3. The null hypothesis of non-stationarity in traders' position data can be rejected at the five per cent level for the wheat market, with the exception of DCOT swap trader position data. In contrast, for coffee the test fails to reject non-stationarity for all, but index and other non-commercial traders' positions. For the cocoa market, all, but positions by non-commercial trader in the CIT report and hedgers in the DCOT report, are found stationary. Against this background, regression results have to be interpreted with great care. Because of the overlapping structure of the data due to the moving averages, I follow Mayer (2012) in choosing Newey-West robust standard errors. Only DCOT and CIT data are used because of the difficulties identified previously with the COT data.

The following analysis contributes to the existing empirical literature in several important ways. Firstly, the sample size is enlarged considerably, which corrects for the small sample used in Mayer (2012). Secondly, the trader types under analysis are extended to commercial hedgers as well as further disaggregated into non-commercial trader types, like money managers, swap traders and other non-commercial traders, as specified in the DCOT data set. Thirdly, the IID index trader data are used in addition. Although the data reflect index investment more precisely, it is only available since June 2010 in a monthly frequency, which limits the sample size used in regressions including IID data to 53 observations. Fourthly, results are tested for parameter instability by recursive and rolling window estimation techniques (Pollock 2003). In this way, the timing of parameter changes can be determined more precisely in comparison to the *ad hoc* periodization of the sample. Finally, alternative definitions for return and correlation variables are suggested which are linked to a commodity basket index rather than to a particular commodity market. If significant, the passivity assumption for index traders is strengthened.

Table 3.10 provides summary results for index and swap trader categories in the wheat market. Results for the same estimation with the remaining trader categories used as dependent variable are reported in Appendix 3.8, Table 3.8.1. In line with previous studies, index traders' positions are not significantly linked to spot returns, but instead to roll returns and opportunity costs. Further, variables, which capture diversification benefits, are found to be significant more often for index and swap trader categories than for any other trader category. Surprisingly, the signs for return variables, in particular roll yield and opportunity cost, are unexpected, while coefficients on diversification variables show the expected signs.

Table 3.10: Estimation Results Heterogeneity Index Traders in Wheat										
Results Passive Trader										
		Return	Roll	Vola.	Interest	Correl.	Inflation	Ex.-rate	Adj. R^2	AR(1) r^2
CIT Index	Jan.2006 - Oct.2014	-0.396* [0.192]	-2.706** [0.823]	-1.138 [0.781]	0.020** [0.005]	0.030* [0.012]	0.012* [0.005]	-0.000 [0.001]	0.663	0.2743
DCOT Swap	Jun.2006 - Oct.2014	-0.262 [0.169]	-4.086** [1.127]	-0.698 [0.869]	0.030** [0.008]	0.017 [0.015]	0.018* [0.007]	-0.002* [0.001]	0.801	0.2225
IID Index	Jun.2010 - Oct.2014	-0.110 [0.300]	-10.89* [4.241]	-4.068 [3.195]	0.003 [0.056]	-0.048* [0.023]	-0.051 [0.033]	-0.002 [0.004]	0.643	AR(0)
Results Passive Trader Stronger Assumptions										
		Return	Roll	Vola.	Interest	Correl.	Inflation	Ex.-rate	Adj. R^2	AR(1) r^2
CIT Index	Jan.2006 - Oct.2014	0.130 [0.434]	-3.248** [0.835]	-0.620 [0.890]	0.020** [0.005]	0.007 [0.009]	0.012* [0.005]	-0.001 [0.001]	0.609	0.3427
DCOT Swap	Jun.2006 - Oct.2014	0.074 [0.304]	-4.795** [1.133]	-0.199 [1.026]	0.028** [0.009]	-0.006 [0.011]	0.017* [0.007]	-0.002* [0.001]	0.776	0.2164
IID Index	Jun.2010 - Oct.2014	-0.705 [1.048]	-12.34** [4.485]	-4.925 [3.555]	-0.029 [0.062]	0.019 [0.022]	-0.050 [0.036]	-0.003 [0.004]	0.630	AR(0)

Notes: Newey-West robust standard error, lag truncation 12. All independent variables are lagged once and the regression is estimated as an AR(1) process (the lag is excluded if found insignificant). Residuals are tested for normality, autocorrelation and heteroscedasticity. The null hypothesis of spherical residuals cannot be rejected at the 5 % level in all cases. * indicates significance at the 1 % level, and ** at the 5% level respectively.

Rolling window estimations reveal that the coefficient on roll returns is significantly positive prior to 2009, as expected, and turns significantly negative at the beginning of 2013 (Appendix 3.9, Table 3.9.1). The coefficient on market beta or correlation—including both the wheat market-specific correlation as well as S&P GSCI commodity index market correlation—has been negative or insignificant previously and turned positive from early 2013 onwards. This switch of coefficients' signs indicates a change in index investment strategies in 2009 and again in early 2013. An explanation is the emergence of roll adjusted and dynamic roll indices which take advantage of both normal and inverted markets, i.e., positive and negative roll yield (Heidorn, et al. 2014). Further, exchange traded notes on specific commodities as well as indices on particular commodity groups became available, so that the mass of index investment might not be linked to large basked commodity indices like the S&P GSCI any longer. This conjecture is supported by the rolling window coefficient for index traders' reaction to S&P GSCI total returns (Appendix 3.10, Figure 3.10.1). The coefficient is significantly positive until 2008, but turns insignificant thereafter.

For the cocoa market, results are similar to wheat; however, less pronounced (Table 3.11). The coefficient on roll yield is negative in all cases but only significant at the five per cent level for the IID data set. Again, index traders show a positive response to higher market correlation and interest rates. The rolling window estimated coefficients reveal that the relationship between net index investment and roll yield had been positive until 2008 and only turned negative in later years (Appendix 3.9, Table 3.9.2). The coefficient on market correlation was negative between 2009 and 2012, but turned positive thereafter. This is even more visible for the S&P GSCI market correlation (Appendix 3.10, Figure 3.10.2).

Interestingly, coefficients for the swap trader category yield insignificant coefficients throughout, which might be due to a low percentage of index based investment in the swap trader category for the cocoa market (Figure 3.9).

Table 3.11: Estimation Results Heterogeneity Index Traders in Cocoa										
Results Passive Trader										
		Return	Roll	Vola.	Interest	Correl.	Inflation	Ex.-rate	Adj. R^2	AR(1) r^2
CIT Index	Jan.2006 - Oct.2014	-0.055 [0.117]	-5.266 [4.100]	1.269 [1.498]	-0.003 [0.003]	0.008 [0.011]	0.003 [0.003]	-0.003** [0.001]	0.822	0.2458
DCOT Swap	Jun.2006 - Oct.2014	-0.156 [0.143]	-3.211 [3.477]	1.835 [1.199]	0.000 [0.002]	-0.008 [0.009]	0.004 [0.003]	-0.001 [0.001]	0.663	0.5182
IID Index	Jun.2010 - Oct.2014	-0.024 [0.337]	-14.15* [6.976]	-2.039 [1.924]	0.038* [0.019]	0.049** [0.011]	0.038 [0.025]	0.003 [0.002]	0.633	AR(0)
Results Passive Trader Stronger Assumptions										
		Return	Roll	Vola.	Interest	Correl.	Inflation	Ex.-rate	Adj. R^2	AR(1) r^2
CIT Index	Jan.2006 - Oct.2014	0.091 [0.157]	-4.585 [3.421]	1.153 [1.171]	-0.001 [0.004]	0.014* [0.007]	0.004 [0.002]	-0.004** [0.001]	0.843	0.2571
DCOT Swap	Jun.2006 - Oct.2014	-0.063 [0.206]	-0.973 [3.380]	0.955 [0.862]	0.002 [0.003]	0.004 [0.003]	-0.001 [0.001]	0.001 [0.001]	0.658	0.4780
IID Index	Jun.2010 - Oct.2014	0.096 [0.500]	-19.26* [9.720]	-1.850 [2.619]	0.0004 [0.019]	0.032** [0.006]	0.015** [0.005]	-0.002 [0.001]	0.713	AR(0)

Notes: Newey-West robust standard error, lag truncation 12. All independent variables are lagged once and the regression is estimated as an AR(1) process (the lag is excluded if found insignificant). Residuals are tested for normality, autocorrelation and heteroscedasticity. The null hypothesis of spherical residuals cannot be rejected at the 5 % level in all cases. AR(1) r^2 is the partial r-square of the autoregressive component. * indicates significance at the 1 % level, and ** at the 5% level respectively.

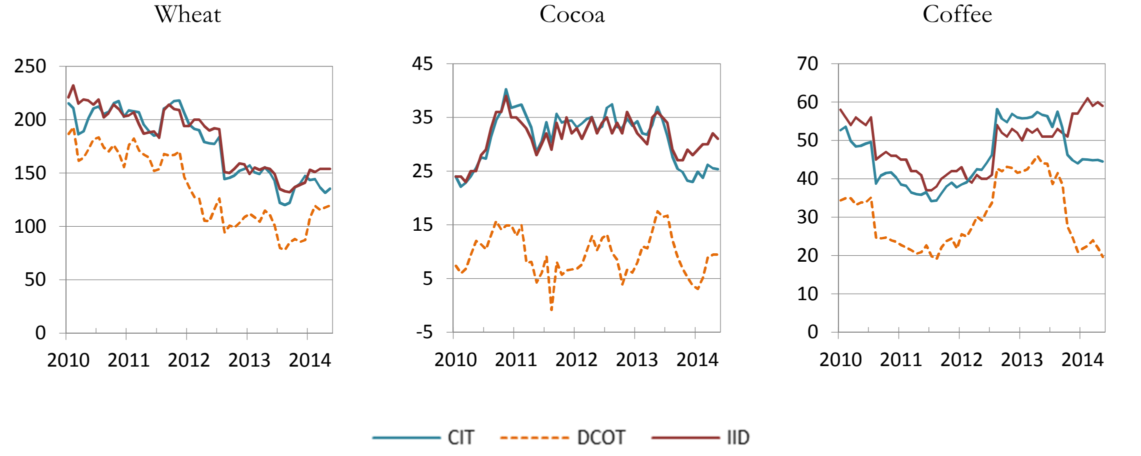
As for the previous two markets, index traders' net positions in the coffee market are significantly negatively related to roll yield, in recent years while previously, the relationship has been significantly positive (Appendix 3.9, Table 3.9.3). Exchange rate diversification benefits are time invariant and significant with the predicted sign for all index categories, but the IID data (Table 3.12). Surprisingly, results for the IID index positions deviate substantially from results for the CIT index and DCOT swap positions.

Table 3.12: Estimation Results Heterogeneity Index Traders in Coffee										
Results Passive Trader										
		Return	Roll	Vola.	Interest	Correl.	Inflation	Ex.-rate	Adj. R^2	AR(1) r^2
CIT Index	Jan.2006 - Oct.2014	-0.102 [0.190]	-8.698** [1.959]	0.259 [0.914]	-0.005 [0.003]	0.007 [0.008]	0.006 [0.004]	-0.004** [0.001]	0.682	0.4721
DCOT Swap	Jun.2006 - Oct.2014	-0.101 [0.155]	-5.794** [1.989]	-1.515 [0.947]	-0.003 [0.003]	-0.002 [0.008]	0.001 [0.004]	-0.003** [0.001]	0.807	0.5816
IID Index	Jun.2010 - Oct.2014	-0.404* [0.154]	-7.670 [5.000]	0.992* [0.369]	-0.015 [0.041]	-0.037* [0.018]	-0.022 [0.027]	-0.006 [0.004]	0.553	0.4233
Results Passive Trader Stronger Assumptions										
		Return	Roll	Vola.	Interest	Correl.	Inflation	Ex.-rate	Adj. R^2	AR(1) r^2
CIT Index	Jan.2006 - Oct.2014	0.153 [0.296]	-11.27** [1.648]	1.448 [0.799]	-0.000 [0.003]	0.009** [0.003]	0.030* [0.008]	-0.005** [0.001]	0.714	0.5273
DCOT Swap	Jun.2006 - Oct.2014	0.248 [0.304]	-7.985** [1.940]	-0.705 [0.760]	0.001 [0.003]	0.021* [0.009]	0.003 [0.003]	-0.004** [0.001]	0.820	0.5890
IID Index	Jun.2010 - Oct.2014	0.405 [0.596]	-0.670 [5.713]	0.609 [0.476]	-0.035 [0.044]	-0.013 [0.025]	-0.034 [0.031]	-0.005 [0.004]	0.402	0.5165

Notes: Newey-West robust standard error, lag truncation 12. All independent variables are lagged once and the regression is estimated as an AR(1) process (the lag is excluded if found insignificant). Residuals are tested for normality, autocorrelation and heteroscedasticity. The null hypothesis of spherical residuals cannot be rejected at the 5 % level in all cases. AR(1) r^2 is the partial r-square of the autoregressive component. * indicates significance at the 1 % level, and ** at the 5% level respectively.

Differences in results obtained from different proxies for index investment are explained by the extent to which these positions resemble another for a particular market. For wheat, all three position series move in parallel, with a slight underestimation of CIT and IID index net-positions by the swap category (Figure 3.9).

Figure 3.9: Index Traders' Positions by CIT, DCOT and IID (net-long in thousands, Jun. 2010–Oct. 2014)



Source: CFTC, Various Reports.

In contrast, for the cocoa market, swap positions are detached from index positions provided by the two other reports. Hence, many of the swap positions in the cocoa market are unrelated to index investment. For the coffee market, positions are more closely related to one another than for cocoa until mid-2013. Thereafter net-long swap and CIT index positions declined while IID index data show an increase. This means that swap traders and other traders acting as index investors went short in their non-index related businesses over this period. A potential reason might be the prolonged price decline in coffee between 2011 and 2014, which could have forced traders into short positions. A similar, but weaker, dynamic is observed for the cocoa and wheat market. Another explanation is the decline in oil prices, which caused investors to bet on falling prices across markets.

Against the evidence provided, it can be concluded that diversification considerations, like changes in exchange rates and expected inflation, have regained importance since 2008. Opportunity costs had a continuous negative impact on index investment, at least in cocoa and coffee markets. Commodity market-specific returns continue to be unimportant for index traders' investment decisions. While previously, index total returns had a decisive impact on index traders' investment decisions, the importance of large basket indices seems to have declined since 2008, probably in favour of more market-specific sub-indices. Most interesting is the fact that the relationship between roll yield and index investment has changed from strongly positive to strongly negative for all three markets under analysis.

One possible explanation is innovations in the structure of indices towards roll optimised indices. Another explanation might be that index traders have caused a larger carry and hence the negative relationship. The reverse relationship, with roll yield as the dependent variable, has been estimated and found significant and negative as well. Furthermore, the coefficient on index net positions is found time invariant in this reverse regression[59], which supports this conjecture.

Table 3.13: Estimation Results Non-Commercial Traders' Strategies

	Return	Roll	Volatility	Interest	Hedging	Buy	Sell	Adj. R^2	AR(1) r^2
Results Wheat									
CIT (Jan. 2006 – Oct. 2014)									
Ncom	0.334 [0.249]	-0.967 [1.089]	-0.410 [0.884]	0.007* [0.003]	0.019 [0.089]	-0.002 [0.002]	0.001 [0.001]	0.641	0.3359
DCOT (Jun. 2006 – Oct. 2014)									
Mm	0.556 [0.403]	-0.641 [1.529]	0.249 [1.532]	0.010* [0.005]	0.075 [0.174]	-0.003 [0.003]	0.001 [0.002]	0.609	0.1941
Other	-0.033 [0.145]	0.472 [0.531]	-0.881* [0.448]	-0.004* [0.002]	-0.042 [0.034]	0.000 [0.001]	0.000 [0.000]	0.590	0.4128
Swap	-0.144 [0.302]	-2.322* [0.993]	1.175 [0.729]	0.008** [0.003]	0.021 [0.062]	0.001 [0.001]	-0.001 [0.001]	0.748	0.6024
Results Cocoa									
	Return	Roll	Volatility	Interest	Hedging	Buy	Sell	Adj. R^2	AR(1) r^2
CIT (Jan. 2006 – Oct. 2014)									
Ncom	-0.354 [0.690]	-2.217 [5.989]	0.948 [1.939]	-0.003 [0.005]	0.276* [0.134]	0.002 [0.003]	0.003** [0.001]	0.759	0.4573
DCOT (Jun. 2006 – Oct. 2014)									
Mm	-0.143 [0.850]	-9.763 [7.049]	1.195 [2.470]	-0.005 [0.005]	0.226 [0.232]	0.003 [0.004]	0.003** [0.001]	0.736	0.2043
Other	0.272* [0.128]	0.180 [1.433]	-0.066 [0.412]	-0.003* [0.001]	-0.007 [0.010]	-0.0004 [0.001]	-0.0005* [0.000]	0.627	0.2816
Swap	-0.466* [0.209]	1.012 [2.037]	0.791 [0.715]	-0.004 [0.002]	0.001 [0.016]	-0.002 [0.002]	0.001** [0.000]	0.691	0.6946
Results Coffee									
	Return	Roll	Volatility	Interest	Hedging	Buy	Sell	Adj. R^2	AR(1) r^2
CIT (Jan. 2006 – Oct. 2014)									
Ncom	-0.351 [0.413]	-2.301 [2.490]	0.074 [1.653]	-0.002 [0.006]	0.073 [0.122]	0.001 [0.003]	0.003** [0.001]	0.716	0.2539
DCOT (Jun. 2006 – Oct. 2014)									
Mm	-0.150 [0.544]	1.780 [3.748]	2.903 [2.032]	0.003 [0.007]	-0.127 [0.122]	0.0001 [0.003]	0.004** [0.002]	0.719	0.2605
Other	-0.137 [0.157]	-1.771 [0.975]	-0.020 [0.610]	-0.003 [0.002]	-0.021 [0.017]	-0.0001 [0.001]	-0.0004 [0.000]	0.519	0.5257
Swap	-0.136 [0.142]	-2.766* [1.198]	-2.212* [0.925]	-0.003 [0.003]	-0.036 [0.024]	-0.001 [0.001]	-0.001 [0.001]	0.799	0.6207

Notes: Newly-West robust standard errors are used. All independent variables are lagged once and the regression is estimated as an AR(1) process. Residuals are tested for normality, autocorrelation and heteroscedasticity. The null hypothesis of spherical residuals cannot be rejected at the 5 % level in all cases. AR(1) r^2 is the partial r-square of the autoregressive component. * indicates significance at the 1 % level, and ** at the 5% level respectively.

In addition to index investment, other non-commercial traders' strategies are analysed. As hypothesised previously, non-commercial traders can either be informed or uninformed. Uninformed traders are thought to rely on technical indicators like buy and sell-signals as well as past returns, while informed traders take market fundamentals and hedgers' demand into consideration. Results for all three markets are summarised in Table 3.13. For the wheat and cocoa market, the relationship between interest rates and net-long positions is

[59] Results are not reported here, but similar evidence and a discussion is presented in Chapter 4.

significantly positive, with the notable exception of the other non-commercial trader category (institutional investors and investment banks). Regarding the two smaller markets, cocoa and coffee, sell-indicators are significant among especially those trader groups associated with short-term trading strategies like money managers (hedge funds and other commodity funds). Volatility is found to affect institutional investors' positions as well as swap traders' positions negatively, while the effect is positive for money managers' positions. This is expected since money managers are known to have a shorter trading horizon and lower risk aversion.

Table 3.14: Estimation Results Commercial Traders' Strategies

	Return	Volatility	Interest	Hedg. Eff.	Basis	ExRate	Carry	Adj. R^2	AR(1) r^2
Results Wheat									
CIT (Jan. 2006 – Oct. 2014)									
Com	-0.470** [0.174]	0.056 [1.235]	-0.005 [0.005]	0.015 [0.019]	-0.0002 [0.000]	0.0002 [0.001]	-0.0001 [0.000]	0.697	0.5357
DCOT (Jun. 2006 – Oct. 2014)									
Pm	-0.785** [0.207]	0.757 [1.625]	-0.012* [0.005]	-0.006 [0.021]	-0.0001 [0.000]	0.001 [0.001]	-0.0003 [0.000]	0.666	0.4536
Results Cocoa									
	Return	Volatility	Interest	Hedg. Eff.	Basis	ExRate	Carry	Adj. R^2	AR(1) r^2
CIT (Jan. 2006 – Oct. 2014)									
Com	0.434 [0.838]	-1.711 [2.037]	0.002 [0.006]	0.018 [0.112]	0.0002* [0.000]	-0.001 [0.002]	0.0004 [0.000]	0.686	0.5791
DCOT (Jun. 2006 – Oct. 2014)									
Pm	0.160 [0.884]	-0.396 [2.831]	0.003 [0.005]	0.033 [0.112]	0.0002* [0.000]	-0.003 [0.002]	0.0004 [0.000]	0.719	0.5677
Results Coffee									
	Return	Volatility	Interest	Hedg. Eff.	Basis	ExRate	Carry	Adj. R^2	AR(1) r^2
CIT (Jan. 2006 – Oct. 2014)									
Com	0.313 [0.372]	-1.082 [1.413]	-0.004 [0.007]	-0.090 [0.191]	0.002 [0.002]	-0.001 [0.002]	0.003 [0.005]	0.704	0.6564
DCOT (Jun. 2006 – Oct. 2014)									
Pm	0.433 [0.503]	-1.33 [1.924]	-0.008 [0.008]	-0.107 [0.197]	0.003 [0.002]	-0.001 [0.002]	0.005 [0.005]	0.749	0.6754

Notes: Newly-West robust standard errors are used. All independent variables are lagged once and the regression is estimated as an AR(1) process. Residuals are tested for normality, autocorrelation and heteroscedasticity. The null hypothesis of spherical residuals cannot be rejected at the 5 % level in all cases. AR(1) r^2 is the partial r-square of the autoregressive component. * indicates significance at the 1 % level, and ** at the 5% level respectively.

In a third step, trading motives by commercial traders, that are believed to be predominantly hedgers, are analysed (Table 3.14). For the wheat market, only returns are significant and negative in line with the hedging pressure hypothesis. Hedgers' positions tend to be negatively related to interest rates, which is linked to inventory choices, since inventory holdings are more costly in a high interest rate environment. For the cocoa market, a positive relationship between market basis and net-long hedging positions is found. If the basis rises, that is if the cash price is greater than the expiring futures contract price, future owners of the physical product have to over-hedge in order to gain protection. For instance, if the cash price declines less than the futures price a hedger would gain less in her short physical position than she would lose in her long futures positions. In order to compensate this effect, she would have to over-hedge, which explains the positive relationship.

3.5 Conclusion

Assumptions made about extrapolative and herding strategies employed by speculative traders under uncertainty are supported by the findings presented in this chapter. An increase in traders' reliance on technical indicators is observed since the early 2000s, concurrently with the liquidity inflow over this period. The use of technical indicators was boosted further around 2007 with the introduction of electronic trading platforms. Short-term traders are found to be risk-averse on average, however in varying degrees. During price slumps, an increase in risk aversion is detected, and during price highs, a decrease in risk aversion. These findings support the cognitive phenomena referred to in the bounded rationality literature. Moreover, small traders are found to engage in herding strategies, particularly regarding commercial hedgers' positions.

Results further confirm the heterogeneity assumption regarding behavioural traits of different trader groups. Index traders do not react to market-specific returns, but to diversification benefits and return considerations relevant to their passive investment strategy. However, index strategies have changed significantly, not only regarding diversification benefits, but also in relation to returns. Changes in coefficient estimates suggest that index traders have moved away from large basket commodity indices towards roll adjusted and more commodity-specific indices. Moreover, managed money funds are found to be less risk-averse and more short-term oriented in their trading strategies than institutional investors and investment banks. Funds are found to base their trading strategies, at least to some extent, on technical trading indicators, as suggested by the literature. The findings also support the hedging pressure theory and suggest that commercial hedgers take hedging effectiveness and storage costs into consideration when taking positions.

It can be conclude that, despite various shortcomings in the data available, convincing evidence in favour of the assumptions made by the financialisation hypothesis has been found. Uninformed speculative traders engage in extrapolative trading and herding, and traders active in the market are heterogeneous in their investment motives and trading strategies. However, parameter instability unveils the difficulty to attribute trader-position data to investment strategies. Results suggest that strategies change dynamically and not independently of market developments.

Identified shortcomings in trader-position data have important repercussions for the analyses of the following two empirical chapters. Firstly, while herding and trend following behaviour was identified via volume and open interest data, this behaviour could not be assigned to a defined trader category. Traders in other categories than the index trader category appear to be too heterogeneous in their trading strategies to make meaningful inference about their behaviour on the basis of the predefined categories. Given the data constraints, the following analyses will predominantly focus on the role of index traders.

Chapter 4 Futures and Cash Market Linkages

4.1 Introduction

Commodity futures markets fulfil two key functions: price discovery and risk management. The orderly performance of these functions critically depends on the close relationship between the physical and derivative markets. These are tied together by common fundamentals (fundamental arbitrage), as well as the possibility of arbitrage between these markets (spatial arbitrage). In the context of the discussion in Chapter 2: Section 2.4, it is argued that if spatial arbitrage is limited *and* if factors driving price dynamics in the futures market systematically differ from factors driving prices in the physical market, these divergences show in a large basis which is carried from one contract to the next. If fundamental arbitrage does not happen and spatial arbitrage is limited, non-convergence between cash and futures prices at a futures contract's maturity date can emerge (see Figure 2.5).

In recent years, the market basis for many commodities reached unprecedented levels and non-convergence became a frequent phenomenon. On the basis of hypotheses substantiated in Chapter 2 and evidence presented in Chapter 3, this Chapter 4 links traders' behaviour to the increasing basis risk and the non-convergence of prices. Hypotheses are empirically tested for the wheat and cocoa market. Both markets exhibited large market basis and limits to spatial arbitrage in recent years which makes them good case studies[60].

The remainder of this chapter is structured as follows. Section 2 elaborates on arguments made by the financialisation hypothesis and sets out implications for the relationship between the futures and the underlying physical market. Section 3 analyses the continuous relationship between cash and futures markets. The co-integrating relationship between price series is modelled and amended by cost of carry and risk premium variables. Further, tests for structural breaks are conducted and regime changes identified. Section 4 investigates potential reasons for the occurrence and extent of consecutive non-convergence by testing various hypotheses raised in the literature as well as alternative interpretations derived from the financialisation hypothesis in this thesis. Section 5 summarises the key findings.

[60] Space constraints do not permit to extent the analysis to the coffee market. The coffee market serves as a cases study in the next Chapter 5.

4.2 The Fragile Relationship between Futures and Cash Markets

A close relationship between price dynamics in physical and futures markets is ensured by two underlying mechanisms: (1) common market fundamentals, which equally drive price formation in both markets, and (2) spatial arbitrage opportunities, which arise if prices in these two markets deviate. Various studies have investigated the relationship between futures and their underlying physical markets. The objective of these studies is twofold. Firstly, they seek to test whether markets are efficient and well behaved, that is, whether there exists a clearly defined and stable long-run relationship between the cash and the futures market. If such a relationship breaks down or varies over time, those events are ascribed to inefficiencies and market failure. Secondly, they seek to establish a lead–lag relationship between the two markets with the aim of testing which market incorporates any new information first.

Although theories, as reviewed in Chapter 2: Section 2.2–3, agree on a close relationship between cash and futures markets, they disagree on the channels through which the link is enforced, as well as the direction of price signals from one market to the other. Conceptually, futures prices are derived from cash market prices by accounting for carry costs in a no-arbitrage equation. Cash market prices, in turn, are governed by supply and demand in a general equilibrium framework. Pindyck's (2001) structural model is symptomatic of such an approach. In his model, the futures market is thought to mirror developments in the physical market and as such reveals useful information about the more opaque cash and storage markets. However, he fails to discuss the mechanisms through which information enters the futures market and hence how prices are formed. While he asserts that the futures market follows the cash market, his model does not suggest or explain a direction of causation.

The efficient market hypothesis, in contrast, allows price formation to take place in the futures market since the driving force of price discovery is thought to be traders' expectations. Demand and supply in the physical commodity market only indirectly enter the futures market through traders' expectation formation. In such a framework, information efficiency dictates that both futures and cash markets should be perfectly and contemporaneously correlated at all times and one should not lead the other (Brooks, Rew and Ritson 2001). Only if one market incorporates information more slowly than the other, i.e., one market is informationally inefficient, does a lead–lag relationship arise[61]. Attempts

[61] The reason for lead–lag relationships between markets is not necessary inefficiency as shall be argued in Chapters 6 and 7 of the thesis.

to expose lead–lag relationships between markets are motivated by the assumption that both markets are driven by the same fundamentals and hence move towards the same fundamental value. If this assumption holds, the market that resembles the fundamental value first, i.e., incorporates new information faster and more accurately, firstly indicates potential arbitrage opportunities and secondly serves an important price discovery function for the other market.

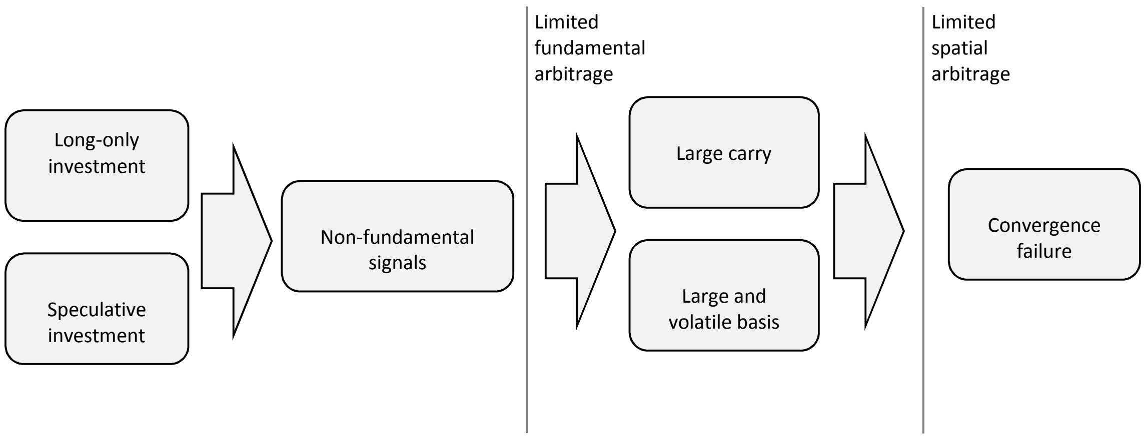
The question of which market is leading is important also from the financialisation point of view. If the futures market is serving a price discovery function for the physical market, deviations from the fundamental value in the financial market due to speculative investments could easily spill over to the physical market. Although a lead–lag relationship does not prove causality, it could add evidence to a more thorough analysis as presented in Chapters 6 and 7. For example, it is known that the commodity futures market is often considered as a benchmark by practitioners for physical transactions. This is because financial markets are perceived as more transparent and more liquid, and because trading involves almost no transaction costs and is close to frictionless (Brooks, Rew and Ritson 2001). The physical market, by contrast is considered to be opaque and prone to externalities.

Another subject of empirical investigations is the question of whether the equilibrium relationship suggested by theory holds. The theory of storage and the theory of risk premium provide explanations for the deviation—despite common fundamentals—between cash and futures prices over a contract's life cycle. These are based on features, which distinguish the derivative from the underlying physical product. Since these features vanish with a futures contract's maturity, futures and cash markets are notionally forced to converge over time—if physical delivery is possible. Similarly, the efficient market hypothesis explains price deviations by differences in the product itself, such as quality, origin, etc. Theoretical approaches alike argue for a stable long-run equilibrium relationship between cash and futures markets. Systematic and prolonged deviations from the equilibrium are ascribed to externalities, like transaction costs and market failure.

This thesis argues otherwise. In Chapter 2: Section 2.4 it is questioned whether fundamental arbitrage is always riskless. It is argued that if the market weight of uninformed speculators, who obscure the information content of commodity futures markets, grows, fundamental arbitrage becomes impossible and markets can move away from their fundamental value for a prolonged period of time. In such a market regime, factors driving price discovery in physical and financial markets differ. With inconsistent demand signals, prices and market basis might become highly volatile and hedging effectiveness declines. This thesis hypothesises that if limits to spatial arbitrage exist, the price differential, which is caused by distinct factors driving price formation in both markets, can build up over a contract's life cycle and can be carried over from one contract to the next. This results in convergence failure and a large market basis. While a volatile basis and the declining hedging effectiveness show the failure of fundamental arbitrage, non-convergence only occurs in the additional presence of limits to spatial arbitrage. Such cases of limits to spatial arbitrage are of special interest, not only because these became more frequent over the last decade (Irwin and Sanders 2010), but also because the extent of the basis at a contract's maturity date gives some indication of the extent to which factors driving prices in the futures diverge from factors driving prices in the physical market.

Figure 4.1 summarises how speculation in commodity futures markets is revealed in dynamics in the cash–futures relationship if limits to both fundamental and spatial arbitrage exist. These effects, large volatile basis and convergence failure, will be analysed in the following two sub-sections in turn.

Figure 4.1: Speculative Investment and Limits to Arbitrage



Source: Author.

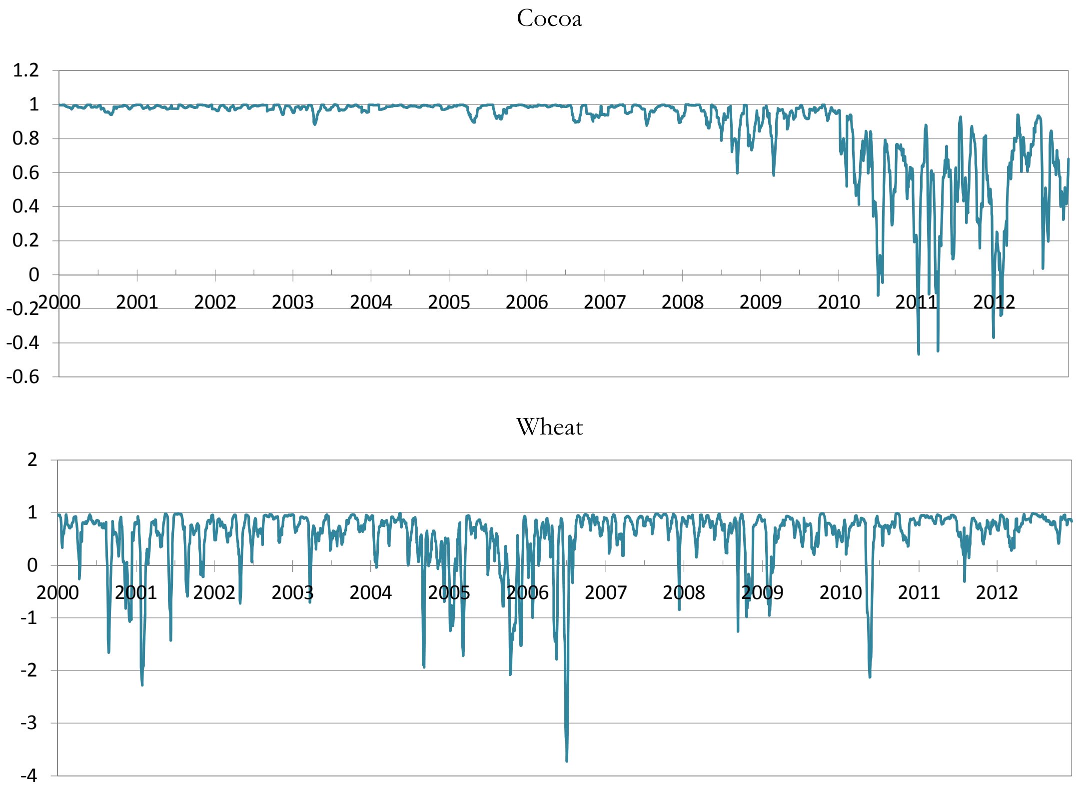
For the following empirical analyses, the cocoa and wheat markets are chosen as case studies. Both markets recently exhibited a large basis and incidences of non-convergence. They make an interesting comparative case, since the relative market weight of passive traders is different (see Chapter 3) and the sign of the basis is reversed. While in the wheat market physical wheat was trading significantly below the futures market price, in the cocoa market the case was the reverse.

4.3 Basis Risk and Market Failure

The close relationship between physical and futures markets is of immediate importance for market practitioners, who seek to hedge their physical exposure via futures positions. If price dynamics and price levels in both markets diverge, the effectiveness of hedging strategies diminishes. The market basis measures the difference in price levels, while a measure for hedging effectiveness regarding dynamics is one minus the ratio between the variance of the hedge (basis) and the physical position (cash price).

If the variance of the hedge, relative to the variance in the outright physical position is relatively small, the measure is close to one and the hedge is considered effective. Figure 4.2 depicts the hedging effectiveness measure for the cocoa and wheat markets over the time period from January 2000 to December 2013. For the cocoa market, the measure is close to one until 2008 when it starts decreasing. Especially from 2010 onwards, hedging effectiveness rapidly deteriorates and the volatility of the hedge outperforms the volatility of the outright physical position on several occasions. For the wheat market, the volatility of hedging positions frequently exceeded the volatility of the physical position since 2000, and in earlier times not depicted.

Figure 4.2: Hedging Effectiveness
(daily monthly, Jan. 2000–Dec. 2013)

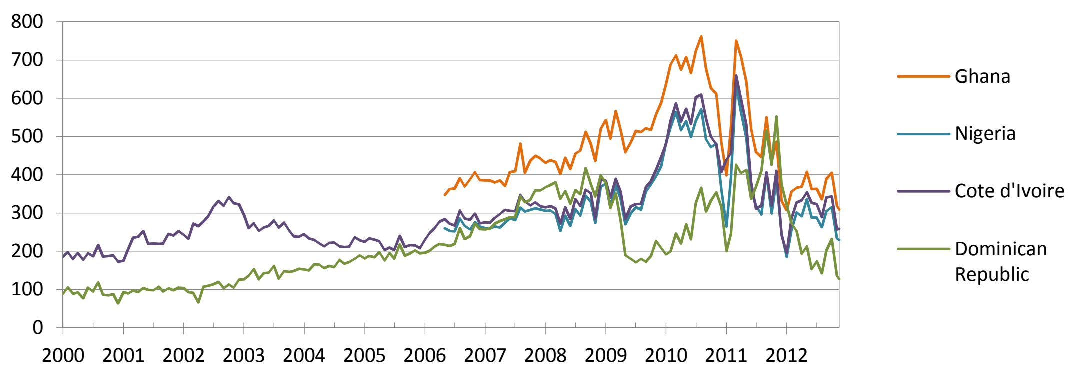


Notes: The underlying cash positions are Cocoa Ivory Coast beans and Wheat No.2 Hard (Kansas). Source: Datastream (author's calculation).

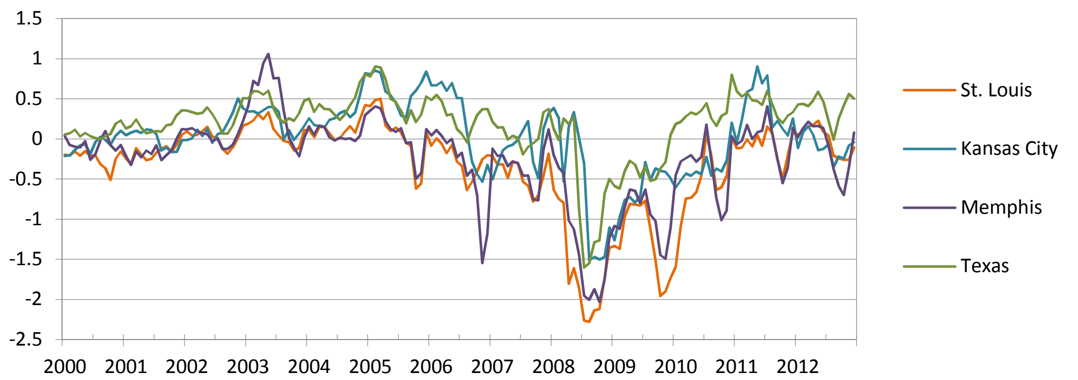
An exceptionally high basis occurred over the last decade in the cocoa and wheat market (Figure 4.3). Although low hedging effectiveness in the wheat market does not necessarily coincide with a large basis, when the wheat market basis exceeded $2 per bushel of wheat (in absolute terms) in mid-2008, the hedging effectiveness measure was relatively low and large spikes in the basis are accompanied by a negative hedging effectiveness measure. For the cocoa market the increase in the size of the market basis clearly coincides with a decrease in hedging effectiveness. The basis of cocoa from four different origins increased from about 2006 onwards and peaked in late 2008 and again in mid-2010. There is a small lag with which hedging effectiveness is restored after the basis shrinks. This is probably due to the fact that the hedging effectiveness measure is calculated with backward looking variances. Hence the value on a particular day does capture the last month's market adjustment mechanisms, which might have brought down the market basis already.

Figure 4.3: Market Basis for Various Cash Markets
(daily monthly average)

Cocoa
(in USD per ton, Jan. 2000–Dec.2013)



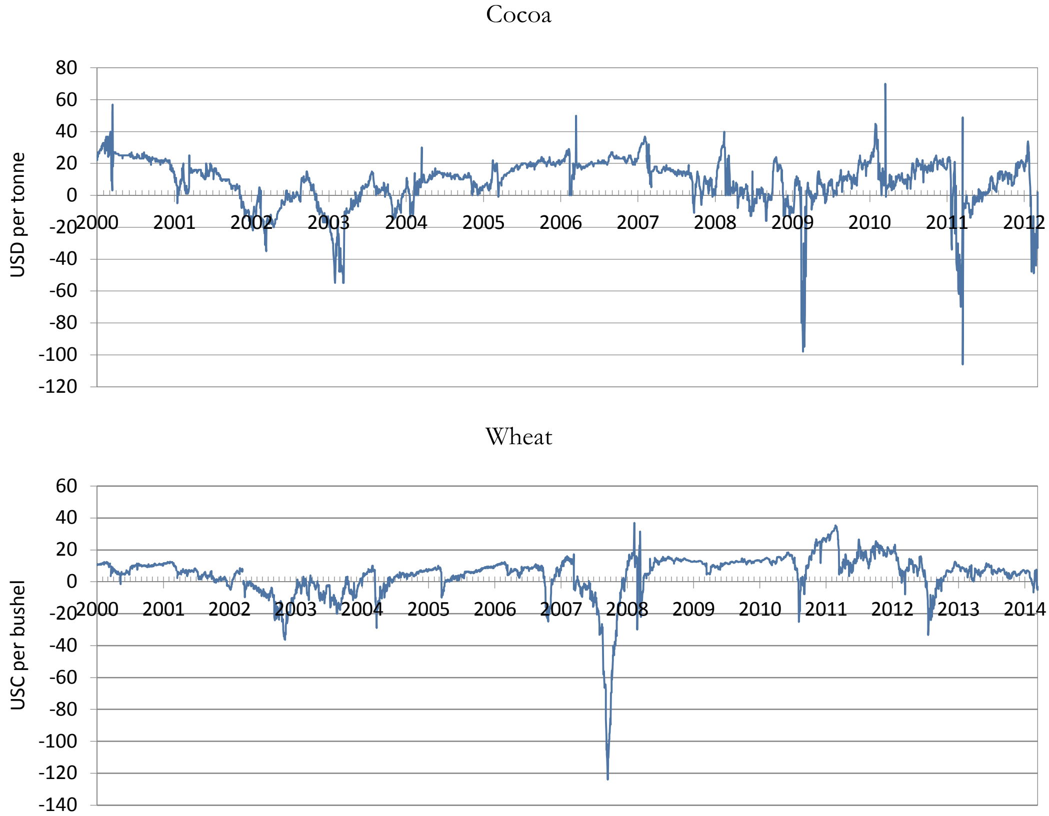
Wheat
(in USD per bushel, Jan. 2000–Dec.2012)



Source: Datastream; US Merchant; USDA (author's calculation).

A particularly low hedging effectiveness measure indicates market adjustments that result in a volatile basis. Figure 4.4 provides a different angle regarding adjustments in the futures price on the example of the spread between the May and March futures contracts (also referred to as the two-to-one calendar spread). The spread is calculated taking the difference of the two next-to-maturity March and May futures contracts until the maturity date of the March contract. At this date both contracts are rolled over into the consecutively maturing March and May contracts. Large spikes at the maturity of the March contract imply that either the price for the May contract suddenly drops (shoots up) or the price of the March contract shoots up (drops). The latter is likely the case in the presence of a large basis. At the contract's maturity, arbitrage traders try to exploit the basis and hence drive the futures price of the maturing contract upward if the market is in backwardation and downward if the market is in contango. The extent of the spike then reveals the degree of previous detachment between futures and cash markets.

Figure 4.4: Continuous Daily May-March Spread
(Jan. 2000–Nov. 2012)



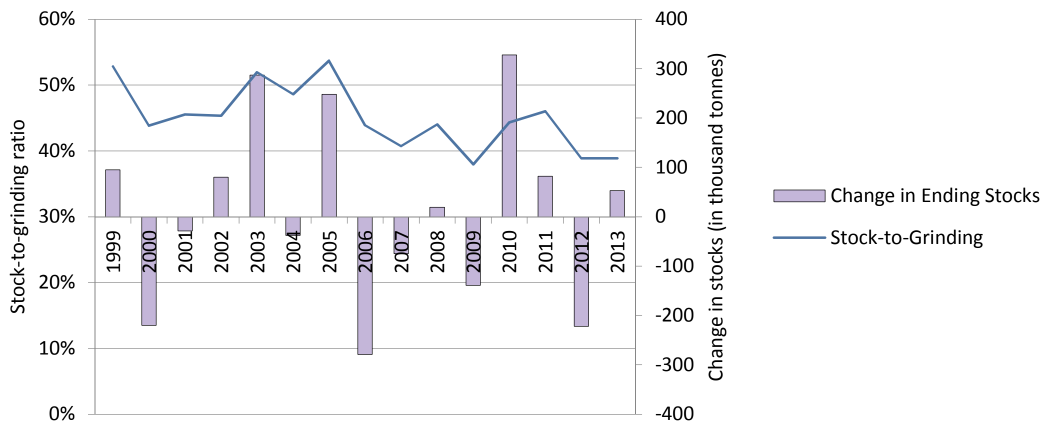
Source: Datastream (author's calculation).

Particularly large spikes are observed between 2009 and 2012 for the cocoa market and volatility in the spread increases from 2008 onwards. These patterns probably arise due to large price adjustments at the end of the March contracts, since the spikes coincide with a large market basis and low hedging effectiveness. Further, the spread between the March and May contracts appears to increase over the March contract's life cycle. This is expected since the March contract approaches the cash price towards its maturity date while the deferred May contract reflects the market carry. This pattern only breaks in 2002–03 and

2008–09 in the presence of physical shortages that result in an inverted market (Figure 4.5). The wheat market shows similar patterns, which are interrupted between 2007 and 2008 when the spread turns negative and exceptionally large, reaching more than \$1.20 per bushel of wheat. This spike coincides with a large market basis. Further, after 2008 the spread flattens out, not showing any market adjustment at the March contract's maturity dates, although the market basis remains high until mid-2010. This anomaly is addressed in greater detail in Section 4.4.

Following general equilibrium theories, a volatile market basis and large market adjustments are linked to changes in market fundamentals, especially changes in inventories. For cocoa, a large positive market basis (backwardation) was partly accompanied by a relatively low stock-to-grinding ratio indicating shortages in physical supply (Figure 4.5). In the presence of shortages, the futures price is expected to be downward-biased through the convenience yield, resulting in a positive basis. However, the extent of the basis remains puzzling. Although the large adjustment in the two-to-one spread and a large basis occurred in a year where supply fell short of demand, this event is unlikely to solely account for the spike in the spread and the basis size, since an even larger decline in end-of-season stocks was observable in 2006, while the calendar spread did not show any striking features (Figure 4.4) and the basis remained relatively small (Figure 4.3).

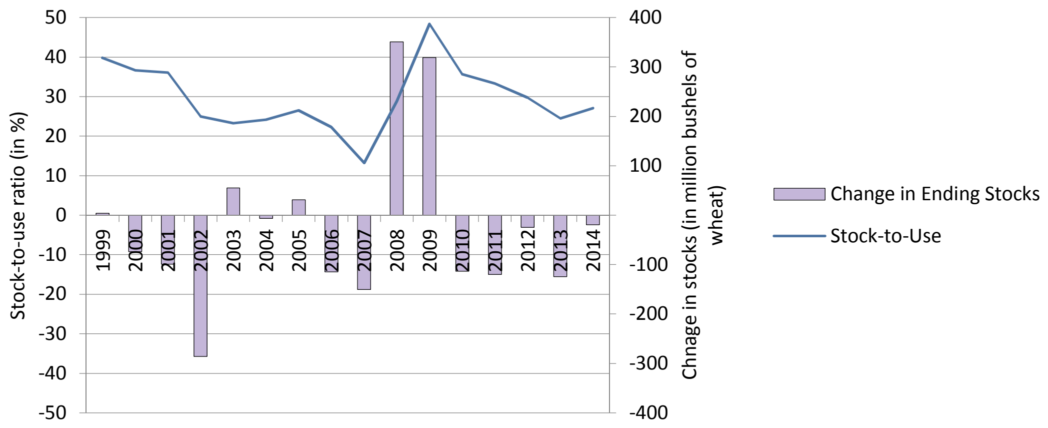
Figure 4.5: Cocoa Stock-to-Grinding Ratio and Changes in End-of-Season Stock (annual, 1999–2013)



Source: ICCO, Quarterly Bulleting of Cocoa Statistics (author's calculation).

For wheat, the market basis turned negative during a time of abundance, which occurred due to an exceptionally good harvest in the 2008/09 crop season (Figure 4.6). Again, this is expected since in times of abundance the convenience yield is small and storage costs high, resulting in a large carry, i.e., upward bias of the futures price relative to the cash price (a move into contango). The previously low stock-to-use ratio in 2007 coincides with large price adjustments at the future contracts' maturity dates and a backwardation, which is reflected in a negative two-to-one spread (Figure 4.4).

Figure 4.6: Wheat Stock-to-Use Ratio and Changes in End-of-Year Stock (annual, 1999–2014)



Source: USDA Wheat Yearbook, Table 5 (author's calculation).

Cocoa and wheat markets differ not only in the sign of the market basis, but also in the composition of traders active in the market. While the cocoa market is generally dominated by commercial traders with little index investment, the wheat market is dominated by non-commercial traders with a significant share of index traders (see Figure 3.5).

Both markets recently experienced periods of exceptionally high market basis, although with opposing signs, and consequently abrupt price adjustments at the contracts' maturities. These events can partly be related to changes in supply and demand patterns. However, especially for the wheat market, dynamics in the market basis and volatility remain puzzling. In the following, the relationship between cash and futures prices over the last decade will be analysed and linked to trader composition.

4.3.1 Data and Methodology

No-arbitrage conditions suggest that there is a stable long-run equilibrium relationship between futures and cash market prices and that price series do not drift apart over time. This means deviations are stationary (Brooks 2008, 344). This condition is exploited by co-integration analysis. Two time series are co-integrated if the residual series of the co-integrating regression is stationary. If co-integration is confirmed arbitrage is effective (Gregory and Hansen 1996).

The conjecture that futures markets tend to incorporate new information on market fundamentals faster than physical markets is supported by many empirical studies—e.g., Asche and Guttormsen (2002), Garbade and Silber (1938), Kuiper, Pennings and

Meulenberg (2002). Nevertheless, some studies find that lead–lag relationships are bi-directional—e.g., Mahalik, Acharya and Babum (2009), Lagi, et al. (2011); that lead–lag relationships are time variant—e.g., Silvapulle and Moosa (1999), Crain and Lee (1996), Baldi, Peri and Vandone (2011); and that the cash market is leading the futures market—e.g., Mohan and Love (2004), Quan (1992). However, empirical studies univocally detect a long-run relationship between cash and futures markets, but the answer to the question of which market is the leading one appears to differ with markets and observation periods (see Appendix 4.1). In the following, I will adopt methodologies used in previous studies including Granger non-causality tests, co-integrating residual ADF (CRADF) tests and ECMs for an analysis of the wheat and cocoa markets.

The concept of co-integration reaches back to Engel and Granger (1987), according to whom the co-integrating relationship between commodity futures and cash prices at time t can be specified as in Equation 4.1. F_t is the futures price, S_t is the cash price, γ_2 is the co-integrating vector, and u_t is the equilibrium error that is the deviation from the equilibrium relationship at time t.

$$F_t = \gamma_1 + \gamma_2 S_t + u_t \tag{4.1}$$

Equation 4.1 captures the long-run relationship between futures and cash prices. The co-integrating vector is considered to be time invariant. For a co-integrating vector to exist, both time series have to be integrated to the same order—commonly I(1)—and the equilibrium error has to be stationary, that is integrated to the order zero, I(0).

The theories of storage and risk premium amend this long-run equilibrium relationship by adding interest rates [i_t], storage costs [w_t], convenience yield [y_t] and risk premium [r_t]. Following the hedging pressure and financialisation hypotheses, additional factors are suggested, which are index pressure and speculative investments [h_t]. If and only if these factors are stationary, the equilibrium error in Equation 4.1 can be assumed to be stationary as well. The fully amended regression equation specifying the long-run equilibrium reads as follows:

$$F_t = \alpha + \beta S_t + \gamma_1 S_t i_t + \gamma_2 w_t + \gamma_3 y_t + \gamma_4 r_t + \gamma_5 h_t + u_t \tag{4.2}$$

In order to conduct a co-integration analysis, the time series under consideration need to be continuous. For both cocoa and wheat up to nine futures contracts with different maturity dates are traded simultaneously. A continuous time series for futures prices is constructed by taking the next-to-maturity contract and rolling it over into the second next-to-maturity contract once the maturity date of the first contract is reached. Therein, the effect of carry costs is smallest. Complications arising from non-stationary carry variables are hence limited and Equation 4.1 is expected to hold. However, the results might give a misleading picture of hedging effectiveness, since hedgers often take positions in deferred contracts. Hence, an additional specification for the continuous futures price is proposed, which is the weighted average of all simultaneously traded futures contracts. The weights are estimated by the share of each contract's open interest in total market open interest. Hence, contracts which have a stronger trader interest receive a higher weight. Price and open interest data are obtained from Thomson Reuters Datastream. The no. 2 soft red winter wheat spot price at St. Louis, provided by the United States Department of Agriculture (USDA), is chosen as the wheat cash price. For cocoa, the Ivory Coast good fermented cocoa cash price, provided by the Cocoa Merchants Association of America[62] (CMAA) is chosen.

Carry and risk variables are also considered. These include interest rate, storage costs, convenience yield, systematic risk, hedging pressure and speculative demand. The interest rate is approximated by the US dollar based LIBOR rate plus 200 basis points, which is obtained from Thomson Reuters Datastream. Storage costs are unfortunately not publicly available, but since they are known to vary little over time the bias introduced by omitting those should be minimal. The convenience yield is latent and conceptually thought to vary with the level and change of inventory. For the cocoa market, inventory data are provided by the 'Cocoa Warehouse Stock Report', published monthly by the ICE Report Center. For the wheat market, data on inventory levels are not available in monthly frequency. USDA Wheat Yearbook Table 5 is used instead, which provides end-of-quarter data. In order to derive a time series at monthly frequency, the quarterly entries are matched with the last month of the respective quarter. The remaining months are interpolated. Systematic risk is approximated by Pearson's correlation coefficient between the S&P 500 index and commodity prices over the past three years.

Hedging pressure is calculated based on the COT report and the CIT supplement. Every last Thursday of a month's observation is used. For the COT data set, hedging pressure is calculated, following De Roon, Nijman and Veld (2000) and Acharya, Lochstoer and

[62] The price is based on differentials collected by a weekly survey conducted by the association among its regular members.

Ramadorai (2013)[63], by taking the net-long commercial positions normalised by total open interest:

$$D_{com} = \frac{com_{nl}}{OI_{total}} \tag{4.3}$$

For the CIT data set, it is possible to differentiate between index pressure and hedging pressure. Two variables are calculated on the basis of the sum of the net-long index and commercial traders' positions normalised by total open interest:

$$D_{com} = \begin{cases} \dfrac{com_{nl} + index_{nl}}{OI_{total}}, & if |com_{nl}| > index_{nl} \\ 0, & if\ |com_{nl}| < index_{nl} \end{cases}$$

$$D_{ix} = \begin{cases} \dfrac{com_{nl} + index_{nl}}{OI_{total}}, & if |com_{nl}| < index_{nl} \\ 0, & if\ |com_{nl}| > index_{nl} \end{cases} \tag{4.4}$$

Unfortunately, the CIT data only cover the time period January 2006 to December 2013, while the COT data reach back to April 1995. Hypotheses made regarding the impact of passive traders on futures prices can hence only be tested for a smaller data set. Because of the small sample constraint, both the COT and CIT data sets are used, despite the limitations identified with the former. In addition to the hedging and index pressure variables, index traders' market weight is included, defined as the average percentage share of index traders' open interest (long plus short) in total open interest. Seasonality in the data is controlled for by taking annual differences. The logarithm of prices is taken. The full data set ranges from April 1996 to December 2013.

ADF tests are conducted with a constant, and with a constant and a trend on variables in annual differences to identify the order of integration. Results are reported in Appendix 4.2, Tables 4.2.1–3 for coca and Tables 4.2.4–6 for wheat. All time series are found to be first difference stationary. In addition, all price series are found to be integrated to the order one.

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63 These studies use a slightly different indicator, with $H_{com} = \frac{com_{ns}}{OI_{com}}$. In order to make the indicator comparable to the index pressure variable, both hedging pressure and index pressure are net-long positions and standardized by total open interest.

4.3.2 Lead–Lag and Co-integrating Relationship

In a first step, the lead–lag relationship between futures and the underlying cash market is identified by Granger non-causality tests. According to Granger (1969) a random variable Y_t is said to 'cause' another random variable X_t if it is "better able to predict X_t using all available information than if the information apart from Y_t has been used".

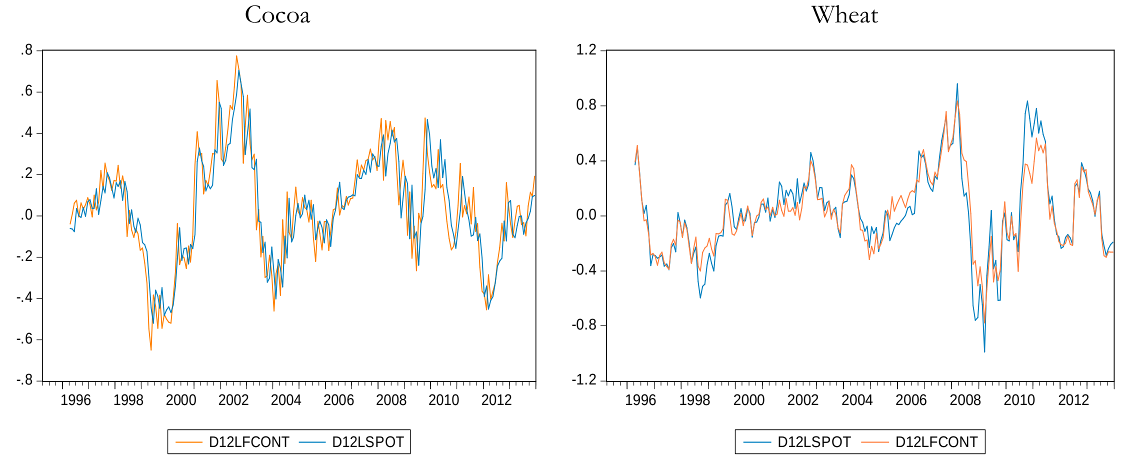
Since the price series under consideration are non-stationary, a procedure proposed by Toda and Yamamoto (1995) is used. A VAR model is estimated including the cash and the futures price in logarithms as endogenous variables. The order of the VAR is determined using the Schwarz information criterion (SIC) with a maximum lag length of 12. An additional m lags are added to the optimal lag length found, with m being the maximum order of integration of the included variables. In the present case m=1.

In order to prepare for a later analysis which, due to data restrictions, demands separating the full sample into sub-samples, additional Granger non-causality tests are run for the sub-samples April 1996 to December 2005 and January 2006 to December 2013. Both the relationship between cash prices (*spot*) and the continuous time series of close to delivery futures prices (*fcont*) and the relationship between cash prices (*spot*) and the weighted average of simultaneously traded active contracts (*fwa*) are analysed. Full results are reported in Appendix 4.3.

For the cocoa market, the null hypothesis of *fcont* not leading *spot* can be rejected at the five per cent level for the full sample and both sub-samples. No evidence is found for the reverse case of *spot* leading *fcont*. Further, no significant Granger causal relationship is found between *fwa* and *spot*. This is not surprising since, for deferred contracts, omitted carry and risk variables gain importance when considering the relationship between cash and futures prices. For the wheat market, only for the later sub-period the null hypothesis of no Granger causality, that is *spot* leading *fcont,* can be rejected at the five per cent level. Weak evidence for the same relationship is found for the entire sample. Results do not change if taking *fwa* instead of *fcont*. The similarity between results for *fcont* and *fwa* in the case of wheat is probably caused by the high weight given to near-to-maturity contracts in the creation of *fwa*, especially before 2006 (see Figure 3.7).

In a second step, the long-run equilibrium relationship as specified in Equation 4.1 is estimated. An ADF test is conducted on the residuals u_t with no constant (Dickey and Fuller 1979; Said and Dickey 1984). The lag length for the test regression is chosen by SIC. Residual diagnostics have been applied in order to test for remaining autocorrelation up to the 12th lag, and additional lags are considered if residuals show remaining autocorrelation. Further, if heteroscedasticity is detected in the residuals, the Phillips-Perron test (PP) is used instead of the ADF test (Phillips and Perron 1988). In addition, the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test is used in order to check for robustness of previous findings (Kwiatkowski, et al. 1992). As before, the observation period is split into two sub-periods and estimated for forward (futures market is leading) and backward (cash market is leading) co-integration using *fcont* and *fwa*.

Figure 4.7: Annual Difference of Logged Futures and Cash Prices (Apr. 1996–Dec. 2013)



Source: Datastream (author's calculation).

Graphically, cash and futures markets appear to have common dynamics (Figure 4.7). However, deviations are observable, especially for the wheat market in June 2005 and December 2011. Results for the co-integration analysis are reported in Appendix 4.4, Table 4.4.1 for cocoa and Table 4.4.2 for wheat. Strong evidence for both forward and backward co-integration is found for the cocoa market. This is even true for the relationship between *fwa* and *spot* for which previously no Granger causality was found. The exception is the later sub-period for *fcont* where forward co-integration is rejected by KPSS at the five per cent level. Results for the wheat market resemble the cocoa market case and forward and backward co-integration is significant at the five per cent level for the full sample and both sub-samples. An exception is again the later sub-sample where in all cases co-integration is rejected at the five per cent level by KPSS.

According to the Granger Representation Theorem, the relationship between two time series can be expressed as an ECM if these two series are co-integrated (Engle and Granger 1987). By exploiting this theorem one can test for co-integration by testing whether the relationship between the variables can be expressed in an ECM. An ECM has the advantage that it incorporates the previous period's disequilibrium error in the long-run relationship. Both long-run and short-run dynamics can be modelled simultaneously with a test for co-integration (Banerjee, Dolado and Mestre 1998). Starting from a simple ARDL model for the cash–futures relationship, one can derive an ECM that incorporates the long-run equilibrium Equation 4.1, so that (the derivation is provided in Appendix 4.5):

$$\Delta F_t = \beta_2 \Delta S_t + \rho[F_{t-1} - \gamma_1 - \gamma_2 S_{t-1}] + \varepsilon_t \tag{4.5}$$

The [.] brackets above enclose the last period's long-run equilibrium error. Hence, the long-run coefficients are nested in the error correction term. The coefficient ρ indicates the speed with which the market adjusts to its long-run equilibrium, i.e., the extent to which the last period's error is corrected. For the two time series to be co-integrated: $\rho < 0$, that is, the speed of adjustment coefficient has to be significantly different from zero and negative. Since in the case of co-integration the t-statistics calculated do not follow the student t-distribution, Banerjee, Dolado and Mestre (1998), five per cent critical values are used. Regression Equation 4.6 is estimated:

$$\Delta F_t = \beta_0 + \beta_1^* F_{t-1} + \beta_2 \Delta S_t + \beta_3^* S_{t-1} + \varepsilon_t \tag{4.6}$$

with $\beta_0 = -\rho\gamma_1$, $\beta_1^* = \rho$, and $-\rho\gamma_2 = \beta_3^*$. Residual diagnostics are estimated and the optimal lag length is identified by testing downwards from a lag length of 12. Further, the model is re-estimated on the split sample. Results are reported in Appendix 4.6, Table 4.6.1 for cocoa and Table 4.6.2 for wheat.

ECM t-tests for the cocoa market confirm the existence of a co-integrating relationship between *fcont* and *spot* in all cases, but backward co-integration in the later sub-sample. For the relationship between *fwa* and *spot* a significant co-integrating relationship is found only for the full sample but not the sub-samples. In the case of the wheat market, results confirm findings by the KPSS test and reject a forward co-integrating relationship for the later sub-sample.

Table 4.1 summarises the evidence gained regarding co-integration and direction of causation between futures and cash market prices. The cocoa market forward co-integrating relationship between *fcont* and *spot* is found to be significant by all tests and only the KPSS test rejects the null of a co-integrating relationship for the later sub-sample. Less evidence is found for backward co-integration, given results from Granger non-causality tests. Regarding *fwa*, results are inconclusive regarding the question which market is leading. For the wheat market, in contrast to the cocoa market, most evidence is found for the existence of a significant backward co-integrating relationship over the entire sample period, while forward co-integration is mostly rejected for the latter sub-period. Results are almost identical for *fcont* and *fwa*.

Table 4.1: Summary Evidence on the Presence of a Co-integrating Relationship (at 5 % significance level)

	Cocoa fcon-spot						**Cocoa fwa-spot**						**Wheat fcon-spot**						**Wheat fwa-spot**					
	Forward (Y=S)			Backward (Y=F)			Forward (Y=S)			Backward (Y=F)			Forward (Y=S)			Backward (Y=F)			Forward (Y=S)			Backward (Y=F)		
	F	E	L	F	E	L	F	E	L	F	E	L	F	E	L	F	E	L	F	E	L	F	E	L
Granger	O	O	O	X	X	X	X	X	X	X	X	X	X	X	X	O	X	O	X	X	X	O	X	O
CRADF	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
KPSS	O	O	X	O	O	O	O	O	O	O	O	O	O	O	X	O	O	X	O	O	X	O	O	X
ECM	O	O	O	O	O	X	O	X	X	O	X	X	O	O	X	O	O	O	O	X	X	O	O	O
Σ "O"	11			8			7			7			7			10			6			10		

Notes: "O" indicates significance at the 5 % level of a co-integrating relationship and "X" indicates no significance respectively. "F" indicates estimation over the full sample, "E" the early sup-sample, and "L" the late sub-sample.

In the following, explanatory variables, which capture variations in market fundamentals, risk components and speculation, are added to the co-integrating relationship. Assumptions made on the significance and impacts of these variables are assessed, and it is tested whether those additional variables control for potential structural breaks in the co-integrating relationship between cash and futures markets.

4.3.3 Conventional Theories and the Long-Run Equilibrium

Following theories of storage and risk premium, deviations between cash and futures prices over a futures contract's life cycle can be attributed to interest rates, costs of storage, and level of inventory relative to demand. The theory of the risk premium is more controversial and there are competing suggestions of what drives the premium. Among these are hedging pressure, idiosyncratic risk, and systematic risk. Linked to hedging pressure theories, an alternative driver of the premium has been identified by this thesis, which is index pressure (see Chapter 2: Section 2.4). With reference to Equation 4.2, the ECM regression Equation 4.6 is extended by these additional explanatory variables so that:

$$\Delta F_t = \beta_0 + \beta_1 F_{t-1} + \beta_2 \Delta S_t + \beta_3 S_{t-1} + \sum_{i=1}^{k} \alpha_i \Delta X_{i,t} + \sum_{i=1}^{k} \alpha_i^* X_{i,t-1} + \varepsilon_t \qquad (4.7)$$

with k explanatory variables X, including the interest rate times the original cash outlay, storage costs, convenience yield, risk premium, and hedging and index pressure. The co-integrating relationship is modelled as before. Table 4.2 summarises expected signs of estimated coefficients.

Table 4.2: Expected Signs of Explanatory Variables in Backward ECM

$Y = F_t$	α	S_t	$S_t i_t$	$w(I)_t$	$y(I, \Delta I)_t$	r_t	D_t	
Theory	0	+	+	+	–	–	+/–	
$Y = F_t$	α	S_t	$S_t LIBOR_t$	I_t	ΔI_t	$SPcor_t$	$Dcom_t$	Dix_t
Expected	0	+	+	+	+	–	–	+

If the regression is specified with the futures price as the dependent variable, the coefficients for S_t is expected to be strictly positive. Opportunity costs, that is, interest rate, are expected to be positively related as well. The storage rate should be a function of storage and is hence thought to increase with the level of storage and hence the coefficient for level of storage should be positive. The convenience yield is approximated by level and level change in inventories. Since the convenience yield should decrease with an increase in inventories and a higher level of inventories, the coefficient for level and for level change of inventories should be positive[64]. Following the theory of a risk premium, the coefficient on the risk variable is expected to be negative. The coefficient for hedging pressure is expected to be negative while it is expected to be positive for index pressure. If the regression is calculated with the cash market price being the dependent variable, coefficients are expected to switch signs.

Equation 4.7 is run for both forward and backward co-integration taking *fcont* and *fwa* price series into consideration. By estimating both forward and backward co-integration, it is tested whether previously rejected cases of co-integration might turn out to be significant when controlling for carry, risk and speculative variables. Further, as before, the regression is estimated over the full sample and two smaller sub-samples, which split in January 2006. For the later sub-sample, index pressure and hedging pressure variables are jointly included in an alternative model specification. Full estimation results are reported in Appendix 4.7 for cocoa and Appendix 4.8 for wheat.

4.3.3.1 Results Cocoa

Previously gained evidence suggests that the cocoa futures price is leading the cash prices, that is, that the two price series are forward co-integrated. Multivariate forward ECMs only reject the significance of a co-integrating relationship between *fwa* and *spot* for the early sub-sample. Interestingly, a significant co-integrating relationship is found for all later sub-sample cases where bivariate ECMs reject such a relationship. Hence, the previous rejection of a co-integrating relationship appears to be caused by omitting carry, risk and trader-position variables.

[64] The coefficient for convenience yield should be negative but since there is an inverse relationship between storage and convenience yield the expected sign is the reverse.

Results of the multivariate forward ECMs are summarised in Table 4.3. Regression specifications for which no significant co-integrating relationship is found are left blank. The lagged level change short-run inventory variable is excluded due to multicollinearity and hence left blank in all cases. If a variable is significant at the five per cent level, the sign of the coefficient is provided. The insignificance of a variable is denoted by a '0' in the respective field.

Table 4.3: Cocoa Summary Results Forward ECM

$Y_t = S_t$	F_t				S_tLIB				I_t				ΔI_t				$SPcor_t$				$Dcom_t$				$D\_$	%i
Exp.	+				–				–				–				+				+				–	–
Short-run																										
	F	E	L	A	F	E	L	A	F	E	L	A	F	E	L	A	F	E	L	A	F	E	L	A	A	A
fcon	+	+	0	0	0	+	0	0	0	0	0	0	–	–	–	–	0	0	0	0	0	0	0	0	0	0
fwa	+		+	+	0		0	0	–		–	–	–		–	–	+		0	+	0	0	0	0	–	0
Long-term																										
fcon	+	+	+	+	0	0	0	0	+	+	+	0					–	0	–	–	0	+	0	–	+	0
fwa	+		+	+	0		0	–	0		–	–					0		–	0	0		–	0	–	+

Note: F is full sample, E is early sub-sample, L is later sub-sample, and A is alternative model specification later sub-sample.

Generally, carry, risk and trader-position variables show the predicted signs and are significant in more instances for the ECM based on *fwa* than for the ECM based on *fcont*, as expected. Carry and risk variables are assumed negligible for the latter case since they approach zero with a contract's maturity. Coefficients for level and level change in inventory are significant in the short-run and long-run throughout all time periods. However, for *fcont* the level of inventory is only significant in the long-run and with a positive sign which is puzzling.

Coefficients for the systematic risk premium are insignificant for the early sub-sample but significant for the later sub-sample. This is in line with the observation made by Domanski und Heath (2007), who claim that commodity futures markets increasingly behave like asset markets and Tang and Xiong's (2012) observation that the correlation between stock and commodity markets increased over the last decade. However, the sign switches for the long-run to a negative which is puzzling. Also, the sign for the hedging pressure coefficient appears to contradict theory for the later sub-sample, while it is significant with the predicted sign for the earlier sub-sample.

Data restrictions make it impossible to test for index pressure effects in the earlier sub-sample. Hence regression equations over the full sample and the earlier sub-sample only consider hedging pressure, while for the later sub-sample both hedging and index pressure effects are accounted for in an alternative model specification. Index pressure is significant with the predicted sign in the short- and long-run. The sign only contradicts theory for *fcont*. This could be due to the fact that index traders execute a positive price pressure in general but a negative price pressure when exiting a maturing contract for their roll. Since *fcont* comprises maturing contracts only, index positions induce a negative price pressure.

The same regression analysis is conducted for backward ECMs, taking the futures price as the dependent variable. Results are summarised in Table 4.4. No significant backward co-integrating relationship is found between *fcont* and *spot*. However, when using *fwa,* co-integration is found significant for all sample periods except for the early sub-sample. While a co-integrating relationship has previously been rejected for the later sub-sample it is found significant if accounting for carry, risk and trader-position variables.

Table 4.4: Cocoa Summary Results Backward ECM

$Y_t = F_t$	S_t				S_tLIB				I_t				ΔI_t				$SPcor_t$				$Dcom_t$				Di	$\%i$
Exp.	+				+				+				+				–				–				+	
Short-term																										
	F	E	L	A	F	E	L	A	F	E	L	A	F	E	L	A	F	E	L	A	F	E	L	A	A	A
fwa	+		+	+	0		0	0	+		+	+	+		+	+	0		–	–	0		0	–	+	0
Long-term																										
fwa	+		+	+	0		0	0	0		+	+					0		+	0	0		0	0	+	0

Note: F is full sample, E is early sub-sample, L is later sub-sample, and A is alternative model specification later sub-sample.

With the exception of the systematic risk premium in the later sub-sample, all coefficients show the predicted sign. While interest rates are insignificant throughout all sample periods, inventory level and level change are highly significant across all observation periods. Again, coefficients for systematic risk are only significant in the later sub-sample. Distinct to the forward EMCs, hedging pressure is only significant jointly with index pressure. As before, index pressure is significant in both the long- and short-run with the expected sign.

4.3.3.2 Results Wheat

Table 4.5 summarises the results for forward ECMs on the wheat market. The existence of a co-integrating relationship has previously been rejected for the later sub-sample by bivariate ECMs. Even when accounting for carry, risk and trader-position variables, this finding is not contradicted. However, co-integration is significant for the earlier sub-sample period in the case of *fwa*, while it was formerly rejected by the bivariate ECM. Evidence hints towards a general break in the co-integrating relationship in the latter half of the sample, which cannot be captured by the added explanatory variables. Coefficients in the multivariate forward ECMs are either insignificant or come with a reverse sign. An exception is the coefficient for the futures price, which is significant and positive. The insignificance of inventory variables is probably due to both the insufficient data frequency and the heavy weight put on the near-to-maturity contracts for which carry variables are less significant.

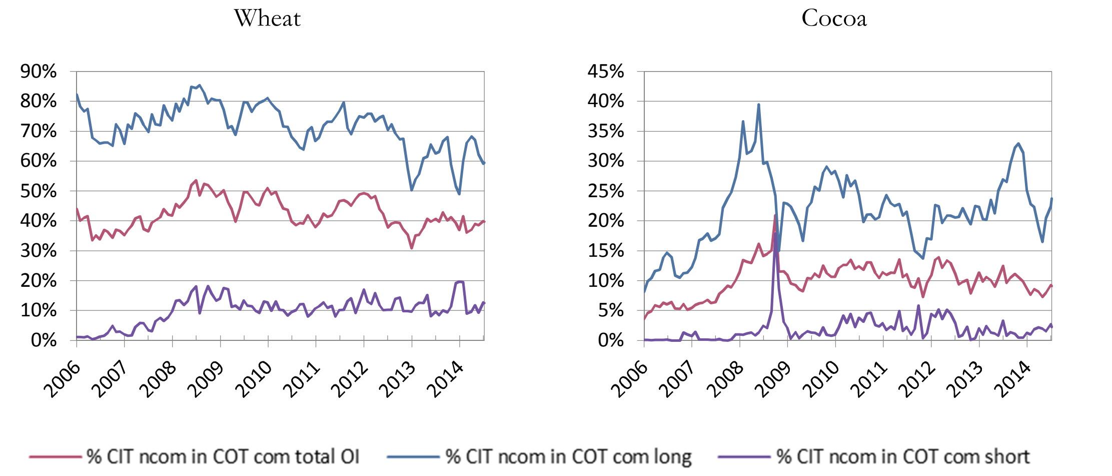
Table 4.5: Wheat Summary Results Forward ECM

$Y_t = S_t$	F_t				S_tLIB				I_t				ΔI_t				$SPcor_t$				$Dcom_t$				Di	$\%i$
Exp.	+				–				–				–				+				+				–	
Short-term																										
	F	E	L	A	F	E	L	A	F	E	L	A	F	E	L	A	F	E	L	A	F	E	L	A	A	A
fcon	+	+			0	+			0	0			0	0			0	0			0	0				
fwa	+	+			0	0			0	0			0	0			0	0			–	–				
Long-term																										
fcon	+	+			0	0			0	0							+	0			0	0				
fwa	+	+			0	0			0	0							0	0			–	–				

Note: F is full sample, E is early sub-sample, L is later sub-sample, and A is alternative model specification later sub-sample.

Hedging pressure is significant in the short- and long-run for *fwa*, however, with a sign that is contrary to the hedging pressure hypothesis. An explanation is that the hedging pressure variable, which is constructed with the commercial category of the COT report, does capture index instead of hedging positions (see Chapter 3). If index traders outweigh commercial traders—a likely scenario for the wheat market where up to 80 per cent of COT commercial long positions are CIT index long positions (Figure 4.8)—the hedging pressure variable might indeed capture index pressure instead.

Figure 4.8: Wrongly Categorised Traders in the COT Commercial Category
(in %, weekly, Jan. 2006–Aug. 2014)



Source: CFTC, COT and CIT (author's calculation).

In contrast to the cocoa market, the inclusion of carry and risk variables for the wheat market results in a rejection of formerly significant backward co-integrating relationships for the case of *fcont*. The hedging pressure coefficient shows the correct sign for the case of the backward ECMs throughout all sample periods and index traders' market weight has a significantly positive effect on the price level (Table 4.6).

Table 4.6: Wheat Summary Results Backward ECM

$Y_t = F_t$	S_t				S_tLIB				I_t				ΔI_t				$SPcor_t$				$Dcom_t$				Di	%i
Exp.	+				+				+				+				–				–				+	
Short-term																										
	F	E	L	A	F	E	L	A	F	E	L	A	F	E	L	A	F	E	L	A	F	E	L	A	A	A
fcon	+	+			0	0			0	0			0	0			0	0			–	–			0	0
fwa	+	+	+	+	0	+	0	0	0	0	0	+	0	0	0	0	0	0	0	–	0	0	0	–	0	+
Long-term																										
fcon	+	+			0	0			0	0							0	0			–	–				
fwa	+	+	0	+	0	0	+	0	0	0	+	–					+	0	0	+	0	0	0	0	–	+

Note: F is full sample, E is early sub-sample, L is later sub-sample, and A is alternative model specification later sub-sample.

Results for the cocoa and wheat market generally seem to confirm the theory of storage, risk premium, hedging pressure and index pressure hypotheses. However, results for the wheat market are weaker, which is probably partly linked to data insufficiency regarding inventory and partly due to structural breaks and omitted variables dominating in the later sub-sample.

4.3.4 Structural Breaks in the Long-run Equilibrium

Parameter instability can arise due to omitted variables or structural breaks (Hansen 1992a; 1992b). In the application at hand, this could mean that instability in the co-integrating relationship between cash and futures prices arises because of omitted carry variables or structural breaks in the co-integrating relationship. In the following, formal statistical tests for parameter instability on the long-run co-integrating vector between cash and futures prices are conducted. In addition, the time invariance of the speed of adjustment parameter of restricted and unrestricted ECMs is assessed graphically by recursive estimation techniques and rolling window estimation with reference to Pollock (2003). Since the co-integrating vector, as well as the speed of adjustment parameter is estimated on a non-stationary variable, the previously used Hansen parameter instability test is invalid (Hansen 1992a) and alternative tests are used (Hansen 1992b).

Hansen (1992b) suggests three different tests for parameter instability of coefficients estimated on non-stationary variables. These are distinct in their test statistics as well as alternative hypotheses. The null hypothesis for all three tests is constancy of the coefficient under consideration. In the first test, denoted 'SubF', the timing of the break is treated as unknown, but is otherwise conceptually similar to the break point Chow test in that it takes as an alternative a significant difference between the parameter estimates before and after the break point. This test is particularly useful to discover sudden regime shifts. For the second and third test, denoted 'MeanF' and 'Lc', the alternative hypothesis is that the parameter follows a Martingale process. Due to the nature of the alternative hypotheses, the latter two tests are better in detecting a gradual shift over time rather than a sudden regime shift. Results for all three tests are reported in Table 4.7.

Table 4.7: Hansen Test for the Restricted Model (monthly, Jan. 1996–Dec. 2013)

	Forward				Backward			
	Spot - Fcont		Spot – Fwa		Fcont – Spot		Fwa - Spot	
	test stat.[2]	p-value[1]	test stat.[2]	p-value[1]	test stat.[2]	p-value[1]	test stat.[2]	p-value[1]
Wheat								
SupF	6.494562	0.20	7.217602	0.20	6.714887	0.20	7.558482	0.20
MeanF	3.42081	0.20	3.443334	0.20	3.100561	0.20	3.343982	0.20
Lc	0.3019767	0.20	0.3062145	0.20	0.3012116	0.20	0.3204551	0.20
Cocoa								
SupF	11.85312	0.17	8.342783	0.20	61.78043	0.01**	16.35072	0.03*
MeanF	2.86531	0.20	2.179609	0.20	14.49844	0.01**	6.454183	0.04*
Lc	0.3178899	0.20	0.2109136	0.20	1.587633	0.01**	0.6816465	0.04*

[1] p-value 0.20 means greater or equal to 0.20. [2] Estimated using R program file by Hansen (1992c). Method of estimation of covariance parameters: pre whitened, quadratic spectral kernel, automatic bandwidth selection. ** indicates significance at the 1% level and * indicates significance at the 5% level.

The long-run co-integrating relationship for the wheat market is found stable for all model specifications. For the cocoa market, parameter stability is rejected at the one and five per cent level for the backward co-integrating relationship using *fcont* and *fwa* respectively. This adds to previous evidence which favours forward over backward co-integration. The graphs in Appendix 4.9 depict the sequence of F statistics for structural change along with the five per cent critical values (straight lines) of the 'MeanF' and 'SubF' as well as for a test close to the break point Chow test. For the wheat market, the sequential F statistic increases from about 2002 onwards and crosses the 'MeanF' five per cent critical value in 2005 for all four model specifications. Another break emerges in 2009, where the test statistic approaches the five per cent critical value once more. This is evidence of an increasing instability of the cash–futures relationship. A more swift structural change is observed for the forward co-integrating relationship of the cocoa market in recent years. In 2011, the sequential F statistic crosses the five per cent critical value of both the 'MeanF' and the known break point test.

In addition to the instability tests on the co-integration regression, recursive coefficients are estimated for the speed of adjustment term[65] obtained by the ECMs reported previously. The recursive estimation is done over an initial sample of 36 months for the COT data and 12 months for the CIT data. Then the model is re-estimated, adding one observation at a time until the full sample is included. Estimations are conducted for both forward and

[65] A separate statistical test for parameter instability is not needed for the long-run coefficients in the ECM since the long-run has been estimated and tested previously already (Gabriel, Lopes und Nunes 2003).

backward ECMs taking *fcont* and *fwa* as the regressant. Graphical results are reported in Appendix 4.10 for wheat and Appendix 4.11 for cocoa.

Regarding recursively estimated coefficients for the wheat market, three patterns emerge. Firstly, the speed of adjustment coefficient is generally larger, in absolute terms, for the unrestricted model than for the restricted. Secondly, recursive residuals only exceed the two standard deviation band after 2007 for the unrestricted model, while this is observed throughout the sample for the restricted model. Thirdly, recursive residuals increase and turn more volatile from 2007 onwards. This is more visible for the unrestricted model than for the restricted model. These observations suggest that the addition of carry variables helps to recover the co-integrating relationship between cash and futures markets. However, this relationship, while stable before, weakens in more recent years. This is exhibited by a stepwise reduction, in absolute terms, of the speed of adjustment coefficient in 2003 and again in 2007 when taking the futures price as the dependent variable and in 2006 and 2011 if taking the cash price as the dependent variable. In recent years, the speed of adjustment coefficient converges towards the level of the unrestricted models, which suggests that carry variables have lost power in explaining the relationship between cash and futures prices since then. Regarding the post-2006 sub-sample estimation, the decline in the speed of adjustment coefficient is visible from late 2010 onwards for the unrestricted model. However, the coefficient remains significant for the unrestricted model, while it turns insignificant for the restricted model, suggesting no co-integration between cash and futures prices for the latter time period.

Results for the recursive estimation of the speed of adjustment term in the ECMs estimated on the cocoa market can be condensed in three main observations. Similar to the case of wheat, the speed of adjustment coefficient is found larger, in absolute terms, for the unrestricted than for the restricted models. Further, coefficient estimates for the unrestricted models also tend to be more stable. This is particularly visible for the post-2006 sub-sample estimation using *fwa*, where the restricted model shows a successive deterioration in the speed of adjustment coefficient from 2010 onwards while the same coefficient remains relatively stable for the unrestricted models. This is evidence for carry and speculative variables accounting at least partly for the parameter instability.

Secondly, recursive residuals appear to increase over time and frequently move outside the two standard deviations interval in more recent years. This is particularly pronounced for ECMs based on the full sample estimation using *fwa*. For these models, residuals increase for both the restricted and unrestricted models from late 2008 onwards, which surprisingly coincide with an increase, in absolute terms, of the speed of adjustment coefficient as well as more varying coefficient estimates.

Thirdly, the situation regarding the full sample estimation using *fcont* appears to be almost the opposite, with the speed of adjustment coefficient deteriorating from 2009 onwards. These seemingly contradictory results can be interpreted as a deteriorating relationship between cash and futures market as well as an assimilation between the *fwa* and *fcont* variable. This is either caused by a greater consonance of price variation in simultaneously traded contracts or a greater weight given to the near-to-maturity contract in the *fwa* variable due to an increase in open interest in this contract (see Figure 3.7). Since the speed of adjustment coefficient is generally larger for the *fcont-spot* relationship than for the *fwa-spot* relationship, the speed of adjustment coefficient for *fwa* improves.

Further, rolling window estimation is used for the speed of adjustment coefficient of the full sample between *fcont* and *spot* forward and backward ECMs over a five year window. Results are reported in Appendix 4.10. There is some evidence for an increasing gap between the cash and the futures market from about 2004 onwards. For cocoa, there are two interesting observations to make. The first is that the assumption that the cash market is leading can be discarded. The second is that the relationship between cash and futures prices is close until 2008, after which it deteriorates until a new, lower level of integration is reached in 2012.

Overall, the long-run equilibrium relationship between cash and futures prices is maintained throughout the sample January 1996 to December 2013. However, a weakening of the relationship is observed over recent years for both markets. While the co-integrating vector for the wheat market turns gradually more unstable and shows greater variation, revealed in both the sequence of the F-statistic and the rolling window estimation, the cocoa market has experienced a more sudden structural change in 2011. This is revealed in the transition of the speed of adjustment term from -0.9 to -0.7 between 2009 and 2011 in the rolling window estimation as well as in the detected structural break by the "MeanF" and "SubF" test. Carry and trader-position variables appear to account for at least some of the variation in coefficient estimates, but, especially, in recent years, they fail doing so.

The weakening and increasingly volatile link between cash and futures markets, reflected in a reduced and unstable speed of adjustment coefficient, is strikingly obvious for both the wheat and the cocoa market. Carry variables have lost explanatory power over recent years and fail to explain the growing volatility in market basis. Concurrently, systematic risk and index pressure have become significant drivers of market basis—an observation which strongly supports the hypothesis that commodity markets increasingly behave like asset market as a result of speculative trading. However, no conclusion can be drawn regarding implications of changing price dynamics in the futures market for the cash market. For the cocoa market, there is strong evidence for the futures leading the cash market, while the evidence for wheat is weaker and the lead-lag relationship between futures and cash markets shifts over time. A more thorough analysis of the relationship between cash and futures markets, as will be presented in Chapter 7, is needed.

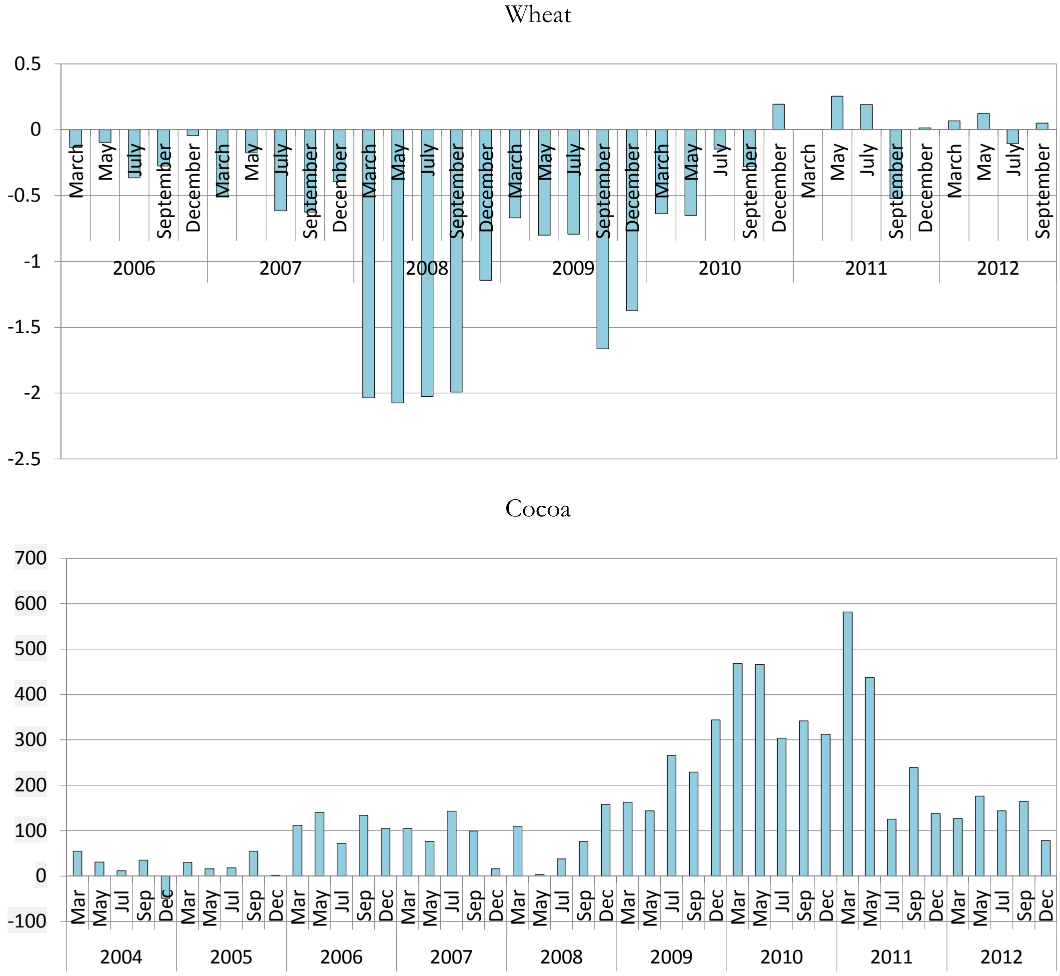
4.4 The Conundrum of Non-Convergence

The previous sub-section analysed the continuous relationship between the cash and futures market. A related, but slightly different, question is whether both markets do not only closely relate to each other but also converge at a futures contract's maturity date. This is an important question as non-convergence, similar to breaks in the co-integrating relationship, points to market and hedging inefficiencies. In practice, convergence between futures and spot prices is rarely exact as arbitrage is not costless. However, historically, large differences between cash and futures prices during a contract's delivery period have been rare. If they occur, they are one-off events often associated with market manipulation by single actors (Garcia, Irwin and Smith 2011). Against this background, the occurrence of consecutive convergence failure in both the cocoa and the wheat market is puzzling.

Since March 2008, wheat contracts failed to converge for 11 consecutive months and the futures contracts repeatedly matured with a price far[66] *above* the cash market price. In the cocoa futures market, convergence started to fail since the end of 2008 and was only re-established in late 2011 (Figure 4.9). Differently from the wheat market, cocoa futures consecutively matured *below* the cash market price. The large deviations between cash and futures prices at maturity in March and May 2011 might partially be linked to the outbreak of the second civil war in Ivory Coast, which resulted in a larger premium for cocoa from this region. However, during the first civil war in 2002-04, non-convergence did not occur. Further, the large basis was not specific to Ivorian cocoa (Figure 4.3).

[66] The difference amounted to 25 per cent of the futures price.

Figure 4.9: Basis at Each Futures Contract's Maturity Day
(in USD, Mar. 2006–Sep. 2012)

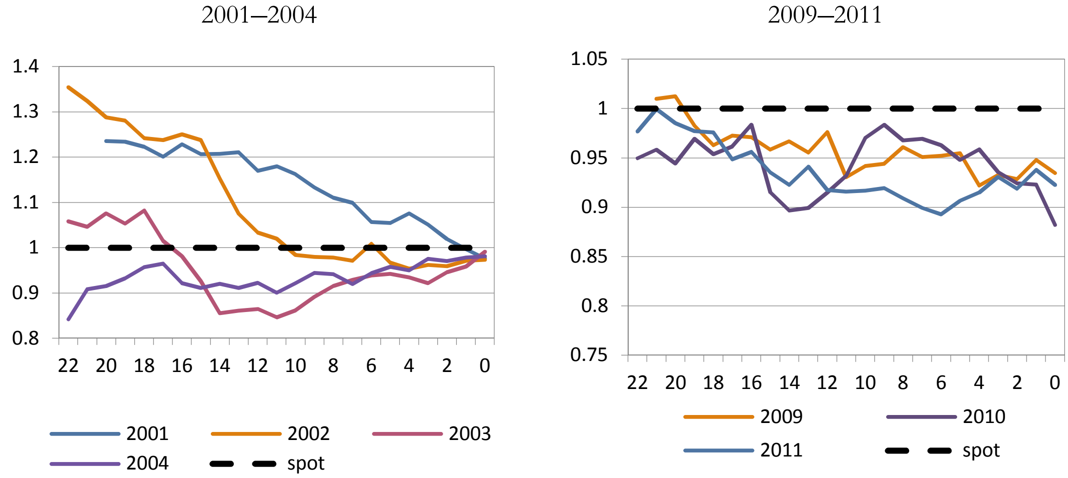


Source: Datastream (author's calculation).

Figures 4.10-11 illustrate how non-converging futures contracts varied relative to the cash price throughout their life cycles. Contracts are normalised by the cash market price and the x-axis shows the remaining months to maturity. Before convergence failed, the cocoa market turned from a contango in 2002 into a backwardation in 2003 (Figure 4.10).

Backwardation is commonly interpreted as a sign of a shortage in the physical market. This is puzzling, since during 2003 stocks were increasing and the stock-to-grinding ratio improved (Figure 4.5). However, the outbreak of the first civil war in Ivory Coast, the largest cocoa producing country globally, gave rise to an expected shortage which explains the backwardation. During the contract months when non-convergence was prevalent in 2009-11, contracts were surprisingly close to the cash market price before they moved into a backwardation and further away from the underlying cash price.

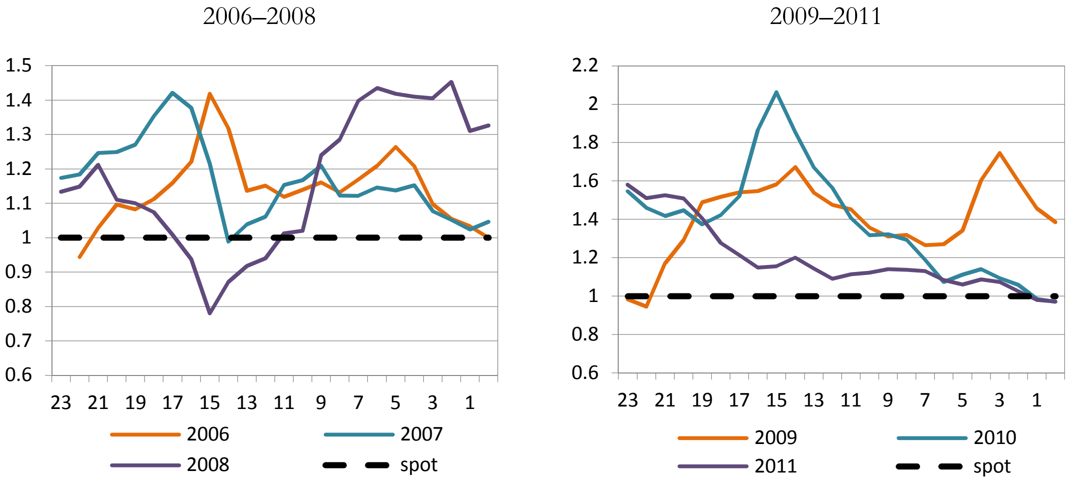
Figure 4.10: March Cocoa Contracts Relative to Cash Prices
(daily monthly centred average)



Source: Datastream (author's calculation).

The situation for the wheat market is different (Figure 4.11). Although the contango weakened in 2007, before the occurrence of non-convergence, the market did not turn into a backwardation. With the exception of 2008, contracts show a contango throughout their life cycle. Non-converging contracts in 2008-09 exhibit wave forms, whereby the basis increases sharply months before the maturity date and declines slightly in the maturity month. This tendency to revert to the cash market price in the maturity month is absent in the cocoa market, where prices in the last contract month even diverge further away from the physical price.

Figure 4.11: December Wheat Contracts Relative to Cash Prices
(daily monthly centred average)



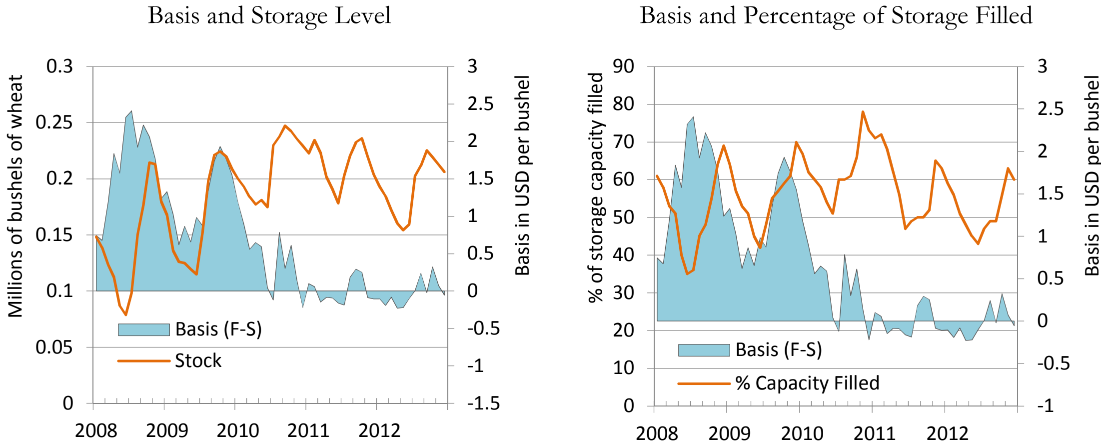
Source: Datastream (author's calculation).

Consecutive convergence failure is heavily discussed for Chicago wheat, but it has gained less attention in the case of cocoa. For the wheat market, the literature has put forward various explanations for limits to spatial arbitrage that then result in non-convergence.

However, while studies suggest plausible theories about the occurrence of non-convergence, it is argued here that those fail to explain the extent of the basis at the contracts' maturity date. The reasons for limits to arbitrage put forward in the literature include insufficient storage space, specifications of the delivery certificates, and factors like a large carry and price volatility which cause practitioners to refrain from selling inventories.

Seamon (2010), for example, blames non-convergence on a shortage in delivery space. He argues that, after a decade of a declining stock-to-use ratio, the good harvest in 2008/09 quickly exhausted existing storage capacities. Storage costs in turn increased, which suppressed cash prices relative to futures prices. Indeed, wheat stocks in exchange registered warehouses were high during the second jump in the basis from mid-2009 to mid-2010 (Figure 4.12). This, however, was not the case when non-convergence started to occur. In fact, stocks were low when the basis reached its first maximum in mid-2008 and warehouses were only about 30 per cent full.

Figure 4.12: Wheat Basis and Storage at Exchange Registered Warehouses (monthly, Jan. 2008–Dec. 2012)



Source: Datastream; USDA.

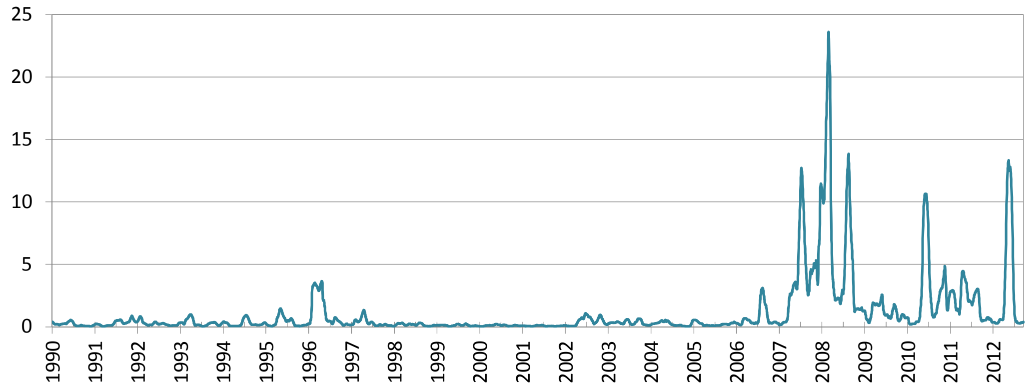
However, this observation on storage space can be explained by the time lag with which stocks at the exchange-registered warehouses reflect new supply, especially in times of previously low inventories. The harvest period for US winter wheat starts in mid-May, which is about the time when the non-convergence problem started. Since commercial storage space is filled before stocks in exchange-registered warehouses pile up, the excess supply only becomes visible in exchange-registered storage facilities in later months. This is a reasonable assumption as exchange inventories commonly reflect the quantity of residual wheat, i.e., wheat that is not currently needed for commercial business, and hence it can be freed for speculative purposes. With commercial storage facilities filling up, storage rates were rising in May 2008 already, which then brought about the non-convergence.

Another explanation is based on the availability of delivery instruments. It is argued that issuers of shipping certificates were reluctant to sell those certificates to potential arbitrage traders, as the selling would have interfered with their normal merchanting activities (O'Brien 2010). Every short trader in the futures market who seeks to make delivery has to buy a shipping certificate from a regular firm—commonly a large commercial grain merchant—that is eligible to issue such certificates. Hence, unless the short position holder at the exchange is a regular firm, she is reliant on the availability of such certificates. Regular firms, however, are not obliged to issue certificates. Although, according to the CBOT rulebook, shipping certificates allow such firms to issue certificates over more wheat than they store, the factor by which the certificates can exceed the amount stored in registered warehouse is fixed (CBOT 2014). If they want to issue more certificates, they eventually have to transfer wheat from their own warehouses to the exchange. Further, it has been argued that since storage space at the exchange was already filled with wheat, issuers of shipping certificates were reluctant to take on new wheat arriving due to high opportunity costs incurred by a loss of space that could be used for storing other commodities like soybeans and corn (Garcia, Irwin and Smith 2011).

The first argument fits the early period of non-convergence, when commercial grain traders were still stocking up their previously depleted inventories for regular business. Hence, they might have been reluctant to fill exchange-registered warehouses in order to sell shipping certificates to potential arbitrage traders. The latter hypothesis applies to the second period of non-convergence. During the time when the extent of non-convergence peaked first in mid-2008, only 30 per cent of storage capacity at exchange registered warehouses was filled. At the second peak, 70 per cent of storage capacity was taken (Figure 4.12).

Aulerich, Fishe and Harris (2011) ascribe the failure of convergence to a change in delivery instruments. Instead of ‘warehouse receipts’, ‘shipping certificates’ were introduced. Shipping certificates provide the owner with the option to choose if and when to take control of the underlying physical commodity. The owner of the certificates can, instead of executing his right to take physical delivery, sell the certificate into the next futures contract. Since a shipping certificate can be conceptualised as an ‘embedded real option’, which gains value with an increase in the price volatility of the underlying physical product, owners of the certificate are incentivised to delay load-out when price volatility is high. This might result in convergence failure. Indeed, price volatility was, by historical comparison, high over the entire non-convergence period (Figure 4.13).

Figure 4.13: Wheat Price Volatility
(3 months daily centred moving variance, in hundred USD per bushel,
Jan. 1990–Dec. 2012)



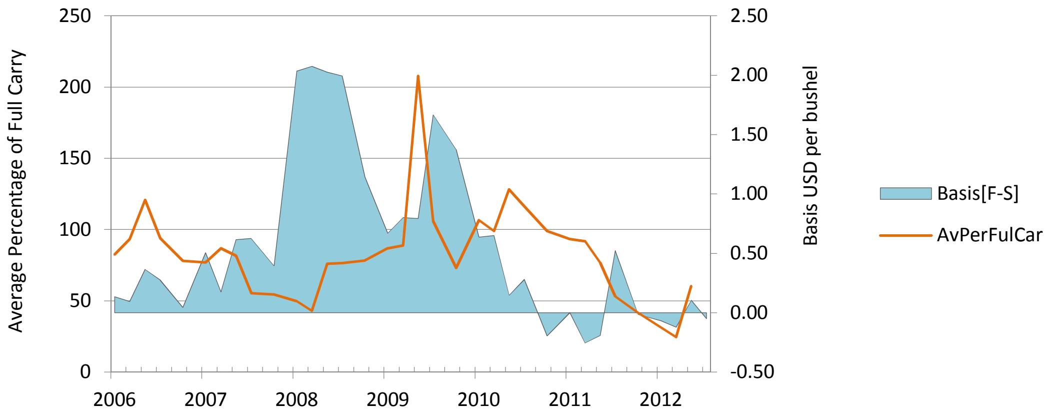
Source: Datastream (author's calculation).

However, the CBOT wheat market was no exception and various other commodity futures markets suffered from consecutive non-convergence, ones that had not introduced a shipping certificate. In addition to wheat, Baldi, Peri and Vandone (2011) analyse the CBOT corn and soybean markets, and Kaufman (2011) examines non-convergence in the WTI crude oil market. Not all of these markets share the same delivery instruments.

Irwin, et al. (2011) argue that if the spread between the price of the expiring and the next-to-expire contract is large enough to compensate for the costs of owning the delivery instrument, i.e., the shipping certificate, the owner faces an incentive to postpone load-out. This, in turn, postpones the purchase of the cash commodity, which holds back convergence mechanisms. Hence, they investigate whether high two-to-one calendar spreads, which is synonymous with a large financial carry[67], occurred concurrently with non-convergence in recent years. The financial carry was high before mid-2007 and after mid-2009, but in-between the average percentage of full carry was at 50 per cent or below, while non-convergence occurred (Figure 4.14).

[67] The carry usually refers to the "percent of full carry" which is estimated as the percentage of the storage plus interest opportunity costs compensated for by the spread between the nearest to expiration and next nearest to expiration contract price. This is represented by $Carry_t = \left[\frac{F2_t - F1_t}{C_t^S + I_t}\right] * 100$, with C_t^S being the cost of storage, I_t the foregone interest rate, and $F1_t$ and $F2_t$ the price of the nearest and next-nearest contract to maturity (Irwin, et al. 2011).

Figure 4.14: Wheat Basis and Average Percentage of Full Carry
(at each contract's maturity, Jan. 2006–Dec. 2012)



Source: Datastream (author's calculation).

Irwin, et al. (2011) further investigate a hypothesis proposed by a staff report of the Permanent Subcommittee on Investigations of the United States (US Senate 2009). The staff report argues that index traders' passive long positions have successively increased futures prices, while physical prices remain unaffected by their demand and as a result led to a large basis. Irwin, et al. (2011) test this hypothesis by event studies and Granger non-causality tests. The event analysis shows a coinciding increase in carry with the roll of index investors. In order to assess the continuity of the effect, Granger non-causality tests are employed. Their results reject a significant impact of index traders' positions on the market carry, which leads the authors to argue that an increase in the precautionary demand for commodity stocks driven by an increase in uncertainty about market fundamentals might be at the root of the non-convergence. However, the observation that poor convergence occurs whenever the carry is high is interesting and provokes the question: what caused the large carry in the first place?

The previously discussed literature suggests cogent arguments for limits to arbitrage in the wheat market. However, it fails to explain the extent of non-convergence. While non-convergence can emerge if spatial arbitrage is limited, the extent of non-convergence should still be confined by the possibility of fundamental arbitrage. Only a few researchers attempt to explain this anomaly.

Garcia, Irwin and Smith (2011) argue that since storage costs at exchange-registered warehouse are fixed by the exchange, physical storage charges eventually exceeded the storage premium fixed by the exchange so that the calendar spread, which is bound to not exceed financial full carry, could not fully reflect the costs incurred by storage in the physical market. As a result costs were reflected in the non-convergence of futures and cash markets. They propose a 'dynamic rational expectations commodity storage model' in which non-convergence could arise in equilibrium when the market price of physical storage is greater than the cost of holding the delivery instrument, i.e., the premium charge set by the exchange. They show that the 'wedge', which they define as the difference between market storage costs plus convenience yield and the cost of holding the delivery instrument, drives the basis at maturity.

Two independent equations for the cash and the futures market are assumed in their model. The current cash price is defined as the continuously discounted expected future cash price minus storage costs plus convenience yield, while the futures price is defined as the continuously discounted expected futures price minus the exchange premium. The difference between the current cash and futures price (basis) is hence the continuously discounted expected basis plus the 'wedge' defined as: $W_T = \delta_T - y(I_T) - \gamma_T$, with δ_T being physical storage costs, $y(I_T)$ being the convenience yield which changes with inventories, and γ_T being the storage premium at the exchange[68]. The wedge is assumed to vary with the level of inventories through the convenience yield and the physical storage costs as long as the exchange premium remains constant. The authors argue that "a relatively small wedge term in period t can have a large effect on the basis if it is expected to persist for an extended period", that is if it enters the expectation on the future basis.

However, for Garcia, Irwin and Smith's (2011) model to be coherent, one has to accept assumptions that violate the no-arbitrage conditions. Their model, and hence their conclusion, is based on the crucial, however, implicit assumption that the cash price is determined independently of the futures price. This assumption enables them to explain the increasing basis in terms of the continuously discounted expected basis. This assumption is necessary for their model to hold as otherwise the size of the basis could only be related to the difference between physical storage costs and the storage premium at the exchange (the wedge) and not to the expected basis. However, the size of the basis at non-convergence is shown to be about 50 times the size of the wedge (van Huellen 2013).

Such a violation of no-arbitrage conditions demands justification. This can be found in the financialisation hypothesis as outlined in Chapter 2. It has been argued that traders in the physical and the futures market differ systematically in their investment motives and strategies. As a result, expectations, investment decisions and hence prices are formed in a fundamentally differently way in those markets. Depending on the relative weight of

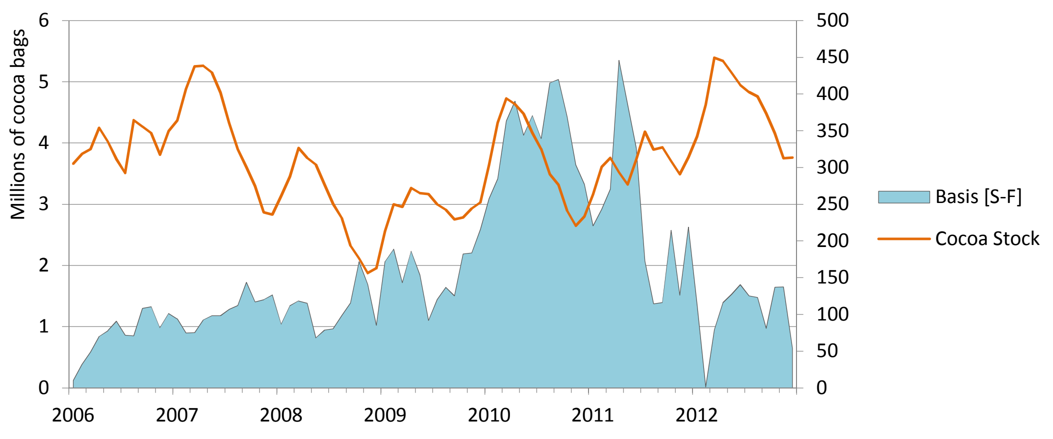
[68] The basis at maturity date T: $S_T - F_{T,T} = \left[\frac{E_t[S_{t+1}]}{(1+r_t)} - \delta_t + y(I_t)\right] - \left[\frac{E[F_{T+1,T+1}]}{(1+r_T)} - \gamma_T\right] \Leftrightarrow B_T = \left[\frac{E_t[B_{T+1}]}{(1+r_T)} + W_T\right]$.

traders, which are solely represented at the futures exchange, price differences can be substantial. If limits to spatial arbitrage exist, those differences are carried over from one contract into the next and the basis becomes excessive even at a contract's maturity.

What distinguished the Chicago wheat market case from other incidences of non-convergence, and hence attracted attention, is that futures contracts traded far above physical wheat prices. The rule that a contango has its maximum in the 'carry cost proper' (Lautier 2005) is hence consecutively violated. This is because a negative basis, as observed in the case of wheat, in theory cannot exceed storage costs ($w_{t,T}$ in Equation 2.2, with $\varphi_{t,T} = 0$; physical full carry). However, if limits to spatial arbitrage exist, this equation cannot be enforced and the basis might exceed full carry.

For the <u>cocoa market</u>, in contrast to wheat, the sign of the basis was less puzzling, since a positive basis depends on the 'size' of the convenience yield and hence has no limit according to conventional theories. The case of the cocoa market consequently attracted almost no attention. Commonly, a high marginal convenience yield, and hence a situation of strong backwardation, is explained by a shortage of inventories. Cocoa storage levels appeared relatively low during the months before non-convergence. This would explain the market turning into backwardation. However, storage levels were rising again in late 2009 when non-convergence was prevalent (Figure 4.15).

Figure 4.15: Cocoa Basis and Storage Level at Exchange Registered Warehouses (monthly, Jan. 2006–Dec. 2012)



Source: Datastream; ICE Reporting Centre.

Arguably, in the wake of the crisis in Ivory Coast, market uncertainty was high and so was the demand for precautionary inventories. Nevertheless, the convenience yield should decline with a contract approaching its maturity date and eventually reach zero. Again, the assumption of limits to spatial arbitrage is crucial. If these were not present, arbitrage traders would take delivery in the futures market and sell in the physical market at a higher price. However, as argued for wheat before, if limits to arbitrage exist, convergence might not be enforceable and the basis is carried over from one contract to the next.

For the cocoa market, reluctance or inability of physical traders to free their inventories for speculative purposes could have contributed to limits to arbitrage. One likely reason is an attempted squeeze, timed well with the arising shortage in the physical market, in the London cocoa exchange, by one single hedge fund. Since October 2009, a single trader built up a large long position in the July 2010 contract and eventually forced delivery of over 240 thousand tonnes of cocoa—the entire European speculative stock (ICCO 2010). As a result, cocoa prices at the London exchange reached a 33-year high, the basis spread was inflated and the price differential between the American and the British exchange reached more than $1,000 USD per tonne.

Hedgers assume that they are able to close out their futures position at a contract's maturity date. However, if a long trader is reluctant to close out her position, a short trader has to deliver. When the hedge fund forced delivery for almost the entire long positions in the July 2010 contract, short traders were forced to sell their inventory or acquire physical cocoa to subsequently sell. If a short trader fails to deliver, the position is settled in cash, which implies huge gains for the hedge fund and losses for the short trader (ICCO 2010). As a result, inventories became scarce which, although the squeeze occurred on the London exchange, had arguably direct implications also for the availability of speculative stocks in the American futures market[69].

While various cogent reasons for limits to spatial arbitrage have been presented for both wheat and cocoa, research papers fail to explain the *extent* of non-convergence. I have shown that Garchia, Irwin and Sanders' (2011) structural model, which claims to explain the extent of non-convergence, is based on the implicit assumption that price formation mechanisms on the physical and the futures market differ systematically, which is a sharp break with conventional rational expectation theories. In Chapter 2: Section 2.4 of this thesis, a similar argument has been developed in the context of the financialisation hypothesis, which suggests that physical and futures markets are driven by different market fundamentals due to the different nature of traders active in the two markets. In the following section I show that, by taking the assumption of trader heterogeneity serious, not traders' expectations of a continuously discounted market basis, as suggested by Garchia,

[69] Such shortage would not show in the storage level since it is not caused by usage but by a change in ownership.

Irwin and Sanders' (2011), explain the extent of non-convergence, but the different, though linked, nature of investments and hence price formation at futures and cash market.

4.4.1 An Alternative Explanation for the Extent of Non-Convergence

Under normal market conditions, spatial arbitrage ensures that the equilibrium relationship between cash and futures market prices holds at maturity regardless of the enforceability of fundamental arbitrage. However, if there are limits to spatial arbitrage, deviations from the efficient market hypothesis, that is limits to fundamental arbitrage, are revealed in the market basis. In the presence of limits to spatial arbitrage, three market regimes can be distinguished: (i) failure of fundamental arbitrage and storage cost differential, (ii) failure of fundamental arbitrage, (iii) fundamental arbitrage.

$$F_{T_1,T_2} - S_{T_1} = max \begin{cases} \dfrac{E_{T_1}\left[F_{T_2}\right] - E_{T_1}\left[S_{T_2}\right]}{(1 + r_{T_1})} - \gamma_{T_1,T_2} + \delta_{T_1,T_2} - y_{T_1,T_2} & (i) \\ \dfrac{E_{T_1}\left[F_{T_2}\right] - E_{T_1}\left[S_{T_2}\right]}{\left(1 + r_{T_1}\right)} & (ii) \\ 0 & (iii) \end{cases} \quad (4.8)$$

The efficient market hypothesis postulates that: $E_{T_1}\left[F_{T_2}\right] = F_{T_1,T_2} = E_{T_1}\left[S_{T_2}\right] = S_{T_2}$ so that the futures price at T_1 maturing at T_2 is an unbiased estimator of the futures price at T_2 maturing at T_2, and the futures price maturing at T_2 is an unbiased estimator of the expected and realised cash price at T_2. If these conditions hold, case (iii) prevails and convergence is established despite limits to spatial arbitrage. However, if fundamental arbitrage is rejected, expectations on futures and cash markets might not be congruent and this gives rise to case (ii). In this case, expectations regarding future cash prices and future futures prices are formed independently. Case (i) corresponds to Garchia, Irwin and Sanders' (2011) model in which price expectations are independent and storage cost differentials occur.

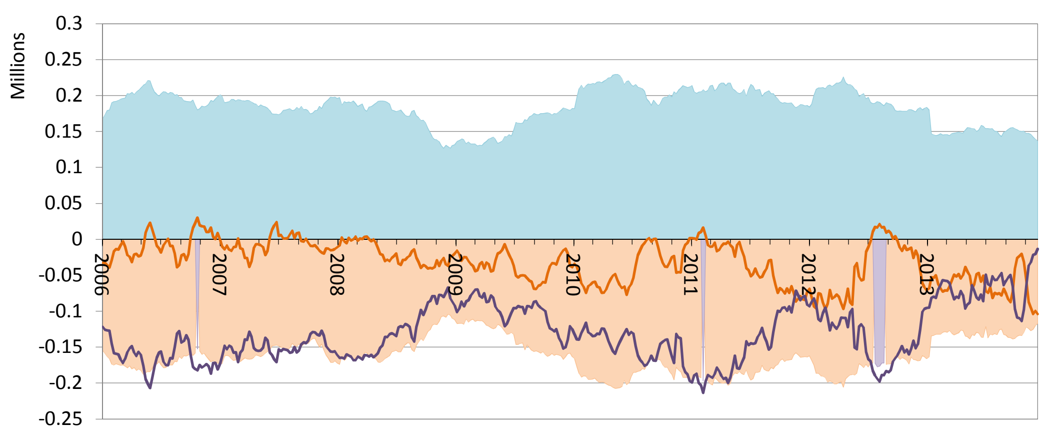
If fundamental arbitrage is rejected, Keynes's normal backwardation, which was later transformed into hedging pressure, provides a strong argument for why expected cash prices do not need to equal expected futures price. Hedging pressure models build on the crucial dichotomy between 'hedgers' and 'speculators' as two distinct types of market actors. With the entrance of new types of traders, this assumption has to be amended by another category: index traders. Following the rationale of the hedging pressure hypothesis, if a counterparty is scarce, due to market frictions like transaction costs, capital constraints or fundamental uncertainty, the price has to move in order to attract traders to enter into the market as a counterparty. Index traders, similarly to commercial hedgers, have to compensate other non-commercial traders for entering into a contract. This consequently causes the futures price to be a biased estimator for the expected future cash price. In other words, the futures price will diverge from its fundamental value by the price pressure exerted by either hedgers or index traders.

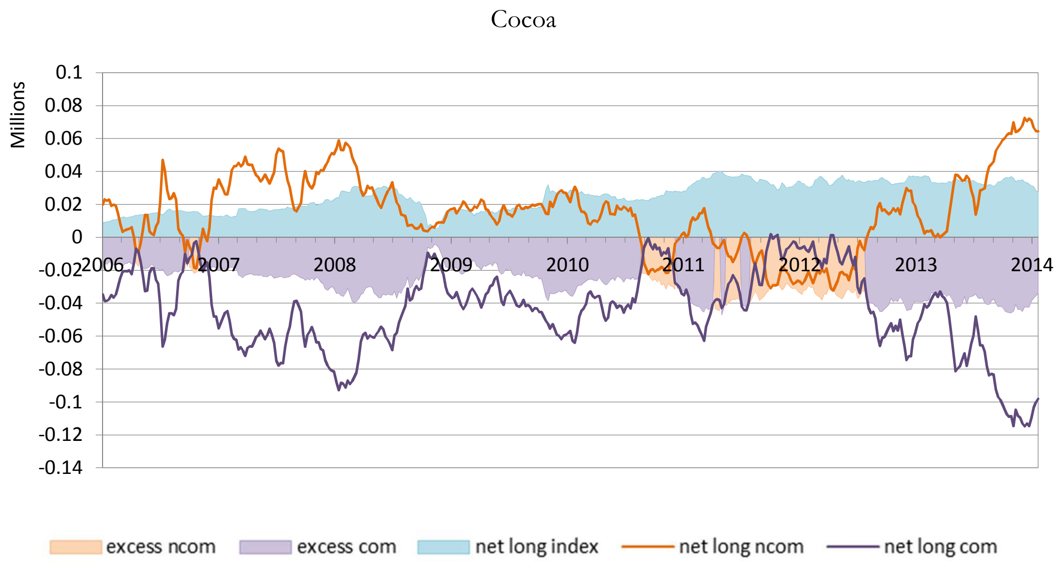
Since hedgers are predominantly net-short, index traders essentially supply liquidity to commercial traders. This decreases the costs of hedging and as a result eases the (downward) hedging pressure on prices. Hence, the presence of index traders could even increase market efficiency in that they decrease the bias arising from hedging pressure. This is only the case as long as index demand is not in excess of hedging positions. Index traders indeed appear to have taken over the counterparty role for commercial hedgers from other non-commercial traders for the cocoa and wheat market. However, in some cases, index traders are far in excess of commercial traders' hedging demand, so other non-commercial traders have to step in to cover the index traders' long positions. I refer to such situation as *index pressure*.

In Figure 4.16, the area for jointly commercial and non-commercial net-long positions turns into a light purple (labelled *excess com*) when index traders' net-long positions are fully covered by commercial traders' net-short positions. That is when non-commercial traders are needed to take the counter position to commercial hedgers as in the hedging pressure hypothesis. In the case where the area is in a light orange (labelled *excess ncom*), non-commercial traders are needed to take the counter position of index traders because these are not fully taken up by commercial traders. This is a case of index pressure.

Figure 4.16: Hedging and Index Pressure
(monthly open interest, Jan. 2006–Dec. 2013)

Wheat





Source: CFTC (author's own calculation).

For the wheat market, the case where index traders' net-long positions are in excess of hedgers' net-short positions prevails. As a result, the hedging pressure hypothesis is reversed: speculators are needed to fill the long positions of index traders. In this case, the futures price is expected to be upward-biased, since short traders need to be attracted. For the cocoa market, the graph looks quite different. Only in late 2010 and between mid-2011 to mid-2012 did index traders' positions exceed hedgers' demand.

The predictions made by the index pressure hypothesis appear to be validated by the examples of the cocoa and the wheat market. If index traders' net-positions exactly cover commercial traders' net-hedging positions, the premium is expected to be zero. If passive long traders exceed net-short hedging positions, the bias is expected to be positive, which means a negative basis (index pressure: futures exceeds cash price). The reverse is predicted when commercial net-short positions exceed index traders' net-long positions, which means a positive basis (hedging pressure: cash exceeds futures price), as summarised by Equation 4.9.

$$bias \begin{cases} = 0, & if\ com_{nl} + index_{nl} = 0 \\ > 0, & if\ com_{nl} + index_{nl} > 0 \\ < 0, & if\ com_{nl} + index_{nl} < 0 \end{cases} \tag{4.9}$$

Since index trader participation in the cocoa market is relatively low so that the *excess com* situation dominates in Figure 4.16, a positive market basis is expected. For the wheat market, where index participation is relatively high and non-commercial traders have to cover the excess long positions by index traders, the reverse is the case. As net-long index positions are larger than net-short commercial positions, the market basis is expected to be negative. Both predictions are reflected in the actual market regimes.

Various causes for the occurrence, inspired by existing literature, of non-convergence were noted in the previous section, while the present section has put forward a hypothesis on the factors that explain the extent of non-convergence, which especially in the case of wheat, was puzzling and remains so far unexplained. Garcia, Irwin and Sanders (2011) attempt a formal model which they argue explains the extent of non-convergence. However, their model was built on the implicit assumption that the formation of expectations in the physical and the futures markets takes place independently. It is argued here that such a deviation from conventional theories demands justification. This justification is found in the financialisation theory. The reference of the financialisation hypothesis does not only justify the implicit assumption made by the Garcia, Irwin and Sanders (2011) model, but also suggests a radically different explanation for the extent of non-convergence, which is index and hedging pressure. In the following sub-section, the hypotheses about the extent of non-convergence discussed in the literature and the alternative explanations promoted by this thesis are tested.

4.4.2 Data and Methodology

In an attempt to explain the extent of non-convergence, i.e., the size of the basis at maturity, a simple regression analysis is conducted which relates the basis to various factors which have been advanced in the literature cited above as well as to hedging and speculative demand as hypothesised in this thesis.

The basis is defined as the difference between cash and futures prices $S_T - F_{i,T} = B_{i,T}$ at each contract's maturity, with i indicating the i^{th} contract (e.g., May 2008 contract) at its maturity date T (e.g., 14th of May 2008). For the wheat market, price data for the cash and the futures price have been obtained from Thomson Reuters Datastream. The futures price is the CBOT no. 2 soft red winter wheat settlement price at the last day of trading of each contract. The cash price is the no. 2 soft red winter wheat spot price at St. Louis provided by the USDA.

Open interest differentiated by trader type, with commercial, non-commercial, index, and non-reporting traders who hold positions below the reporting level, is obtained from the CIT report. The relative market weight of each trader type is calculated as the average percentage share of traders' open interest (long plus short) in total open interest in the last trading days of the contract, starting with the first trading day of the expiration month and ending with the contract's expiry day, which is usually two weeks into the maturity month.

The storage premium at the exchange is obtained from the CBOT. Data on storage costs outside the exchange are not available, and hence the exchange premium can only serve as an approximation for the variation in the storage costs difference. In order to capture limits to arbitrage, which were related to storage capacity, the wheat stock-to-use ratio is used. The estimate for the stock-to-use ratio is based on the USDA Wheat Yearbook Table 5 and calculated as the ratio between ending stocks and total disappearance (depletion of inventory) over the same period. As the data are available only quarterly, the ratios are matched with different contracts in the following way: March with Q3[70] (December to February), May with Q4 (March to May), July with the average of Q4 and Q1 the following year, September with Q1 (June to August), December with Q2 (September to November). The stock-to-use ratio is not ideal, as it does not capture the opportunity costs that might have arisen due to a shortage of storage space. An alternative variable, the percentage of storage capacity filled in CBOT exchange-registered warehouses is obtained from the USDA Grain Stock Report, published every Friday. The observation on the last Friday before each contract's final trading day is used.

Lastly, the average percentage of full carry is estimated as the ratio between the total costs of holding the delivery instrument until a contract's maturity and the two-to-one calendar spread over the life cycle of each contract from the point where it became the next-to-maturity contract till its maturity (CME Group 2009). The interest rate used is the three-month USD LIBOR plus 200 basis points, which is obtained from Thomson Reuters Datastream. The variables used are summarised in Table 4.8.

Table 4.8: List of Wheat Market Variables

Variable	Description
basis	CBOT Soft Red Winter Wheat basis in USD cents per bushel of wheat.
index	Average percentage share of index traders open interest (long plus short).
ncom_sp	Average percentage share of non-commercial spread trader's open interest.
ncom-sp	Average percentage share of non-commercial traders' open interest (long plus short excluding spread traders).
com	Average percentage share of commercial traders' open interest (long plus short).
nrep	Average percentage share of non-reporting traders' open interest (long plus short).
StCost	Exchange premium for the currently trading contract in USD cents per bushel per day.
StToUs	Stock-to-use ratio.
AvFlCar	Average of the percentage of financial full carry over the contract's life cycle.
CapFil	Percentage of capacity filled in exchange registered warehouses at the contract's maturity.

70 The quarters do not follow the calendar year, but the crop year.

The time period covered starts with the March 2006 contract and ends with the maturity of the September 2012 contract. There are 35 observations in total. Unfortunately, data for the percentage of storage filled in exchange-registered warehouses are only available from January 2008 onwards, which constrains the sample of the model in which the variable is included to 22 observations.

For cocoa, the traders' position data are chosen in the same way as for wheat. For the cash price, the Ivorian cash market price provided by Thomson Reuters Datastream is chosen. The stock-to-grinding ratio is taken from the ICCO Quarterly Bulletin of Cocoa Statistics. The data entries are available for March, June, October, and December. March is paired with the March contracts' maturity dates. For the May contracts' maturity dates the average between the March and June stock-to-grinding values is taken. July is paired with June. Stock-to-grinding values for October are paired with the September maturity contracts and the values for December with the basis values for contracts maturing in December.

Table 4.9: List of Cocoa Market Variables

Variable	Description
basis	ICE Cocoa basis in USD per tonne of cocoa.
index	Average percentage share of index traders open interest (long plus short).
ncom_sp	Average percentage share of non-commercial spread trader's open interest.
ncom-sp	Average percentage share of non-commercial traders' open interest (long plus short excluding spread traders).
com	Average percentage share of commercial traders' open interest (long plus short).
nrep	Average percentage share of non-reporting traders' open interest (long plus short).
stCost	The weighted average of storage costs in ICE registered warehouses.
stToGr	Stock-to-grinding ratio.
iceMilSt	Level of stocks at the ICE exchange registered warehouses.
exRate	The end of month exchange rate CFA Franc per USD for the contract month.

The storage rate is calculated based on the actual storage rates as of date May 2001. The weighted average was calculated from the storage rates at Port of New York, Port of Delaware River, Port of Baltimore, and Port of Hampton Roads. The weights are derived from the percentage share of cocoa stored at the respective ports. Regarding the interest rate, the end of month value for the month in which the contract matures is taken. The data are provided by the IMF, IFS data service. Variables used are summarised in Table 4.9:

4.4.3 Empirical Results

Different model specifications are run with the basis $[B_T]$ as the dependent variable and varying explanatory variables in order to assess the contribution of each factor to the size of the basis at maturity. The models are specified as:

$$B_T = \beta_0 + \sum \beta_i X_{i,T} + u_T, with\ u_t \sim IID \quad (4.10)$$

$X_{i,T}$ is the i^th^ explanatory variable at the T^th^ maturity. β_0 is the intercept coefficient and β_i is the slope coefficient of the i^th^ explanatory variable, and u_T is the error term. The tables below provide an overview of estimated coefficients, their standard errors, partial r-squares, and residual diagnostics for each model (Tables 4.10-13).

4.4.3.1 Results for Wheat

Table 4.10 shows the regression results for the first three model specifications for the wheat market. The first model specification includes the weight of speculative demand as the percentage share of each trader group in total market open interest. Commercial traders' share is excluded in the first model specification to avoid perfect collinearity between explanatory variables. The coefficient for the market weight of non-commercial non-spread traders and index traders is negative and highly significant. The remaining coefficients are insignificant. The overall fit of the model appears relatively good, with an R-squared of about 0.6. However, residual diagnostics reveal a significant degree of autocorrelation that indicates omitted variables.

Table 4.10: Wheat Regression Results and Residual Diagnostics for Model 1–3

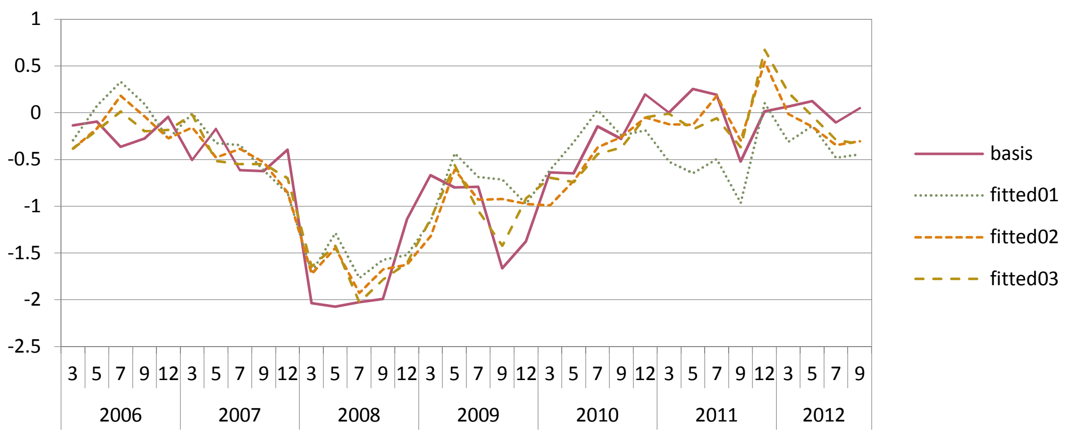
	Model 1			**Model 2**			**Model 3**		
basis	coeff.	s.d.	part. r^2	coeff.	s.d.	part. r^2	coeff.	s.d.	part. r^2
constant	1113.20***	200.1	0.5178	947.81***	164.0	0.5439	917.243***	180.4	0.5084
index	-25.273***	4.490	0.5221	-24.882***	3.574	0.6339	-24.9211***	3.392	0.6834
ncom_sp	-1.36663	2.602	0.0094	-2.77120	2.097	0.0587	-3.85766*	2.096	0.1284
ncom-sp	-16.823***	4.566	0.3189	-14.257***	3.684	0.3485	-14.010***	4.239	0.3040
nrep	-18.4642	8.471	0.1408	-10.3022	7.013	0.0716	-7.60530	6.867	0.0468
stCost	-	-	-	17966.***	4259.	0.3886	16188.3***	4132.	0.3804
stToUs	-	-	-	-	-	-	0.167315*	0.09663	0.1071
avFlCar	-	-	-	-	-	-	-0.394175*	0.2141	0.1194
Diagnost.	sigma RSS R^2 Adj.R^2 log-likelihood Joint test: F(4,29) AR1-2.: F(2,27) Normal: Chi^2(2) Hetero.: F(8,25)		47.3613 65049.7463 0.596734 0.541111 -176.705 10.73 [0.000] 3.756 [0.036] 0.300 [0.861] 0.588 [0.779]	sigma RSS R^2 Adj.R^2 log-likelihood Joint test: F(5,28) AR1-2.: F(2,26) Normal: Chi^2(2) Hetero.: F(10,23)		37.6883 39771.3305 0.753443 0.709416 -168.341 17.10 [0.000] 0.468 [0.631] 1.653 [0.438] 1.130 [0.383]	sigma RSS R^2 Adj.R^2 log-likelihood Joint test: F(7,26) AR1-2.: F(2,24) Normal.: Chi^2(2) Hetero.: F(14,19)		35.6689 31806.6893 0.80045 0.744576 -160.195 14.30 [0.000] 0.214 [0.809] 2.684 [0.261] 0.845 [0.620]

Note: * indicating significance at 10% level, ** indicating significance at 5% level, and *** indicating significance at 1% level respectively.

Since the market weight of different trader groups in the derivative market is unlikely to directly affect the cash market, the negative coefficients indicate that non-commercial traders' relative demand results in a significant increase in the futures prices relative to the cash prices. Estimated coefficients suggest that, ceteris paribus, if the market weight of index traders increases by one per cent (either due to decreasing positions of non-index traders or increasing open interest by index traders), the futures price increases by about \$0.25 USD per bushel of wheat on average relative to the cash price. For non-commercial non-spread traders' this would ceteris paribus result in a \$0.17 USD per bushel of wheat increase on average in the futures relative to the cash price.

In order to solve the non-convergence problem, the CBOT introduced a variable storage rate (VSR) that was designed to successively narrow the gap between the storage premium at the exchange and the storage rate in the physical market—the wedge. The VSR, effective since the July 2010 contract's maturity, increases at each contract's maturity as long as financial full carry prevails (CME Group 2009). Since the model seems to systematically under-predict the size of the basis after mid-2010, when the VSR was introduced (Figure 4.17), the second model specification includes the exchange storage premium (*stCost*) as an additional explanatory variable.

Figure 4.17: Model 1–3 Observed and Fitted Basis at CBOT Wheat
(in USD per bushel)



Source: Author's calculation.

The additional coefficient is significant and the model has a better fit compared to the previous one. Residual diagnostics also suggest spherical residuals. The size of the coefficient indicates that for a 10/100 cent per bushel per day increase in the storage premium, the futures price would *ceteris paribus* decrease by almost \$1.80 USD on average relative to the cash price.[71] This effect counterbalances the otherwise upward price pressure on the futures prices by non-commercial traders' market weight, and hence adjusts for the under prediction of the basis in the latter half of the sample period. This confirms Garcia,

[71] Note that the storage rate is expressed in USD cents and is increased by 10/100 USD cents each time the average percentage of full carry over the maturing contract exceeded 80 per cent. Hence, it increases stepwise by 0.001 USD cents and not 1 USD cents, which means that the coefficient has to be divided by 100 for a meaningful interpretation.

Irwin, and Sanders' (2011) hypothesis that a mismatch in the storage premium causes non-convergence. According to their model, a higher exchange premium results in a smaller wedge and consequently in a reduction of the difference between cash and futures prices (decrease of the basis in absolute terms), as predicted in Equation 4.8.

Besides the storage premium mismatch, two further explanations for successive non-convergence in the wheat market were put forward in the literature: firstly a high market carry which resulted in a reluctance to load out, and secondly, insufficiencies in the delivery system. In order to account for these two effects, the average percentage of full carry (a*vFlCr*) and the stock-to-use ratio (*stToUs*) are included. Both coefficients are weakly significant. The coefficient on the average full carry is negative, supporting the theory that the compensation for storage costs is related to non-convergence. However, the carry can only explain the existence of limits to arbitrage but not the extent of non-convergence, which probably accounts for its low significance. The coefficient on the stock-to-use ratio is positive, indicating that as stocks increase relative to use, that is as supply becomes relatively abundant, the premium of the futures price relative to the spot price decreases. This is consistent with the theory of storage, which predicts that the marginal convenience yield is a negative function of inventories (Pindyck 2001).

One might argue that the significance of the market weight of non-commercial traders is due to a decreasing market weight of commercial traders resulting from a loss in hedging effectiveness. Hence, the causality would be the reverse, where commercial traders exit the market because of an increasing basis. The counter image of this effect is an increase in the market share of non-commercial traders, which then shows a significant effect falsely suggesting causality. In order to test for this alternative hypothesis, a fourth model is run with the percentage share of commercial traders included (Table 4.11).

Indeed, by only including the share of commercial traders, the coefficient is significantly positively related to the basis, supporting the above argument. However, the size of the coefficient is smaller than the estimated effect of the market share of non-commercial traders on the market basis. Further, comparing adjusted R-squares of model one with model four, as a rough indicator of the relative goodness of fit, the first model specification appears preferable. However, in order to test whether index trader or commercial traders' market weight has the greater explanatory power, a direct comparison of models with only one of the respective variables included is needed. This is done in model five. Both partial r-square and adjusted R-square are significantly larger for the fifth model specification where index traders' market weight is included compared to the fourth model where only the average share of commercial traders is included. This indicates that, while some of the effect of index traders found in model three might be due to a decrease in commercial traders' share, a great part is solely due to index traders' price pressure effect.

Table 4.11: Wheat Regression Results and Residual Diagnostics for Model 4–6

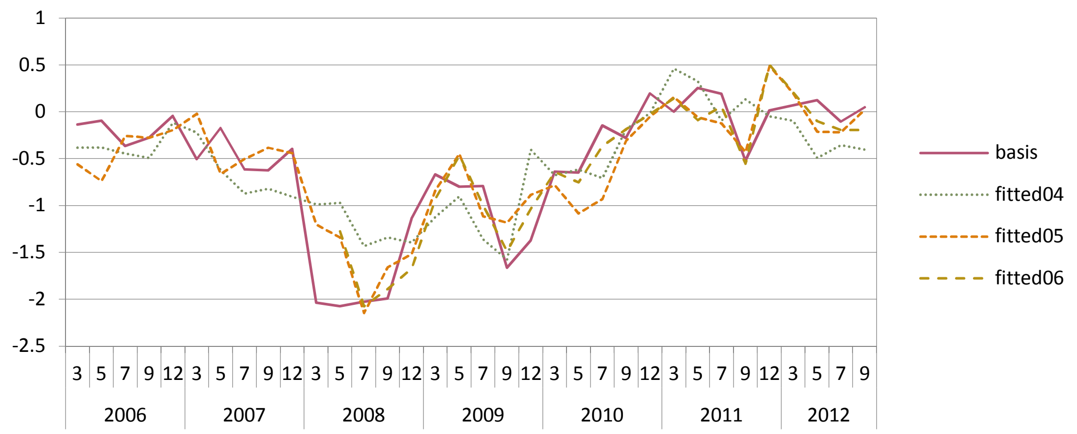
	Model 4			**Model 5**			**Model 6**		
basis	coeff.	s.d.	part. R^2	coeff.	s.d.	part. R^2	coeff.	s.d.	part. R^2
constant	-385.16***	68.40	0.5311	399.44***	91.48	0.4051	976.228***	297.3	0.4182
com	8.74365***	2.184	0.3640	-	-	-	-	-	-
index	-	-	-	-22.375***	3.562	0.5850	-29.2057***	5.822	0.6265
ncom-sp	-	-	-	-	-	-	-13.9427**	5.845	0.2751
ncom_sp	-	-	-	-	-	-	-2.68197	2.725	0.0606
nrep	-	-	-	-	-	-	-7.37043	9.342	0.0398
stCost	20030.1***	5424.0	0.3275	20168.***	4360.0	0.4332	13886.5**	4720.	0.3659
stToUs	0.225253*	0.1248	0.1043	0.3004***	0.1012	0.2392	-	-	-
avFlCar	-0.267085	0.2826	0.0309	-0.15931	0.2260	0.0174	-0.419307*	0.2358	0.1741
capFil	-	-	-	-	-	-	1.81619*	0.9738	0.1882
Diagnost.	sigma	50.72		sigma	40.9724		sigma	36.0535	
	RSS	72030.6072		RSS	47004.5593		RSS	19497.8237	
	R^2	0.548092		R^2	0.705102		R^2	0.84928	
	Adj.R^2	0.483534		Adj.R^2	0.662973		Adj.R^2	0.778944	
	log-likelihood	-173.683		log-likelihood	-166.64		log-likelihood	-110.175	
	Joint test: F(4,29)	8.49 [0.000]		Joint test: F(4,29)	16.74 [0.000]		Joint test: F(7,15)	12.07 [0.000]	
	AR1-2.: F(2,27)	1.14 [0.336]		AR1-2.: F(2,27)	0.091 [0.913]		AR1-2.: F(2,13)	0.090 [0.915]	
	Normal: Chi^2(2)	10.6 [0.005]		Normal: Chi^2(2)	0.341 [0.843]		Normal: Chi^2(2)	3.414 [0.181]	
	Hetero.: F(8,25)	1.05 [0.428]		Hetero.: F(8,25)	2.471 [0.041]		Hetero.: F(14,8)	5.133 [0.013]	

Note: * indicating significance at 10% level, ** indicating significance at 5% level, and *** indicating significance at 1% level respectively.

This conjecture is further confirmed by an additional model (not reported here), which jointly includes commercial and index traders' market share and excludes non-commercial spread traders instead. The coefficient on the market weight of commercial traders turns insignificant while still positive. Although non-significant, the inclusion of commercial traders' market weight seems to result in a decrease of the effect of index traders, which suggests that these trader groups are not independent. However, the effect of index traders' market weight, as well as that of non-commercial non-spread traders' market weight, remains significant. This refutes the pervious hypothesis that non-commercial traders' market weight is only significant on the basis of it being the counter-image of commercial traders' market weight.

Further, the variable for the stock-to-use ratio does not fully capture the argument of the insufficiencies in the delivery system, which is related to high opportunity costs of storing additional wheat as storage space becomes scarce. Hence, the stock-to-use variable (*stToUs*) is replaced by the percentage of storage space filled at exchange-registered warehouses (*capFil*) in a sixth model. Unfortunately, data for this new variable are only available from January 2008 onwards, which reduces the sample size of this particular model to 22 observations. The coefficient for the additional variable is significant at the ten per cent level and positively related to the market basis. This confirms the theory that a shortage in storage capacity has contributed to limits to spatial arbitrage. However, the variable is unable to explain the extent for non-convergence. Fitted and observed values for the basis for model four to six are presented in Figure 4.18.

Figure 4.18: Model 4–6 Observed and Fitted Basis at CBOT Wheat
(in USD per bushel)



Source: Author's calculation.

4.4.3.2 Results for Cocoa

For the cocoa market, similar regression results are conducted, however, explanatory variables differ slightly. The first model, as previously, includes the relative market weight of different groups of non-commercial traders (Table 4.12). As for wheat, index traders' market share is highly significant. A weakly significant coefficient is found for non-commercial excluding spread traders' and non-reporting traders' market share. However, while the coefficient for non-commercial traders has the same negative sign as in the case of the wheat market, index traders' market weight is positively related to the size of the cocoa basis in contrast to findings for the wheat market.

This means that the larger the percentage share of index traders, the larger the market basis. Since index traders are unlikely to directly impact the cash market price, index traders' market weight appears to be negatively related to the futures prices. This is in stark contrast to the index pressure hypothesis, which predicts the reverse. However, it partly supports the information content hypothesis, since the greater the share of uninformed traders, the further the futures prices is assumed to disengage with its underlying physical price. It follows that the greater the share of index traders, the greater the share of uninformed traders, the lower the information density and thus the greater the market basis in absolute terms due to uncertainty and limits to arbitrage arising.

Table 4.12: Cocoa Regression Results and Residual Diagnostics for Model 1–3

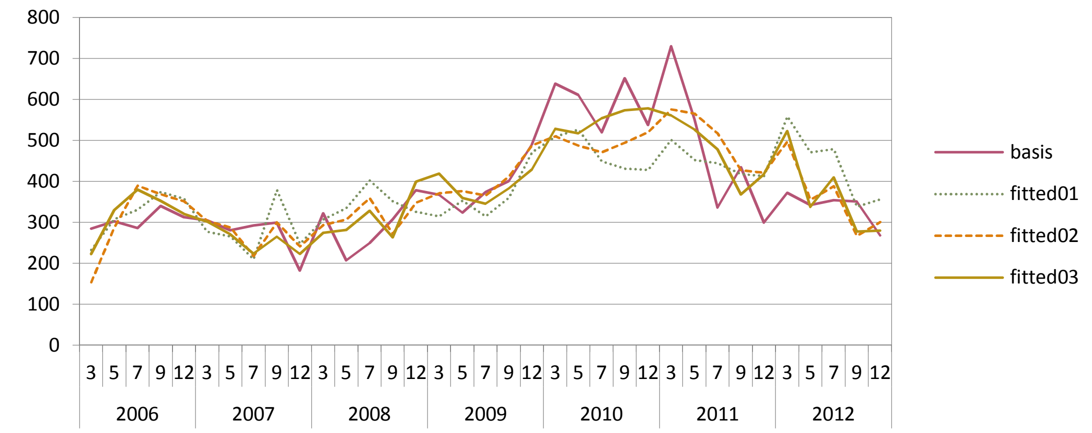
	Model 1			**Model 2**			**Model 3**		
basis	coeff.	s.d.	part. r^2	coeff.	s.d.	part. r^2	coeff.	s.d.	part. r^2
constant	39.6368	238.9	0.0009	224.213	481.5	0.0080	3257.87***	758.2	0.4152
index	24.8985***	8.169	0.2365	25.7324***	7.172	0.3229	35.973***	7.524	0.4679
ncom_sp	1.57133	6.273	0.0021	6.98208	5.691	0.0528	7.99079	5.151	0.0847
ncom-sp	-10.8339*	5.593	0.1112	-3.64360	6.103	0.0130	3.49614	6.123	0.0124
nrep	52.7369*	27.11	0.1120	24.2769	26.11	0.0310	14.0208	23.88	0.0131
stCost	-	-	-	-1403.20**	-2.21	0.1538	-1910.22***	602.6	0.2788
stToGr	-	-	-	16.3691**	6.033	0.2143	15.349***	5.459	0.2332
iceMilSt	-	-	-	-26.2380	21.92	0.0504	-22.4902	19.83	0.0471
exRate	-	-	-	-	-	-	1.51411**	0.5668	0.2153
Diagnost.	sigma RSS R^2 Adj.R^2 log-likelihood Joint test: F(4,30) AR 1-3: F(3,27) Normal: Chi^2(2) Hetero.: F(8,26)	107.169 321588.368 0.439111 0.360885 -198.37 5.80 [0.001] 4.82 [0.008] 0.60 [0.740] 2.37 [0.046]		sigma RSS R^2 Adj.R^2 log-likelihood Joint test: F(7,27) AR 1-3: F(3,24) Normal: Chi^2(2) Hetero.: F(14,20)	90.849 222845.667 0.620563 0.52219 -202.943 6.308 [0.000] 1.278 [0.304] 0.304 [0.859] 0.682 [0.766]		sigma RSS R^2 Adj.R^2 log-likelihood Joint test: F(8,26) AR 1-3: F(3,23) Normal: Chi^2(2) Hetero.: F(16,18)	82.0087 174861.008 0.702266 0.610655 -198.7 7.666 [0.000] 0.542 [0.658] 0.372 [0.830] 1.024 [0.477]	

Note: * indicating significance at 10% level, ** indicating significance at 5% level, and *** indicating significance at 1% level respectively.

In a second model, carry variables are included in addition to speculators' market weight. Storage costs (*stCost*) are highly significant and show an inverse relationship to the size of the basis. The finding confirms the theory of storage, which predicts that *ceteris paribus* the higher the storage cost, the larger the futures price relative to the cash price (stronger contango). The stock-to-grinding ratio (*stToGr*) shows a significant positive relationship to the market basis. This is puzzling, because, conventionally, the convenience yield should be negatively related to the ratio. However, the reverse sign in the context of non-convergence could be an indication of storage hoarding as outlined in Deaton and Laroque's (1992) model. If actors refuse to free speculative inventory for arbitrage trades, non-convergence can arise, resulting in a positive link between basis and stock-to-grinding ratio. This effect has been present in the cocoa market during the previously discussed market squeeze.

In a third model, the CFA Franc-USD exchange rate (*exRate*) is added in order to account for idiosyncratic factors of the particular cash market price. The exchange rate is significant and positively related to the market basis, which can either be due to a positive effect on the cash price or a negative effect on the futures price. This is because the higher the exchange rate the more expensive the domestic currency and the cheaper the product for imports. Both the exchange rate and the commodity futures price are forward looking (Chen, Rogoff and Rossi 2010). Hence, an explanation for the observed sign is that the futures price incorporates the information signalled by the exchange rate sooner than the cash price and hence decreases while the cash price remains unaffected in the short-run. The adjusted r-square is highest for the third model and residuals for the second and third model are spherical. Looking at the fitted values against the observed, the superior fit of the third model is evident (Figure 4.19).

Figure 4.19: Model 1–3 Observed and Fitted Basis at ICE Cocoa
(in USD per tonne)



Source: Author's calculation.

As previously for the wheat market, it is tested whether the significant effect of index traders is a result of a relative change in other trader's market weight. Models four and five include index traders' and commercial traders' market weight, respectively. The results for cocoa are concur with findings for the wheat market in that coefficients for both trader types are significant, however the model fit is better and partial r-square is higher for the model with index traders' market weight included (Table 4.13).

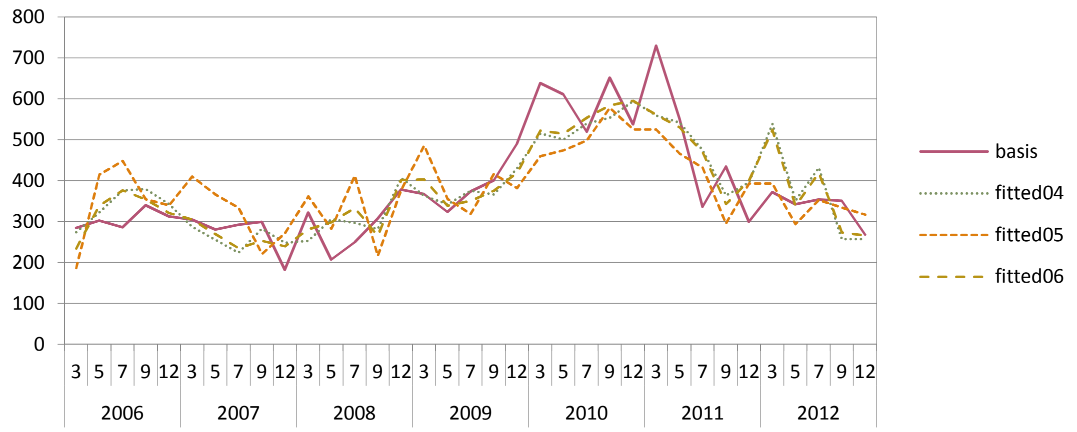
Table 4.13: Cocoa Regression Results and Residual Diagnostics for Model 4–6

	Model 4			Model 5			Model 6		
basis	coeff.	s.d.	part. r^2	coeff.	s.d.	part. r^2	coeff.	s.d.	part. r^2
constant	-196.765	357.3	0.0103	861.605*	492.0	0.0956	119.964	418.5	0.0029
com	-	-	-	-17.799***	4.544	0.3461	-6.15367	4.409	0.0650
index	39.2616***	6.086	0.5893	-	-	-	33.0704***	7.453	0.4129
stCost	-1655.7***	528.9	0.2526	-1782.38**	696.3	0.1843	-1873.58***	543.4	0.2980
stToGr	14.4763***	4.749	0.2427	21.413***	6.038	0.3025	16.2795***	4.848	0.2871
iceMilSt	-22.5945	18.99	0.0465	-13.1589	24.07	0.0102	-19.4593	18.83	0.0368
exRate	1.45531***	0.4977	0.2277	1.35223**	0.6516	0.1293	1.66897***	0.5131	0.2742
Diagnost.	sigma	81.172		sigma	102.432		sigma	79.8771	
	RSS	191077.791		RSS	304277.309		RSS	178649.732	
	R^2	0.674654		R^2	0.48191		R^2	0.695815	
	Adj.R^2	0.61856		Adj.R^2	0.392584		Adj.R^2	0.630632	
	log-likelihood	-200.252		log-likelihood	-208.394		log-likelihood	-199.075	
	Joint test: F(5,29)	12.03 [0.000]		Joint test: F(5,29)	5.395 [0.001]		Joint test: F(6,28)	10.67 [0.000]	
	AR 1-3: F(3,26)	1.021 [0.399]		AR 1-3: F(3,26)	1.759 [0.180]		AR 1-3: F(3,25)	0.638 [0.598]	
	Normal: Chi^2(2)	0.389 [0.823]		Normal: Chi^2(2)	1.019 [0.601]		Normal: Chi^2(2)	0.128 [0.938]	
	Hetero.: F(10,24)	2.353 [0.042]		Hetero.: F(10,24)	1.399 [0.240]		Hetero.: F(12,22)	1.538 [0.184]	

Note: * indicating significance at 10% level, ** indicating significance at 5% level, and *** indicating significance at 1% level respectively.

In a sixth model, both the relative market weight of index and commercial traders' is included. As for the wheat market, the commercial trader variable turns insignificant and the partial r-square for both, index and commercial traders' market weight decline, which indicates that these are not independent. The model fit of the sixth model specification is found best and fitted values are able to replicate most of the basis size at maturity for the observation period. While the first model under-predicts the extent of the basis between 2009 and 2011, model three with carry variables included yields a better fit. When accounting for idiosyncratic factors, by the addition of the exchange rate, the basis size at non-convergence is almost fully replicated (Figure 4.20).

Figure 4.20: Model 4–6 Observed and Fitted Basis at ICE Cocoa
(in USD per tonne)



Source: Author's calculation.

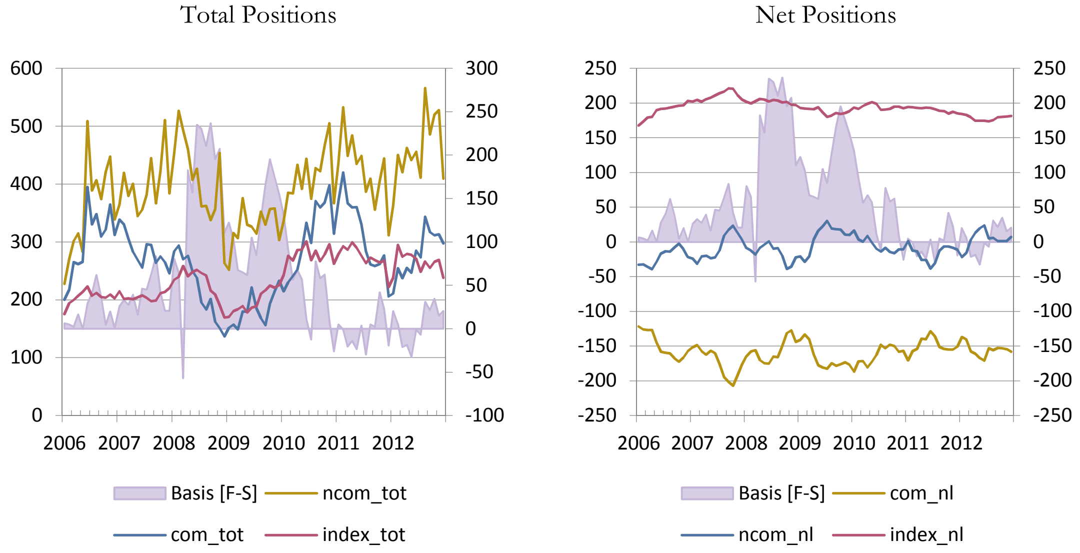
4.4.3.3 Comparison Wheat and Cocoa

Results for the cocoa market regarding the market weight of commercial and index traders are puzzling. While coefficients for wheat regarding traders' market weight yield signs in line with the hedging and index pressure hypotheses, signs are reversed for the cocoa market. The reason for this might be found by taking a closer look at traders' position taking in the two markets.

It is assumed that hedgers are not sensitive to the price level but to hedging effectiveness, while index traders are not sensitive to idiosyncratic market factor. With declining hedging effectiveness, the share of commercial traders is expected to decline, which means that the share of index traders would increase as a result of commercial hedgers reacting to convergence failure. This would mean that the higher the degree of non-convergence, the higher the share of index traders as they react to idiosyncratic anomalies with a lag (or not at all). Consequently, with the increasing share of index traders in the market, index pressure increases. If index traders' net positions exceed commercial hedgers net hedging demand, a positive price bias is introduced, which strengthens the market's contango and causes the basis to turn negative (or become even more negative). The coefficient for the wheat market suggests this relationship.

Looking at total and net positions by different trader types, these behavioural assumptions are confirmed for the wheat market. While net positions remain relatively stable, large swings are observable in total positions. All trader types significantly reduced their total positions over the time period of non-convergence. This is more pronounced for commercial and non-commercial traders than for index traders. As a result, the market weight of index traders increased (Figure 4.21).

Figure 4.21: Wheat Market Trader Positions
(basis in USD (right), positions in thousands(left), Jan. 2006–Dec. 2012)

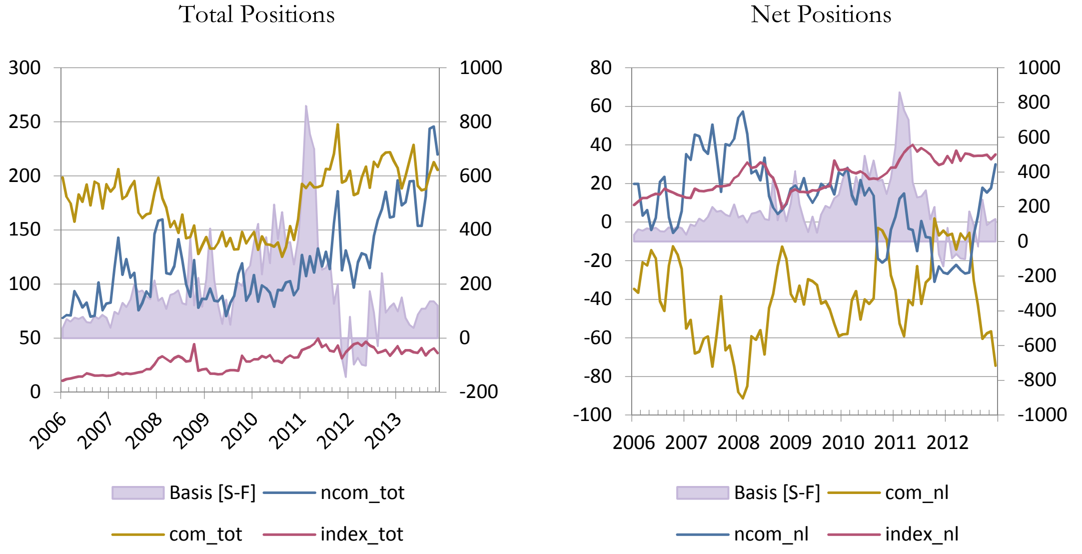


Source: Datastream, CFTC CIT.

For the cocoa market the case is different, since commercial traders did not close out their hedging position when non-convergence occurred. This is because commercial traders, who are mostly short in the futures market, gain from the mispricing between cash and futures prices in the particular case of the cocoa market. In the case of an overall price increase, a positive basis indicates that the futures price does not rise as much as the physical. Short hedgers hence gain on their futures position since the hedge does not fully offset the price rise. Further, if the price level drops, the futures price drops more than the cash market price and hence short hedgers again make a net gain. Therefore, short hedgers are incentivised to stay in the market and even over-hedge. This explains why commercial trader total positions were increasing during the period of non-convergence (Figure 4.22).

However, commercial net positions are not net-short the entire time period. The crisis in Cote d'Ivoire is probably one cause of this development. With traders predicting coming shortages, owners of the commodity are incentivised to under hedge, while consumers are motivated to over hedge. With commercial traders betting on increasing prices, they turn net-long just before the peak of non-convergence in early 2011. With hedgers being net-long, the hedging pressure hypothesis is inverted, which explains the negative sign for commercial traders in the cocoa market in contrast to the wheat market.

Figure 4.22: Cocoa Market Trader Positions
(basis in USD (right), positions in thousands(left), Jan. 2006–Dec. 2012)



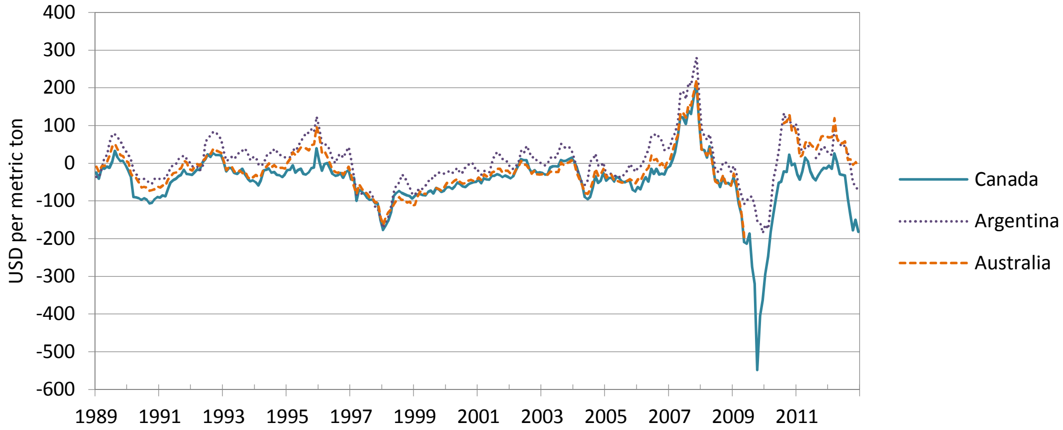
Source: Datastream, DFTC CIT.

The second puzzle for the cocoa maker is the significant positive sign of the coefficient on index trading. A possible explanation is the roll effect executed by index traders. Since the market shows a strong backwardation (and the whole futures curve is inverted) index traders earn roll yields when rolling over their positions. The prospect of a roll yield motivates index traders to roll their positions more frequently (possibly each maturity month). Index traders who close out their positions when a contract matures execute downward pressure on the contract they are in and hence increase the market basis even further (see Figure 2.4).

This explains why the futures price moved even further away from the cash price short before maturity (Figure 4.10). While index traders over the contract's life cycle execute no significant price pressure, since commercial traders fully cover index positions most of the time, they execute price pressure close to a contracts' maturity date, when the market gets thin.

Index traders in the wheat market execute significant price pressure over a contract's life cycle. They hence strengthen the market's contango and contribute to a continuously decreasing market basis. If limits to spatial arbitrage exist, as suggested by the literature and confirmed empirically, this results in a large negative basis which is carried over from one contract into the next. In contrast, the market weight of index traders in the cocoa market is marginal throughout a contract's life cycle but potentially significant at maturity. With those traders having an additional incentive to rollover their contracts frequently due to an inverted market regime, index traders execute downward price pressure on maturing contracts, further increasing a positive market basis shortly before maturity. In both cases, index traders contribute significantly to the absolute size of the market basis at maturity.

Figure 4.23: US Wheat Cash Prices minus Prices in Canada, Argentina, Australia (monthly, in USD per metric ton, May 1989–Apr. 2013)



Source: USDA.

For both markets, convergence was eventually restored. In the cocoa market, the market basis declined again in mid-2011, when expectations about future shortages due to the civil war in Cote d'Ivoire were revised as the harvest and exports remained almost stable and the situation slowly deescalated in late 2011. For the wheat market, convergence was reinforced with the introduction of the VSR. However, although convergence was restored, various complaints by market participants about inflated storage costs, which resulted in excessively high wheat cash prices, indicate that market order was still not fully achieved (Stebbins 2011). Indeed, after the introduction of the VSR, US soft red winter wheat prices increased rapidly relative to Canadian, Argentinean, and Australian prices (Figure 4.23). The extent to which the futures price was previously detached from the underlying cash price is revealed in suppressed cash prices after forced convergence.

4.5 Conclusion

Both wheat and cocoa markets were recently characterised by the excessive level and volatility of the market basis and prolonged periods of convergence failure. These phenomena have been theoretically linked to speculative investments, in particular investments by index traders. Empirical results suggest that index pressure has significantly altered the short- and long-run relationship between futures and cash markets. Further, the continuous relationship between futures and the underlying cash market price is found to have become increasingly volatile in recent years and several structural breaks have been identified. Concurrently, carry variables have lost explanatory power regarding the market basis and adjustment between cash and futures prices takes longer than in previous decades. These developments coincide with an increasing inflow of speculative liquidity into these markets.

While cogent arguments have been proposed by the literature about reasons for limits to arbitrage causing non-convergence, the extent of the basis at a contracts' maturity date has remained unexplained so far. This thesis builds on insights gained from the hedging pressure hypothesis, which inspires the development of the index pressure hypothesis. This way, the thesis is able to theoretically and empirically link the extent of non-convergence to the composition of hedgers and speculators in the respective markets. Presented evidence indicates that index traders have a positive price impact on futures prices over a contract's life cycle, while they execute negative price pressure on the maturing contracts when rolling over their positions. Since index traders are only active on the derivative but not the physical market, they significantly contribute to the extent of the market basis.

Findings suggest that speculative demand, and in particular index pressure, has not only altered the price level in futures markets, but also severely undermined hedging effectiveness in terms of basis size and basis volatility. This conclusion is supported by results presented in earlier studies regarding increasing hedging costs over recent years—e.g., Mallory, Liao-Etienne und Irwin (2011), Brunetti and Reiffen (2014). Consequently, these findings put into question both the price discovery and risk management function of futures markets. Last, but not least, the reaction of physical prices to the enforcement of arbitrage in the case of wheat suggests that the direction of causation at least partially runs from the futures to the cash market. This implies that speculative demand does potentially affect both futures and physical market prices.

Chapter 5 The Commodity Term Structure

5.1 Introduction

Intertemporal price relations in commodity futures markets are of immediate importance for price hedging, efficient inventory management and timing of production decisions. The term structure influences storage, production and other decisions made by consumers, producers and intermediaries in the commodity industry (Borovkova and Geman 2008). An understanding of the term structure is hence imperative for any actor in the physical commodity market.

In Chapter 2 existing theories of price formation on commodity futures markets have been critically reviewed in the light of bounded rationality, rational herding and Post-Keynesian theories. This Chapter 5 revisits the previous theoretical discussion in the context of intertemporal pricing in commodity futures markets. In accordance with the financialisation hypothesis it is argued that not only market fundamental factors, but also factors specific to the derivative market influence the term structure of commodity futures.

The ICE coffee and ICE cocoa markets serve as case studies, which provide an interesting comparison. Both crops have similarities in the production process with seasonality, which would be reflected in their term structure, while, as discussed in Chapter 3, trader composition in the two markets differs.

The introduction apart, Section 2 applies previously developed theories to intertemporal pricing in commodity futures markets and identifies factors which drive prices across different contracts. Section 3 provides graphical analyses of term structure behaviour in the cocoa and coffee markets over the last decade. Potential anomalies are identified and discussed in the context of preceding theoretical considerations. In Section 3 econometric analyses are presented. Firstly, individual calendar spreads are related to various factors identified as influential in the literature. Secondly, a two-step method is applied which links explanatory variables to the particular shape of the futures curve. Section 4 concludes by assessing the evidences and discussing implications for hedgers and speculators.

5.2 A Theory on Intertemporal Pricing

Two strands of theories are commonly referred to when explaining intertemporal price relations on commodity markets: (1) theories based on no-arbitrage conditions, and (2) theories based on informational efficiency. The theories of storage and risk premium belong to the first category and present two complementary approaches to explaining differences in commodity prices for a good acquired/sold at some future date at the exchange (futures price) and a good acquired/sold immediately in the physical market (cash price). Although these theories fall short of explicitly explaining price differences between different futures contracts with distinct maturity dates, the no-arbitrage conditions, on which those theories and progressions rest, are applicable to intertemporal pricing of derivatives as well (Lautier 2005)[72]. The second category of theories related to intertemporal pricing encompasses the efficient market hypothesis, which explains price differentials by differences in expectations regarding future market regimes. Futures prices are thought to be a reflection of what is expected to be the physical price at the expiration date of the respective futures (Geman and Sarfo 2012).

Intertemporal price relations at futures markets are commonly described by the term structure of the market. The term structure refers to a set of prices of futures contracts with different maturity dates. By plotting the set of prices at a particular point in time the futures curve is revealed, which can be understood as an instantaneous 'snap-shot' of contracts with different maturity dates (Borovkova 2010). If the price of the futures contract with longer time to maturity is higher than the price of a contract closer to maturity, the market is said to be normal. In the reverse case the market is said to be inverted[73]. Since at a single point in time several 'live' contracts are traded simultaneously, the futures curve is not one straight line and indeed the slope coefficient of the curve in different segments does not necessarily show the same sign.

Figure 5.1: Stylized Futures Curve Patterns

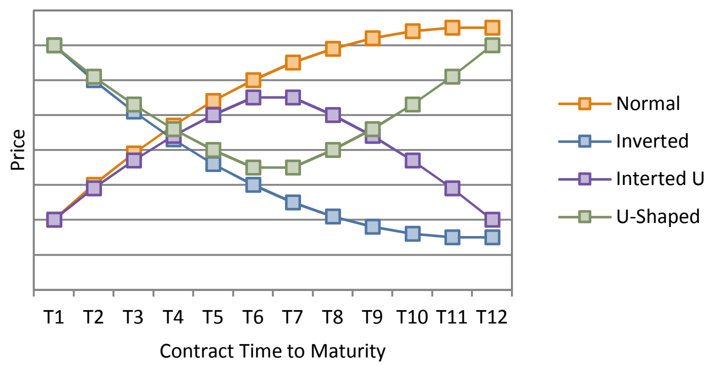


Figure 5.1 distinguishes between four stylized patterns that are frequently observed: normal, inverted, inverted U and U-shaped. The X-axis provides the different maturity

[72] Many empirical approaches to testing the validity of these two hypotheses approximated the spot price with the closest to delivery futures price due to liquidity concerns regarding the underlying physical market. Hence, they implicitly analyse the price relationship between futures of different maturities.

[73] Note the crucial difference to contango and backwardation, which refer to intertemporal pricing between cash and futures prices.

months, while the Y-axis indicates the price. Each node refers to one single contract with a particular maturity date T1, T2 …, T12 and a price.

The simple arbitrage relationship between cash and futures markets, as discussed in Chapters 2 and 4, links the price differential between the two markets to certain properties which distinguish the physical commodity from the futures contract prior to its maturity. If considering the intertemporal price relation between different futures contracts instead of futures and cash prices, the influences of properties like storage costs and interest rate do not decay when a contract approaches maturity. This is an important difference between futures-cash and futures–futures relations. Since the delivery date for the cash price is always the current date, the distance between the future's delivery and the cash position declines continuously with time. The relative time factor, which drives the decline in storage and interest rate in the futures–cash relation, is static in the futures–futures relation, because the distance between the contracts' delivery dates does not decay as time elapses. This is not to say that those factors are invariant through time, but that they do not necessarily decrease proportionally with time.

A more formal way of looking at this is by considering Equation 2.1 for two futures contracts with distinct maturity dates T_1 and T_2 (with $T_2 > T_1$). If solving for the cash market price, the two equations can be set equal which, after rearrangement, yields:

$$F_{t,T_2} = F_{t,T_1} + S_t i_{t,\tau} + w_{t,\tau} \tag{5.1}$$

with τ being the time difference between the two maturity dates[74], $w_{t,\tau}$ being equal to the storage costs incurred by holding the physical product over the duration of τ, and $S_t i_{t,\tau}$ being the interest paid over the same time period. This simple no-arbitrage condition has been amended in the theory of storage and the theory of normal backwardation by a convenience yield and risk premium discussed in Chapter 2.

Since the convenience yield is derived from considerations about the relationship between the physical product and the derivative, it becomes questionable whether this concept is applicable to pricing of derivatives. In theory, a convenience yield accrues to the owner of the physical commodity due to the commodity's use value, which a derivative instrument clearly lacks. Nevertheless, the concept is still applicable if physical delivery is possible. While the futures positions can be liquidated against money any time, it can only be exchanged against the physical goods at a certain point in time which is the contract's

[74] This is $\tau = \tau_2 - \tau_1 = (T_2 - t) - (T_1 - t) = T_2 - T_1$.

maturity date. This means, the contract that matures at an earlier date has a convenience yield earlier than a contract with a later maturity date. Hence, the convenience yield in the intertemporal price relation between derivatives should depend on the distance between those two maturity dates (and as usual the demand for, and supply of, inventory).

In contrast to the convenience yield, the concepts of risk premium are not linked to the physical properties of the commodity and hence directly transferable to intertemporal derivative-pricing. However, various competing interpretations have been identified in the literature, which yield different implications for term structure dynamics. If the risk premium is linked to the own price variance (idiosyncratic risk) or market covariance (systematic risk), the risk premium should vary with the variance and market covariance across contracts. The own price variance, following Samuelson (1965), should be higher for contracts closer to maturity compared to deferred contracts. The market covariance should depend on the correlation of each contract with wider market dynamics. If the conjecture that index traders and other non-commercial traders increase co-movements between commodities and stock markets is true—see Tang und Xiong (2012), Juvenal und Petrella (2011)—the risk premium should be higher for those contracts where a larger number of these traders are active. If, however, the risk premium is understood as suggested by the hedging and index pressure theories, the premium should vary with the relative market weight of hedgers and index traders across the futures curve. Again, implications differ from the cash–futures relationships, where hedging and index pressure can only affect futures prices. For the futures curve each element of the intertemporal price equation is affected and the effect depends on the different traders' relative market weight in each particular contract.

Recalling the simple no-arbitrage condition in Equation 5.1, the concepts of convenience yield and risk premium can be incorporated.

$$F_{t,T_2} = F_{t,T_1} + S_t i_{t,\tau} + w_{t,\tau} - y_{t,\tau} - r_{t,\tau} \tag{5.2}$$

with $y_{t,\tau}$ being the convenience yield gained over the time period τ. The variable $r_{t,\tau}$ resembles the risk premium which can take on different manifestations. More generally, let t be the current point in time, T_i the point in time at which the i^{th} contract matures, T_j the point in time at which the j^{th} contract matures with $j<i$, and τ_i the time span between the maturities of the two contracts $T_i - T_j$, then:

$$F_{t,T_i} = F_{t,T_j} + S_t i_{t,\tau_i} + w_{t,\tau_i} - y_{t,\tau_i} - r_{t,\tau_i} \tag{5.3}$$

From this one can derive the slope coefficients for any two consecutive contracts:

$$m_{t,i} = \frac{F_{t,T_i} - F_{t,T_j}}{T_i - T_j} = \frac{1}{\tau_i}(S_t i_{t,\tau_i} + w_{t,\tau_i} - y_{t,\tau_i} - r_{t,\tau_i}) \tag{5.4}$$

Equation 5.4 describes the slope coefficient of a straight line connecting two adjunct nodes (as in Figure 5.1)—this is, the relationship between two contracts with consecutive maturity dates at time *t*. If storage costs, risk-free rate, convenience yield, and risk premium are assumed constant through time[75], one can rewrite so that:

$$m_t = S_t i_t + w_t - y_t - r_t \tag{5.5}$$

With the above representation, the slope coefficient is steeper, the smaller the convenience yield and the risk premium and the larger are the storage cost and risk-free interest rate. With a relatively high convenience yield and/or high risk premium the slope is flatter or negative. Extending this exercise over all pairs of consecutive futures contracts would then yield the observed shape of the futures curve at any particular point in time:

$$f_t(T_i) = S_t + m_t T_i \tag{5.6}$$

However, if, and only if, storage cost, interest rate, convenience yield, and risk premium are assumed constant through time—that is, for example, at time *t* convenience yield for T_2 is expected to be the same as for T_1—the above Equation 5.6 holds. If this is not the case, which is a more realistic scenario, the slope coefficient does not only vary with time, but also with the segment of the futures curve, i.e., with *i*, so that:

$$f_t(T_i) = S_t + m_t(i) T_i \tag{5.7}$$

The futures curve is hence not restricted to be linear, but can take on various functional forms and shapes. Recalling Equation 5.4, we can identify different factors behind the particular shape of the futures curve, i.e., the slope coefficient in particular segments. Those factors vary with time *t* and segment *i*. A change not in the slope but the intersect coefficient in Equation 5.7 occurs only if the price at zero time-to-maturity, i.e., the spot

[75] So that: $w_{t,\tau_i} = \tau_i w_t$, $S_t i_{t,\tau_i} = \tau_i S_t i_t$, $y_{t,\tau_i} = \tau_i y_t$, and $r_{t,\tau_i} = \tau_i r_t$.

price[76] [S_t], changes. A change in the overall slope of the futures curve occurs if there are even changes in expected interest rate, storage costs, convenience yield, or risk premium across all contracts. That is the slope coefficient for each pair of contract is transformed linearly. A change in the curvature of the futures curve occurs if factors determining the slope coefficient change unevenly across contracts, that is, differ with *i*.

While interest rate, storage cost and convenience yield are subject to traders' expectations, the risk premium is linked to contract-specific variation, correlation and relative trader-positions. Hence on the one hand, the shape of the futures curve reflects participants' perceptions of market fundamentals and anticipated price trends (Borovkova 2010). On the other hand, it reflects trader-positions and contract-specific idiosyncratic and systemic risk. Factors that are hypothesised to drive the risk premium, although derived from competing theories, are not necessarily independent. Following the excessive co-movement hypothesis, index traders are identified as one of the potential drivers of systemic risk, while speculation in general is theoretically linked to excessive volatility and hence idiosyncratic risk.

Along similar lines, Gabillon (1995) combines information efficiency with heterogeneous agents and market microstructure theories in his commodity futures curve analysis. He assumes that the first segment of the crude oil futures curve is populated by hedgers, while the second segment is populated by financial investors. Since the two trader types are driven by different investment motives, he argues that the first part of the futures curve is driven by changes in inventories and supply and demand shocks in the physical market (fundamentals), while the latter part is driven by changes in the interest rate, anticipated inflation and prices for substitutes among the energy commodities (speculative demand). Lautier (2005) seems to support Gabillon's (1995) idea and argues that in order to extend the logic of intertemporal pricing beyond the bivariate relationship between consecutive futures contracts, one has to treat each individual contract as a single market. She consequently links the price differential between contracts to the relative supply and demand for each individual contract. According to her, the presence of wave forms—the simultaneous presence of a normal and inverted market along the curve—can then be explained by a surplus in the supply or demand of particular futures contracts (Lautier 2005)[77].

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[76] The spot price is here understood as the commodity price at the futures market for immediate delivery which is only observable at the contracts' maturity dates.
[77] Working (1934) was probably the first to discuss this possibility, although arguing vehemently against it.

In the following analysis the hypothesised drivers of commodity futures curves shall be tested by taking the two commodities, coffee and cocoa, with maturities in March, May, July, September and December as case studies.

5.3 The Term Structure of Cocoa and Coffee

Over the last decade, the term structures of cocoa and coffee markets have shown some salient features, which are difficult to explain by conventional theories. Figure 5.2 depicts the continuous spread between the maturing and next-to-maturity contract. According to the theory of storage, the spread is expected to exhibit cyclical behaviour reflecting market adjustment processes over seasonal fluctuations in inventories.

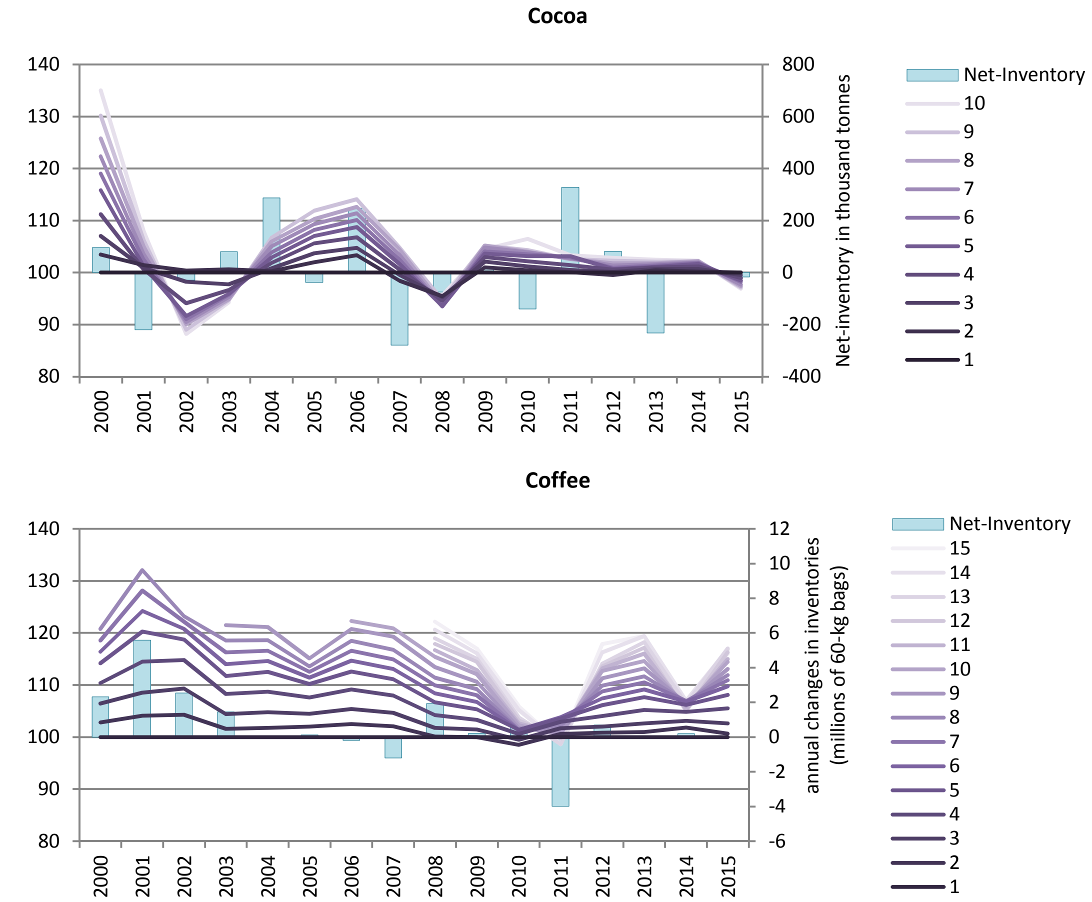
Figure 5.2: Continuous Calendar Spread
(continuous daily 2-to-1 spread and centred moving average, Jan. 2000–Dec. 2013)

Source: Datastream (author's calculation).

For both crops seasonal patterns are clearly visible. While coffee shows annual seasonality, the cocoa spread additionally reflects larger growing cycles over five to six years. These adjustment cycles cause the cocoa market to oscillate between normal and inverted market regimes. In the coffee futures exchange a normal market regime prevails, hinting towards more stable production cycles. However, the calendar spreads in both markets severely misbehave, since 2007 for cocoa and 2009 for coffee. Seasonal cycles are interrupted and flattened out while the size and volatility of the spread reaches exceptional levels, especially for the more tranquil coffee market.

Despite these anomalies, the term structures of both markets appear to retain their links to market fundamentals (inventories) throughout the time period. The bars in Figure 5.3 reflect net-inventory, whereby the lines indicate the price level of simultaneously traded contracts, ordered by their maturity dates—with 1 being the maturing and 10 the most deferred contract. Observations are shown as of each May contract's maturity date. All simultaneously traded contracts are normalised by the maturing May contract.

Figure 5.3: Term Structure and Change in Inventory
(at each May contract's maturity, May=100, normalised prices on left scale, 2000–2015)



Source: Cocoa inventory obtained from ICCO, Quarterly Bulletin of Cocoa Statistics, World Cocoa Bean Production, Net-inventory: current net world crop (gross crop adjusted for loss in weight) minus grinding, several volumes (2015 crop is ICCO forecast in Vol. XLI No.1); coffee inventory obtained from ICO, 2012, Net-inventory: Annual change of inventories at the end of December: Importing country in 60-kg bags; cocoa and coffee futures prices obtained from Datastream (author's calculation).

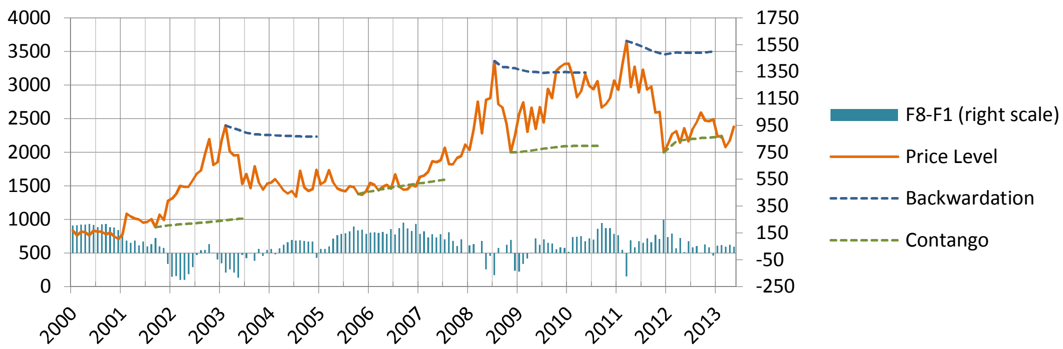
The graphics indicate that an inverted market occurs with tightening conditions in the physical market. This is expected since the convenience yield is negatively related to changes in inventories. For the cocoa market this effect is visible in 2002, 2007–08 and

2015 when inventories depleted. The coffee market is predominantly normal with the exception of 2010 when net-inventory decreased and the market became inverted. Recalling Figure 5.2, the depletion of inventories coincides with volatile calendar spreads.

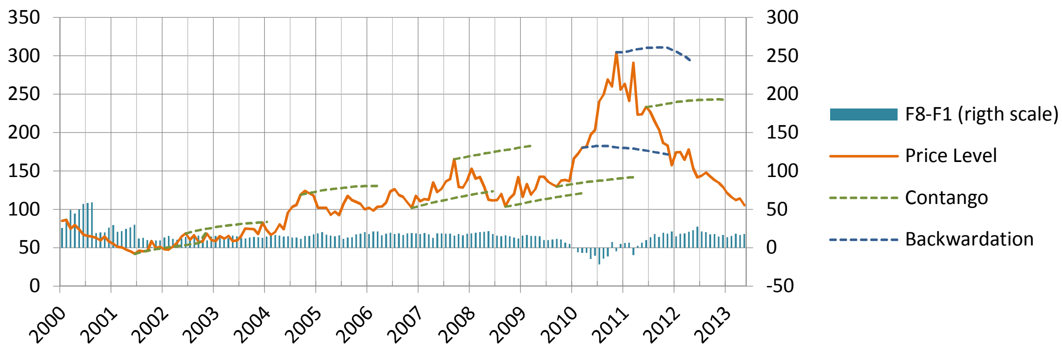
Another way of graphically analysing the term structure of commodity markets is borrowed from Parsons (2010). Figure 5.4 depicts the price level, calendar spread between the deferred (F8) and maturing (F1) contract and futures curves in a single graphic. Each observation of the futures curve T_i at t_0 is paired with the respective future point in time t_i. For the cocoa market the futures curve appears to rightly predict the direction of price changes, however, underestimates its extent. Adjustments take place over the entire futures curve and the shape of the curve is flexibly shifting between normal and inverted market regimes. For the coffee market not much variation in the futures curve is observed until 2010 when a shortage arises. Although the market switches to inverted, as predicted by theory, the futures curve loses its predictive power as it wrongly indicates falling prices in early 2010 and rising prices in mid-2011.

Figure 5.4: Monthly Price Level, Futures Curve, and Intertemporal Spread
(price level in USD left scale, Jan. 2000–Apr. 2014)

Cocoa



Coffee



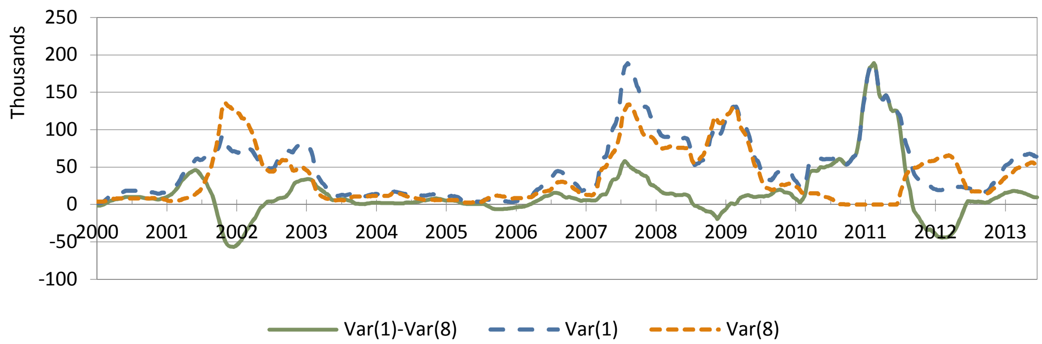
Source: Datastream (author's calculation)

Not only the shape of the futures curve but also the variance is of interest. According to Samuelson (1965), the closer a contract is to its maturity date, the more volatile it should be due to market adjustment effects. This is relevant with regards to Kaldor's (1939) risk premium hypothesis. If there are differences in the variance of simultaneously traded contracts these should result in differences in the risk premium and hence contribute to dynamics in the futures curve.

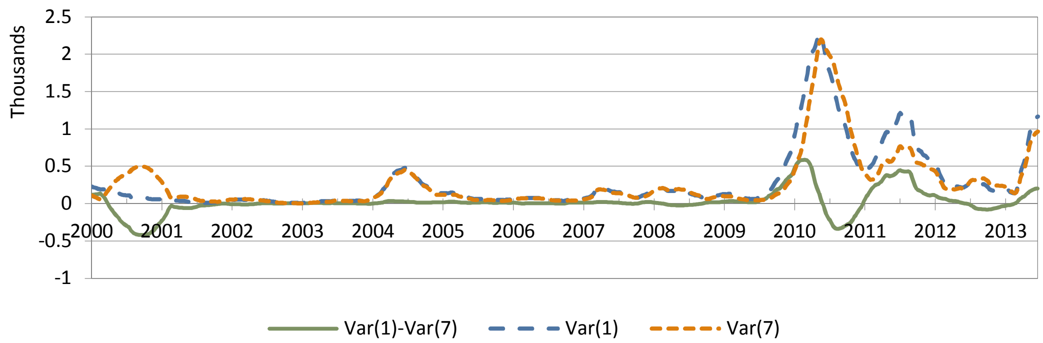
For the cocoa market, as visualised in Figure 5.5, the closest to maturity contract (Var(1)) shows a higher or similarly high volatility compared to the deferred contract (Var(8)) in most times. However, inventory depletion appears to trigger high volatility in the maturing contracts first and in the deferred contracts with a lag, leading to a wave-shape of the volatility difference series in 2002, 2009, and 2012. Further, during the time period 2010 to mid-2011 the volatility in the maturing contract by far exceeds volatility in the deferred contract. This can be linked to convergence failure and potentially abrupt adjustment mechanisms at maturity as discussed in Chapter 4.

Figure 5.5: Difference in Volatility of Next-to-maturity and Deferred Contracts (Var(1)-Var(7/8), 12-month daily centered moving variance, Jan. 2000–Apr. 2014)

Cocoa



Coffee



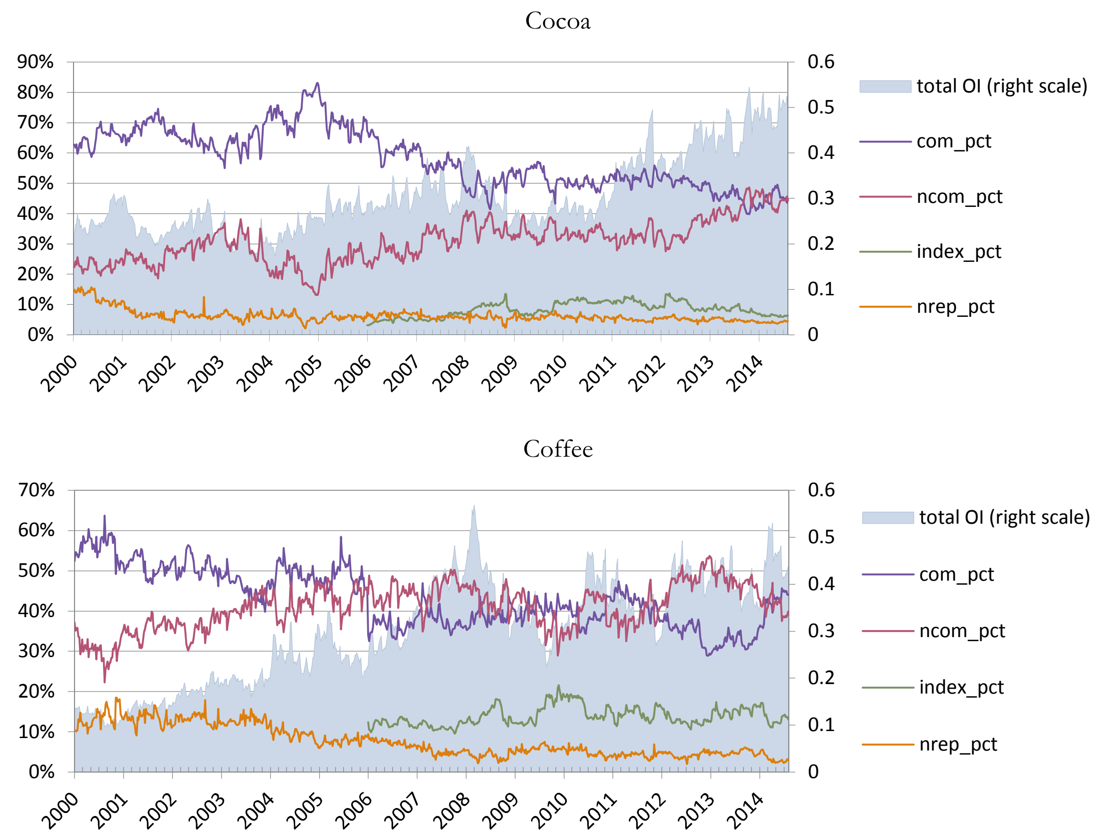
Source: Datastream (author's calculation).

For the coffee market the difference in variance in mid-2000 is puzzling since it is only associated with a decline in the growth rate of inventories but not a decline in net-inventories. Only in 2004–06 inventories shrank, which is associated with volatility in both, the longer- and shorter-dated contract. An even greater decline in inventories took place in

2010. As for cocoa, price adjustments go through the maturing contracts first and affect the deferred contracts with a time lag, which results in a wave shape.

Lautier (2005) suggests that the price of individual futures contracts contributing to the futures curve is determined by the relative demand and supply of traders. Since this demand and supply is motivated by traders' expectations, those expectations should be reflected in the relative price of each contract. According to the financialisation hypothesis, different traders follow different expectations/trading strategies, which are linked to market-specific fundamentals or, alternatively, factors unrelated to the particular market. The effect of different traders on the market term structure is however difficult to determine since disaggregated open interest by trader type is only available as aggregate positions across contracts, but not for individual contracts (see Chapter 3).

Figure 5.6: Percentage Share Trader Type and Total OI
(total OI right scale in million contracts, Jan. 2000–Jun. 2014)



Source: CFTC COT and CIT supplement.

In Figure 5.6 the COT data set is used until December 2005 and the CIT supplement since January 2006. Especially for the coffee market the combination of the two data sets becomes visible in the abrupt drop of the commercial traders' market share in January 2006. While open interest in both markets is similar, index traders' and non-commercial traders' market share is higher for the coffee market than for the cocoa market. Further, while for coffee most open interest is located in the near to maturity contracts, for cocoa a considerable amount of open interest is in deferred contracts, which is probably due to the higher share of commercial hedgers in the market (see Figure 3.7).

5.4 Term Structure Anomalies

Although most term structure models have been developed with reference to the interest rate yield curve (Nelson and Siegel 1987; Litterman and Scheinkman 1991; Diebold and Li 2006), some of these approaches have been adapted to commodity markets. Especially for energy commodity markets a rich literature on term structure forecasts and modelling has evolved (Blanco and Stefiszyn 2002; Borovkova 2010). In particular the oil market enjoys great popularity due to its economic significance, but also because oil futures contracts trade with long maturities so that an extended futures curve and its shape can be observed (Gabillon 1991; Parsons 2010).

Two approaches are commonly taken when analysing a market's terms structure. The first type, which is often referred to as 'state variable approach', is derived from structural no-arbitrage models, which impose equilibrium conditions between futures contracts of different maturities (Lin and Roberts 2006). Factors driving the evolution of the futures curve derived from the equilibrium equation, are then modelled by certain stochastic processes. Such models are deductive as they are based on assumptions about the stochastic properties and functional form of the state variables (or factors) which constitute the commodity futures curve. Various model specifications which differ in their choice of factors and stochastic properties have been proposed, including one factor models (Brennan and Schwartz 1985; Cortazar and Schwartz 1994), two factor models (Gabillon 1991; 1995), and three factor models (Schwartz 1997; Escobar, Hernández and Seco 2003; Geman and Sarfo 2012). Spot price, convenience yield, interest rate, long-term price, and in few cases seasonality (Frackler and Roberts 1999; Borovkova and Geman 2008; Borovkova 2010) are included as stochastic state variables and are modelled as geometric Brownian motions, Wiener processes, Monte-Carlo processes, mean reversion processes and alike (see Lautier (2005) for a more detailed review). Such models are predominantly concerned with pricing of complex derivative instruments and value-at-risk modelling. Applications for agricultural and soft commodity markets include Power and Turvey (2008), Richter and Sorensen (2002) and Geman and Sarfo (2012).

The second type of term structure models is based on some variation of factor or component analysis. Those models capture stylised features of the futures curve in a parsimonious way. Two prominent types can be distinguished which are non-parametric models like principal component analysis (PCA) and parametric models, as for example the factor model suggested by Nelson and Siegel (1987). Compared to state variable approaches, such models are more inductive since they seek to describe the futures curve, rather than impose stochastic properties on structural factors. In PCA common properties of historical price data resembling dominant shapes of the futures curve are extracted, while the Nelson-Siegel factor model pre-imposes stylised shapes and estimates the factor scores on a set of factor loadings.

PCA transforms a bunch of correlated time series into fewer uncorrelated components. Each component captures common variation patterns underlying the time series. As the components are produced by transformation, the original information is fully retained. In addition, the analysis provides information on the degree of communality in variation across the price series (Blanco and Stefiszyn 2002). In contrast to PCA, the model suggested by Nelson and Siegel (1987) presupposes a structure of the components and makes a-priori assumptions about the factor loadings. Factors are hence designed so that they satisfy certain structural properties which are regarded desirable (Dunteman 1984, 171).

Due to their more inductive nature, factors and components lack *a priori* economic meaning. Litterman and Scheinman (1991) were the first to assign different interpretations to the first three components extracted from the yield curve of fixed-income securities by PCA. They coined the terms 'level', 'steepness' and 'curvature' component for the three stylised shapes of the loadings commonly found for yield curves. These interpretations were widely adopted in the analytical literature and given different economic interpretations. Blanco and Stefiszyn (2002) assign changes in the level to changes in the overall price, and changes in the slope to changes in the convenience yield. Chantziara and Skiadopoulos (2008) link the slope component to changes in the term structure from normal to inverted markets and vice versa. They explicitly discard the fourth component as noise. Borovkova (2010) argues that for energy markets the level component is linked to changes in the global economy, the political situation and exploration techniques, while the slope component captures the expected long-term price or a change in the convenience yield. The third factor, according to her, is linked to volatilities of futures prices. Diebold and Li (2006) slightly reformulate the Nelson and Siegel (1987) model specification and show that the factor loadings can then be interpreted as level, slope and curvature in the tradition of Litterman and Scheinman (1991).

Since the purpose of the analysis at hand is to study the relationship between the shape of the futures curve and proposed factors that drive the futures curve, a method is needed, which captures the joint evolution of futures contracts. Both, PCA and the Nelson-Siegel factor model, provide methods to capture the latent factors of the futures curve in a parsimonious way that maximises the amount of information contained in the original data and reduces dimensionality. No-arbitrage models are less suitable since these impose restrictions, which might not hold in reality. If restrictions do not hold, i.e., the model is misspecified, the factors do not resemble the true dynamics of the futures curve (Afonso and Martins 2012), which renders any preceding empirical analysis meaningless.

Although there has emerged a vast empirical literature that investigates the relationship between commodity price levels and speculative investment (see Chapter2: Section 2.5), only a few consider the impact of speculative investment on a commodity market's term structure. For example, Coakley, Kellard and Tsvetanov (2013) take continuous time series of all simultaneously traded contracts into consideration when searching for bubble behaviour in oil futures. Karstanje, Wel and Dijk (2013) employ an extension of the Nelson-Siegel model in order to analyse the excessive co-movement hypothesis for level, slope and curvature factors in futures curves of different commodities. They find a significant increase in co-movement. Brunetti and Reiffen (2014) conduct a two-step regression analysis for soybeans, wheat and corn futures in order to test the impact of index traders' positions on the costs of hedging. Since they approximate the cost of hedging with calendar spreads, they implicitly test for the impact of index traders on the futures curve. Irwin, et al. (2011) also test for the impact of index traders on the calendar spread by event studies as well as Granger non-causality tests.

However, these existing empirical studies have several shortcomings. Irwin, et al. (2011) and Brunetti and Reiffen (2014) only take the first two contracts into consideration but not the futures curve as a whole. Coakley, Kellard and Tsvetanov (2015) analyse all traded contracts, however, not their relationship and hence not the futures curve. Karstanje, et al. (2013) takes the whole futures curve into consideration. However, they do not link the observed co-movement to speculative variables like traders' positions.

5.4.1 Data and Methodology

Previously, the slope coefficients between different nodes of the futures curve have been linked to various explanatory variables. However, some of these hypothesised driving factors, like risk premium and convenience yield, are latent while for others, like storage costs, data are unavailable. These factors have to be approximated. Following earlier deliberations, the convenience yield can be expressed as a function of current and expected inventory changes [$y_{t,i}(\Delta I_t, \mathrm{E}_t[\Delta \mathrm{I}_{T_1}])$]. Current inventory changes should affect the convenience yield evenly across the term structure, while expected inventories, especially for seasonal commodities, explain deviations in slope coefficients across the commodity term structure resulting in bump and wave shapes. Storage cost should be a function of the level of inventories, i.e., the demand for storage space [$w_t(\mathrm{I_t})$]. The risk premium can either be linked to the own price variation [$r_{t,i}(\sigma^2_{t,i})$], the market beta [$r_{t,i}(\beta_{t,i})$], or hedging and index pressure [$r_{t,i}(\sum D_{t,i})$]. Recalling Equations 5.4–5, a functional form of the slope of the futures curve for each pair of consecutive contracts can be derived.

$$m_{t,\tau} = S_t i_{t,\tau} + w_t(I_t) - y_{t,\tau}(\Delta I_t, E_{t,\tau}[\Delta I_{t,\tau}]) - r_{t,\tau}(\sum D_{t,\tau}, \beta_{t,\tau}, \sigma^2_{t,\tau}) \tag{5.8}$$

A regression analysis following the above specification could be run for every observable part of the futures curve, that is, the calendar spread between every two consecutive contracts. Although results give a good indication of the relevance of hypothesised driving factors for the different segments of the futures curve, such analysis misses taking the futures curve as a whole into consideration and hence its particular shape. In order to conduct a time series analysis on the term structure, methods have to be applied which capture a three-dimensional dynamic process—the term structure evolves through time-maturity-value space—into a two-dimensional time-value space only. Both PCA and the parametric factor model developed by Nelson and Siegel (1987) can be used for this purpose.

The advantage of the Nelson-Siegel model is that factors are easier to interpret. The disadvantage is that they are restrictive as they impose properties on the futures curve a-priori. Whether the pre-imposed factor loadings match observed dynamics has hence to be assessed before estimation. Further, extracted factors might be correlated and hence capture related dynamics. While components extracted by PCA are not subject to these shortcomings, component loadings are non-robust in the sense that those are sensitive to the particular sample under consideration. In the following, PCA will be used in order to assess the fit of the factor loadings imposed by the Nelson-Siegel model. After assessing the appropriateness of the Nelson-Sigel model for dynamics in the coffee and cocoa market, factors extracted will be used in an autoregressive model (AR) in a second step, which links suggested explanatory variables to the dynamics in the futures curve. A simpler regression analysis, which tests the significance of identified explanatory variables on individual calendar spreads, is conducted prior to the more complex factor model.

Although this has not been attempted for commodity markets in this precise form before, empirical papers analysing non-commodity futures markets have used a similar methodology. For example Diebold and Li (2006) employ a VAR model for their 'out of sample' forecast of future term structure dynamics. However, no exogenous variables are added. Alfonso and Martins (2012) use the Nelson-Siegel model to decompose the interest rate yield curve into latent factors and then link those to macroeconomic and fiscal policy variables in a VAR model.

In the cocoa and the coffee market, eight contracts are traded simultaneously—in later years more than eight. Price data for each contract are obtained from Thomson Reuters Datastream. Eight continuous time series are generated of the first- to eighth-closest contract to maturity. In order to generate continuous time series, contracts are rolled over into the contract with the next nearest maturity at the last trading day of the maturing contract. Thereby the term structure can be represented in matrix form. For a commodity with at minimum m simultaneously traded contracts [F] and a sample period which ranges from time period t_1 to t_n we would have the following ($m \times n$) matrix representation of the commodity term structure over the sample period:

$$X = \begin{bmatrix} F_{1,t1} & \cdots & F_{1,tn} \\ \vdots & \ddots & \vdots \\ F_{m,t1} & \cdots & F_{m,tn} \end{bmatrix} \tag{5.9}$$

Once the factors, resembling characteristic dynamics of the shape of the futures curve, are extracted, these are linked to explanatory variables as identified in Equation 5.8. We follow German and Sarfo (2012) and approximate the latent *spot price* with an average value of all futures contracts. The advantage of taking all contracts into consideration, rather than using the maturing contract, is that this quantity is void of seasonality and a robust estimator of the overall price level, i.e., the level of the futures curve. The *interest rate* is approximated with the US dollar LIBOR rate plus 200 basis points obtained from Thomson Reuters Datastream. The ICE Report Centre publishes end of month warehouse stocks available for coffee and cocoa, which serve as *inventory data*. An obvious shortcoming in taking only exchange-registered stocks into considerations is that these are residual stocks and hence might not be a reflection of actual supply and demand in the physical market. However, since speculative stocks serve as a buffer, which is depleted in times of shortages and is built up in times of abundance, changes in those should still be a reflection of productive inventories. Speculative stocks can reveal future shortages earlier since they are depleted for precautionary reasons in the wake of an expected squeeze. *Idiosyncratic risk* is measured by the three-year backward moving variance of the weighted average futures price. Weights are determined by the respective contract's share in total open interest. In order to capture differences in idiosyncratic risk across contracts, the difference in variance between the continuous series of the closest and the deferred contract is considered. *Systematic risk* is measured by the three-year backward moving covariance between the weighted average future price and the S&P500 index. Variations across contracts are again captured by the difference in covariance between the closer and the deferred contract.

In addition, explanatory variables capturing *speculative positions* are considered. Hedging pressure (D_{com}) and index pressure (D_{ix}) are specified as in Equation 4.4. An additional variable is designed to capture excessive speculation ($Ncom_{ex}$). Similar to Working's (1960) T-index, it measures the demand of non-commercial traders (non-commercial plus index CIT category), which is in excess of commercial traders' hedging demand. The measure is constructed as following with subscripts *s*, *l*, and *nl* indicating short, long, and net-long positions:

$$Ncom_{ex} = \begin{cases} \dfrac{ncom_s}{com_{nl}}, if\ com_{nl} > 0 \\ \dfrac{ncom_l}{|com_{nl}|}, if\ com_{nl} < 0 \\ 0, \qquad if\ com_{nl} = 0 \end{cases} \tag{5.10}$$

Since inventory data are only available as end of month data, the regression analyses are conducted in monthly frequency. For this, the observations of the last Thursday of each month are taken. If the date falls on a holiday, the previous weekday nearest to the Thursday's value is taken. Trader-position data, which includes index traders, are only available from January 2006 onwards. For this reason the analysis is restricted to the time period from January 2006 to May 2014.

5.4.2 Calendar Spread Analysis

The slope coefficient between each consecutive observable segment of the futures curve was linked to various explanatory variables specified in Equation 5.8. Although a relationship between single contracts does not permit capturing the dynamics of the futures curve as a whole, it provides insights into how factors correlate with particular segments of the curve. In the following, the continuous calendar spreads of the cocoa and coffee markets are regressed in an AR model on explanatory variables which are designed to capture cost of carry, convenience yield, risk premium and trader-positions.

The calendar spreads are defined as the difference between the logarithm of the price of the deferred contract and the logarithm of the price of the near contract. In order to reduce seasonality in the data, all variables are differenced annually. For both, cocoa and coffee markets, calendar spreads have been tested for unit-roots. For the cocoa market all spreads in levels are found stationary at the five per cent significance level. This is in contrast to the coffee market, for which most spreads are found non-stationary and integrated to the order one. This is probably caused by non-stationary carry and convenience yield variables (Appendix 5.1). Since including these carry and convenience yield variables in the regression could still yield stationary residuals, AR models for coffee are run in levels and residuals are tested for non-stationarity. Equation 5.8 is transformed into an AR regression specification so that:

$$m_{\tau,t} = \alpha_0 + \sum_{i=1}^{l} m_{\tau,t-i} + \sum_{j=1}^{k} \alpha_j X_{j,t} + \varepsilon_t \tag{5.11}$$

with $m_{\tau,t}$ being the calendar spread τ and $X = \{S_t i_t; I_t; \Delta I_t; \Delta I_{t-1}; \beta_t; \sigma_t^2; D_t\}$. The appropriate lag length l is determined by testing downwards from a maximum lag length of 12. Lags found insignificant are excluded until the optimal lag length is reached.

Table 5.1: Variable Overview and Expected Signs

Variable Name		Description	Sign
I	I_t	Level of inventory (then-thousand bags of cocoa, million bags of coffee).	+
DI	ΔI_t	Changes in level of inventory.	+
DI_1	ΔI_{t-1}	Last period's changes in level of inventory.	+/–
SLIBOR	$S_t i_t$	Spot price times USD LIBOR rate plus 200 basis points.	+
VAR	σ_t^2	Past three year variance of near contract divided by variance of the deferred.	–
COR	β_t	Past three year correlation S&P500 with near divided by correlation of deferred.	–
OI_WEIGHT	D_t	Past three year average OI of near contract divided by OI of deferred contract.	+/–
D_HEDGE	D_t	See specification Chapter 4.	+/–
D_INDEX	D_t	See specification Chapter 4.	+/–
NCOM_EX	D_t	See above.	+/–

Table 5.1 provides a summary of the variables included in the regression analysis, the respective definitions and expected signs. The trader-position variable is approximated by hedging pressure, index pressure and excess speculation. As an additional control variable the ratio between open interest figures in the two respective contracts is taken. The inclusion is useful since position data do not provide information on the particular contract in which the respective traders are active. For this reason the sign for the position data variable remains undetermined. Note that this is not the case for the two risk variables,

since these are estimated for individual contracts and the ratio of the values for the two contracts is taken.

Results for the cocoa market are summarised in Table 5.2. While the level of inventory shows a positive and significant relationship for near and medium term calendar spreads, changes in inventory are significant and negative for deferred spreads. This effect is probably linked to expected seasonality. The interest rate shows a negative relationship with the spread throughout, which is puzzling since higher opportunity costs should be associated with a larger spread. Risk variables are found to be significant with the predicted signs. While idiosyncratic risk is significant across spreads, systematic risk is only found significant for deferred spreads. This is similar to the impact of hedging pressure and excess speculative demand, which is significant for the same segments of the term structure than systematic risk. This finding supports the previous conjecture that risk variables and speculative positions are not independent. While index pressure is significant in the near and deferred ends of the futures curve, hedging pressure is found to be significant in the medium term, when also inventory variables are found significant. Hence, findings for the cocoa market suggest that medium term contracts are driven and dominated by hedgers, while near-to-maturity and deferred contracts are driven and dominated by speculators. This coincides with a greater dominance of market fundamentals in the medium term contracts and a greater dominance of financial risk variables in the maturing and deferred contracts.

Table 5.2: Results Cocoa Calendar Spread Model

		2-1	3-2	4-3	5-4	6-5	7-6^	8-7
Carry Variables	I	2.093***	1.920***	9.738***	1.389***	7.788***	0.270	0.587**
	DI	2.934	-0.917	7.054	-0.606	-4.276	-1.075**	-1.064*
	DI_1	0.190	-1.107	-7.328	-1.509**	-1.113**	-0.004	-1.654***
	SLIBOR	-0.005*	-0.006***	-0.003**	-0.002	-0.001	-0.001	-0.002**
Risk	VAR	-196.5*	-291.3***	-379.3***	-332.7***	-195.2***	-168.0**	-268.6***
	COR	4.885	-4.453	-4.990	-0.003	-2.191	-3.296***	5.896
Trader Positions	OI_W	69.20	-41.66**	-28.54	18.64	-0.285	-26.39**	-4.115
	COM_H	-0.034	-0.008	0.013	0.020**	0.014*	0.001	-0.009
	IND_H	0.150**	0.074***	0.039	0.001	-0.015	0.061**	0.058***
	NCOM_EX	-1.084	-0.087	-0.390	-0.076	-0.422	-0.956***	-0.576

Note: *** indicates significance at the 1 per cent level, ** indicates significance at the 5 per cent level and * indicates significance at the 10 per cent level. ^ White standard errors are used due to presence of heteroscedasticity.

The same regression specifications are run for the coffee market and reported in Table 5.3. Residuals are tested for unit roots and found stationary. Similar to cocoa, inventory variables are significant in the near and medium term coincidental with hedging pressure. Again, risk variables show the predicted sign and are significant for medium and deferred contracts. Speculative demand and index pressure is significant for deferred contracts for which market fundamental variables turn insignificant. Results, as before for cocoa, confirm the conjecture that hedging pressure is associated with the dominance of market fundamental variables, while index pressure and speculative demand is associated with the dominance of risk variables.

Table 5.3: Results Coffee Calendar Spread Model

		2-1	3-2	4-3	5-4^	6-5	7-6	8-7	9-8^
Carry Variables	I	6.80***	3.60***	1.40*	1.80**	2.85**	0.42	2.33	6.03
	DI	-0.20	-1.49	5.44	3.36	8.75	4.61	-1.98	-21.5
	DI_1	0.36***	4.58	-2.36	0.63	3.83	8.47	8.40	-1.62
	SLIBOR	3.12	12.2**	-2.246	-11.7	-11.6**	2.62	0.28	30.4
Risk	VAR	-0.17*	-0.00	-0.09***	-0.13***	-0.14***	-0.05	-0.04*	-0.18***
	COR	0.02	-0.00	0.00	-0.01	-0.01***	-0.00	0.00	-0.003*
Trader Positions	OI_W	-0.01	-0.01**	0.01	0.01	0.00	-0.01	0.00	0.01
	COM_H	-0.02	0.09**	0.06*	0.15***	0.14***	0.14***	0.08*	-0.05
	IND_H	0.19	0.04	0.10	0.02	0.11	0.19	0.22	1.00**
	NCOM_EX	0.00	-0.00	0.00	0.00	0.00	0.00	-0.00	-0.02**

Note: *** indicates significance at the 1 per cent level, ** indicates significance at the 5 per cent level and * indicates significance at the 10 per cent level. ^ White standard errors are reported due to presence of heteroscedasticity.

An obvious shortcoming of the presented analysis is that it only provides insight into contemporaneous correlation. Dynamics beyond autoregressive elements remain unconsidered. This is because of the low data frequency enforced by the availability of inventory data. Another shortcoming is that the particular signs of the trader-position variables are not interpretable. Despite these shortcomings, the significance of these variables provides evidence for the distribution of different trader types across contracts and their potential impact on particular segments of the futures curve.

5.4.3 Two-Step Futures Curve Analysis

The following analysis will adjust for some of the shortcoming of analysing individual spreads—although not for the low data frequency—and take the shape of the futures curve as a whole into consideration. In a first step, factors resembling the particular shape of the futures curve are extracted using the method developed by Nelson and Siegel (1987) and extended by Diebold and Li (2006). The underlying assumption is that the futures curve can be summarised by three particular shapes commonly found with PCA in yield curves, which are level, slope, and curvature. In order to test whether this assumption holds for cocoa and coffee futures markets, PCA is conducted first. In a second step, the factor scores are used in a regression model. Explanatory variables put forward previously are tested for their significance in explaining the scores and hence the evolution of particular shapes of the futures curves through time.

5.4.3.1 Principal Component Analysis

PCA is a nonparametric method to reduce the dimensionality of the data by linear transformation (Dunteman 1984, 156). Its purpose is to transform a set of correlated variables to an orthogonal set which reproduces the original variance-covariance structure or correlation matrix (Chantziara and Skiadopoulos 2008). For this to be achieved, the weights for the transformation are chosen such that the variance of the linear composite is at maximum, i.e., has the highest possible correlation with the original data. This process of maximising the variance is repeated until it is accounted for a chosen percentage of the original variation. Hence, after the first composite with maximum variance—i.e., the first principal component—is calculated, the second composite with maximum variance is calculated from the residual correlation matrix under the additional restriction that it is uncorrelated with the first principal component. This way, the different independent dimensions of the common variance in the data series are iteratively captured in the components (Dunteman 1984, 157-67). If the covariance matrix of the original variables is non-singular, this process can be iterated as many times as there are variables.

This way, components can be extracted out of the different simultaneously traded contracts. If the first component explains 100 per cent of the variation, the contracts are moving in lockstep. With perfect contemporaneous correlation across futures contracts the vector representing the time t change in the futures curve X_t as defined in Equation 5.9 can be expressed in terms of a single component (Barber and Copper 2012):

$$X_t = b_t U \tag{5.12}$$

With U being an *(mx1)* vector independent of time (direction of the shift) and b_t being a scalar changing over time (component of the shift in the direction U). This would correspond to the case outlined in Equation 5.6. If not all of the variation can be explained by one component, one could either add an error term as in Equation 5.13 or extent the number of extracted components as in Equation 5.14. With *m* maturities a maximum of *m* components would be required in order to capture the total variation.

$$X_t = b_t U + \varepsilon_t \tag{5.13}$$

$$X_t = \sum_{i=1}^{m} b_{it} U_i \tag{5.14}$$

Commonly the number of components is chosen so that *k* << *m*, but still a satisfactory degree of variation is explained, as in Equation 5.15 (Barber and Copper 2012).

$$X_t = \sum_{i=1}^{k} b_{it} U_i + \varepsilon_t \tag{5.15}$$

Various authors stress the importance to de-season the data before conducting PCA. Blanco and Stefiszyn (2002) suggest estimating components for each month individually so that 12 PCAs are conducted over the entire sample period. Borovkova (2010) suggests estimating the seasonal component and then subtracting it from the historical futures curve before conducting PCA. She defines the seasonal component as the long-term (over the entire sample) average price deviation from the daily level. However, Sclavounos and Ellefsen (2009) show on the example of oil and energy commodity markets that only the third principal component is affected by seasonality, while the first and second components are unaffected by seasonal patterns and are unchanged after de-seasoning the data.

Further, the applicability of PCA on non-stationary data is questioned, since components extracted could be spurious (Chantziara and Skiadopoulos 2008). This, however, is not the case if time series are co-integrated. Yang and Shahabi (2005) show that in the presence of a co-integrating vector, PCA analysis with variables in levels resembles the common variation in the underlying data better than PCA analysis based on variables in first differences. Hence, in order to proceed, a Johansen (1992) co-integration test is run on the simultaneously traded contracts for cocoa and coffee. Due to the sensitivity of the test to the choice of deterministic components (Ahking 2002), the test is run with and without a linear trend. The lag length is chosen by testing downward for single time series in an AR process starting from a lag length of 12. Continuous futures series are in logarithms. Results are reported in Table 5.4.

Table 5.4: Johansen Co-integration Test for Continuous Futures Prices

Cocoa (number of co-integration equations)				
Data Trend:	None	None	Linear	Linear
Test Type	No Intercept No Trend	Intercept No Trend	Intercept No Trend	Intercept Trend
Trace	5	4	5	4
Max-Eig	5	4	4	3
Coffee (number of co-integration equations)				
Data Trend:	None	None	Linear	Linear
Test Type	No Intercept No Trend	Intercept No Trend	Intercept No Trend	Intercept Trend
Trace	5	5	8	4
Max-Eig	4	4	4	3

Note: Critical values are based on MacKinnon, Haug, and Michelis (1999) at 5 per cent significance.

For both, cocoa and coffee, the Johansen tests identify several co-integrating relations. However, the number varies with the choice of the deterministic components and test-statistics used. With eight simultaneously trading contracts at most three to five co-integrating equations are found. The exception is the trace test with linear trend included, which detects at most eight co-integrating equations for coffee suggesting stationarity. Given the co-integration results we can conclude that there is at least one co-integrating relationship for the cocoa and coffee futures prices series. As discussed previously the co-integrating relationship is expected to break if the carry variables driving the calendar spread are non-stationary which explains the number of co-integrating vectors found.

Against the background of the previous discussion, PCA is conducted on the continuous price series of simultaneously traded contracts in logarithms and annual differences. By using annual differences, the price series are adjusted for seasonality in a less rigorous way than suggested by Borovkova (2010), using the last year's prices rather than the sample average. Since PCA is not used in the preceding regression analysis but only as a yardstick against which results from the factor model can be compared, this more simple way of de-seasoning should suffice.

For both, cocoa and coffee, the PCA shows that over 99.99 per cent of the common variation in the futures contracts is captured by the first four principal components. This corresponds to findings for other future markets (Lautier 2005). Table 5.5 shows the eigenvalues, percentage of variation and cumulative percentage of variance explained by all principal components. The high percentage captured by the first component is due to the non-stationarity of the data.

Table 5.5: Component Eigenvalues and Percentage of Variation Explained

	Cocoa			Coffee		
	Eigenvalues	% variation	% cumulative	Eigenvalues	%variation	%cumulative
PC1	7.982000	99.77	99.77	7.974000	99.68	99.68
PC2	0.015060	0.19	99.96	0.023490	0.29	99.97
PC3	0.002001	0.03	99.99	0.001036	0.01	99.99
PC4	0.000533	0.01	99.99	0.000603	0.01	99.99
PC5	0.000240	0.00	100.00	0.000262	0.00	100.00
PC6	0.000136	0.00	100.00	0.000072	0.00	100.00
PC7	0.000059	0.00	100.00	0.000051	0.00	100.00
PC8	0.000033	0.00	100.00	0.000032	0.00	100.00

The interpretation of the PCs is revealed by the correlation loadings that show how each component affects or 'loads on' each variable (Chantziara and Skiadopoulos 2008). This is made visible by the eigenvectors which reveal the dominant shapes of the term structure (see Appendix 5.4). For cocoa and coffee the most common variation is a straight line, which means contracts are shifting in parallel, in other words, the overall price level changes. Component loadings have the same sign and are of similar magnitude. This component is commonly interpreted as the level factor. The second component's eigenvector is monotonically increasing and can hence be interpreted as the slope component. The slope component resembles the steepness of the curve, that is, the relative distance between different contracts in terms of price. Component loading for the front months might be of different sign and magnitude than for the back of the curve. The third component's eigenvector reveals a U-shape which can be understood as the curvature of the futures curve. The last and barely significant eigenvector has a wave shape and shall in the following be referred to as the wave component. In the interpretation of the last component we differ from the literature which commonly discards the fourth component as noise. However, the fourth component is retained for comparability with the Nelson-Siegel procedure employed in the next sub-section.

Another way of understanding the loadings of the eigenvectors is in terms of the contribution of each component to the variation in each of the continuous futures contracts (Table 5.6). The first principal component for the cocoa and coffee market loads equally heavy on all contracts (absolute values are considered). The second component loads heavily on the contracts far up and far down the futures curve with reverse signs. The third factor loads positively on both early contracts and contracts further up the futures curve. The fourth factor shifts with relatively heavy loadings on the second, fifth, and eighth contract for cocoa and second and third, sixth and eighth contracts for coffee.

Table 5.6: Component Eigenvectors and Loadings

	Eigenvectors and Loadings for Cocoa				Eigenvectors and Loadings for Coffee			
	PC1	PC2	PC3	PC4	PC1	PC2	PC3	PC4
F1	-0.35	-0.67	0.62	-0.19	-0.35	-0.46	0.68	-0.37
F2	-0.35	-0.33	-0.30	0.54	-0.35	-0.38	0.03	0.41
F3	-0.35	-0.18	-0.38	0.22	-0.35	-0.27	-0.24	0.42
F4	-0.35	-0.03	-0.37	-0.23	-0.35	-0.13	-0.42	0.02
F5	-0.35	0.12	-0.22	-0.52	-0.35	0.04	-0.36	-0.38
F6	-0.35	0.25	0.04	-0.32	-0.35	0.21	-0.15	-0.47
F7	-0.35	0.37	0.24	0.07	-0.35	0.41	0.11	-0.01
F8	-0.35	0.45	0.37	0.44	-0.35	0.58	0.36	0.39

Althouth both markets reveal the characteristic futures curve shapes, as identified in the empirical literature, one difference between the two markets is that the slope component shows a convex form for the coffee market while it is concave for the cocoa market. Further, the wave component loads differently for the coffee market, and the curvature component loadings decay sooner and increase slower for cocoa than for coffee.

Once the eigenvectors are extracted, the matrix of the original data is multiplied with the transpose of the eigenvectors—i.e., components—that are of interest for the following analysis.

$$C = U' \times A \tag{5.16}$$

The transformation yields the features of the original data solely in terms of the vectors chosen (eigenvector one to four). Hence, four continuous time series (component scores) are generated which express the common variation in the originally eight continuous futures contracts in terms of level, slope, curvature, and wave component. The evolution of the scores over time is depicted in Appendix 5.5.

The first component scores reveal the common price level, i.e., the parallel shift of prices across all contracts. The second component scores reveal the slope across contracts, i.e., whether the term structure is normal or inverted. A positive value indicates an upward sloping term structure—that is, the contracts with longer maturities trade at a premium (normal). A negative value indicates a downward sloping term structure—that is, contracts with a shorter maturity trade at a premium (inverted). The third component scores, i.e., the curvature, reveal if there is a maximum or minimum in the futures curve. A positive value indicates a hump-shaped (concave) curve, while a negative value indicates a U-shaped (convex) curve. The values of the fourth component scores indicate the form of the wave. A positive value means the wave form is N-shaped (sinusoidal) and a negative value means the wave form is inverted N-shaped (cosinusoidal).

For the <u>cocoa market</u>, the level closely resembles the inverse of the overall price level (Figure 5.5.1). The component scores are negative as the axis is not the term structure but the eigenvector. The slope indicates an inverted market from mid-2007 to mid-2009, in early 2011 and again from early 2012 onwards. These periods are characterised by depleting or low inventories (Figure 5.3). The curvature shows a positive spike in mid-2008 which is probably due to price corrections after the price peak around that time. The time period from mid-2010 to early 2011 sows a continuously concave term structure. This period is associated with low inventory levels and incidences of convergence failure (cf. Chapter 4). In 2007 and late 2010 the futures curve sowed N-shaped wave forms which in early 2011 switched to in inverted N-shape. This incidence coincides with high volatility in front months (Figure 5.5).

The interpretation for the coffee market is similar to the cocoa market (Figure 5.5.2). The level closely resembles the inverse of the coffee price. With reference to the slope we can see that the coffee market became inverted in 2010 and returned to a normal market in 2011, which is closely linked to developments in inventories (Figure 5.3). The component scores for the slope are generally less volatile than for the cocoa market indicating more stable supply cycles as suggested earlier. Also the curvature scores are less volatile for coffee. Convex futures curves are identified in 2007-08, 2011, and 2014, coinciding with supply shortages (Figure 5.3). Further, the fourth wave component appears to capture seasonal patterns in the term structure, which appear regularly before 2010, but irregularly thereafter. This is also visible in Figure 5.2.

5.4.3.2 Nelson-Siegel Factor Method

An alternative method of reducing the dimensionality of the term structure is proposed by Nelson and Siegel (1987). On the basis of empirical descriptions of yield curves as monotonic, humped or S-shaped, they propose a function based on differential equations of yield curves, which are able to generate these typical shapes:

$$r(m) = \beta_0 + \beta_1(1 - e^{-\frac{m}{\varphi}})^{m/\tau} + \beta_2(e^{-\frac{m}{\varphi}}) \tag{5.17}$$

m is the maturity date and φ is a time constant that determines the rate at which the regressors decay to zero (Nelson and Siegel 1987). The beta coefficients are estimated date-by-date based on the forward rates of the contracts with different maturities and the respective exponential components. The particular shape of the yield curve at each point in time depends on the beta coefficients, which can be interpreted as measuring the strength of the short- [β_1], medium- [β_2], and long-term [β_0] components of the futures curve. With this parsimonious representation, Nelson and Siegel (1987) are able to reconstruct most of the historically observed shapes of the US T-bill with three time-varying parameters.

While the shape of the loading in the Nelson and Siegel (1987) model is determined ex-ante, the rate of decay of the loadings is decided by grid search so that the best fit is reached. Bliss (1997) adds flexibility to the model by introducing a second decay factor for the loading of the curvature component. Svensson (1994) adds a fourth curvature component to the original model which is given a different decay factor than the first curvature component loading. De Rezende and Ferreira (2013) analogue to Svensson's (1994) extension of the curvature component add a fifth factor which functions as an additional slope component with a distinct decay factor from the first slope component. Diebold and Li (2006) present an alternative specification of the Nelson and Siegel (1987) model, given in Equation 5.18, for which the three parameters can be interpreted as the latent level, slope and curvature factors in a similar manner as it has been done in PCA. This is particularly useful for comparability reasons and ease of interpretation.

$$R(\tau) = \beta_L + \beta_S\left(\frac{(1 - e^{-\lambda\tau})}{(\lambda\tau)}\right) + \beta_C\left(\frac{(1 - e^{-\lambda\tau})}{(\lambda\tau)} - e^{-\lambda\tau}\right) \tag{5.18}$$

Diebold and Li (2006) show that the first beta coefficient corresponds to the level component [β_L], the second to the slope component [β_S], and the third to the curvature component [β_C]. The λ value, similar to φ in Equation 5.17 governs the exponential decay rate. The factor loading for the level is assumed to be one. The factor loadings of slope and curvature vary with the number of month remaining until maturity [τ] and the decay rate [λ]. The loading for the slope factor is a function of τ that starts at one and decays monotonically to zero, while the loading for the curvature factor is a function of τ that starts at one, increases and then decays to zero. The value of λ determines at which month τ the curvature has its maximum.

The factor scores can be extracted from the term structure by firstly estimating the factor loadings for the slope $\left(\frac{(1-e^{-\lambda\tau})}{(\lambda\tau)}\right)$ and the curvature $\left(\frac{(1-e^{-\lambda\tau})}{(\lambda*\tau)} - e^{-\lambda\tau}\right)$ for each contracts' maturity at each point in time (for the level component this is always one) and secondly using OLS[78] estimation method in order to find values for β_L, β_S and β_C for each point in time. The OLS regression equation is specified as[79]:

$$R_t(\tau) = \beta_{t,L} + \beta_{t,S}S_\tau + \beta_{t,C}C_\tau + \varepsilon_t \tag{5.19}$$

As there are as many regression equations as observations per continuous time series, i.e., one regression result for each month for a monthly data set, the exercise yields a continuous monthly time series for β_L, β_S, and β_C.

Considering the strong seasonality in coffee and cocoa markets, level, slope and curvature factors might be insufficient for capturing seasonal patterns in the futures curve. For

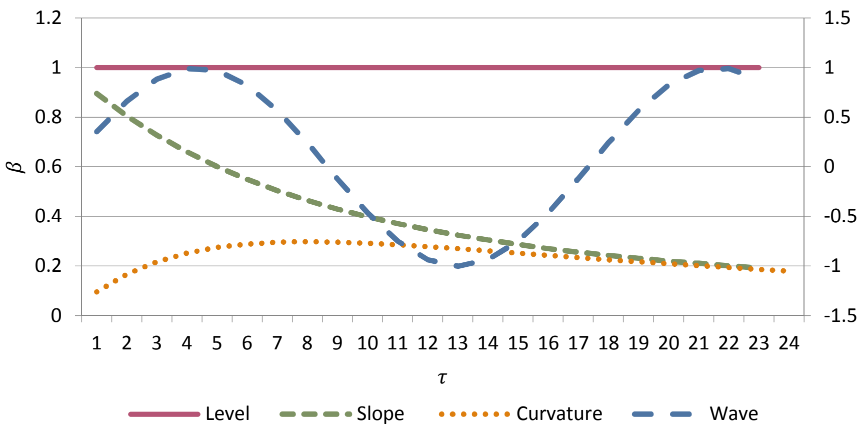
[78] Fixing λ allows estimation by OLS. Diebold and Li (2006) have shown that the loss of precision is marginal if λ is fixed and is hence determined by grid search, which eases estimation.
[79] In contrast to conventional notations, the β coefficients vary with time t while level, slope and factor loadings only vary with τ,

example, employing the Nelson-Siegel model on the cocoa market, the λ coefficient is fixed at 0.22416, which maximises the curvature factor loadings at the 8th month (see Appendix 5.6). This value is identified by grid search over the entire data set and found to yield the best fit on average. However, despite a good average fit, for some months the model is unable to capture the particular shape of the futures curve (Figure 5.6.1). When analysing the outlier dates, these mostly exhibit wave shapes, which cannot be captured by the three defined factors. Inspired by Power and Turvey (2008) a fourth sinusoidal wave component is added, which should increase the fit of the model:

$$R(\tau) = \beta_L + \beta_S\left(\frac{(1-e^{-\lambda*\tau})}{(\lambda*\tau)}\right) + \beta_C\left(\frac{(1-e^{-\lambda*\tau})}{(\lambda*\tau)} - e^{-\lambda*\tau}\right) + \beta_W(-\sin(\pi(-\lambda)\,\tau))) \tag{5.20}$$

While the other factors have the same properties as before, the sinusoidal element loads heavily on early and late months but less on medium-term months as it is shown in Figure 5.7.

Figure 5.7: Four Factor Nelson-Siegel Properties



Note: For this example λ is fixed at 0.163026, so that the curvature factor has its maximum at the 11th month. Source: Author.

The regression equation for each time period *t* then reads as following:

$$R_t(\tau) = \beta_{t,L} + \beta_{t,S}S_\tau + \beta_{t,C}C_\tau + \beta_{t,W}W_\tau + \varepsilon_t \tag{5.21}$$

For the <u>cocoa market</u>, as before, the grid search finds that $\lambda = 0.22416$ reveals the best fit. In comparison to the earlier specification, the fit of the model increases substantially at occasions where the futures curve takes on wave shapes. In Appendix 5.6 the improvement is demonstrated on the example of the March 2008 futures curve (Figure 5.6.2).

The beta coefficients (factor scores) evolve similarly to the principal components scores estimated previously, however, with reversed signs (Appendix 5.7, Figure 5.7.2). The level reflects the overall price trend, while the slope indicates whether the market is normal or inverted. A positive value indicates a downward sloping futures curve, i.e., the contracts with longer maturities trade at a discount (inverted), and a negative value indicates an upward sloping futures curve, i.e., contracts with shorter maturity trade at a discount (normal). A positive value for the curvature coefficient indicates a convex and a negative a concave curve. The wave component follows the same sign as the PCA wave component. A positive value signals an N-shaped futures curve and a negative value signals an inverted N-shaped curve.

As suggested, the level factor resembles the overall price level in the cocoa market. The market is inverted only in 2008–09 and briefly in 2010. These time periods are associated with declining inventory levels, and hence shortages in the physical market in line with the theory of storage. These findings roughly coincide with what was revealed by PCA, with the exception of early 2011, where PCA suggests an inverted market. The time periods 2008–10 and 2012 show a convex futures curve while in remaining time periods the futures curve appears to have been concave. The wave component oscillates with increasing amplitudes around zero from 2008 onward, while an increase in the volatility of the wave component extracted by PCA is only visible from 2010 onwards.

For the coffee market, grid search analysis finds that $\lambda = 0.199254$ yields the best fit, which means that the curvature has its maximum at the 9th month. Considering the coefficient of contingency, the fit of the four factor model appears even better for the coffee market than for the cocoa market (Appendix 5.7, Figure 5.7.3). However, between the years 2010 and 2012 the fit of the model—although excellent during the remaining time period—deteriorates slightly.

As for cocoa, the level factor closely resembles the overall price level. Further, according to the slope factor, the coffee market is only inverted over the time period mid-2010, which is slightly later than what PCA indicates. The inverted market coincides with a convex futures curve. These years are associated with a shortage in the physical market (Figure 5.3). However, an abrupt change of the curvature scores in mid-2008 and early 2011 is visible which is striking. This change is found again in both the slope and the wave factor, however, remains undetected by PCA.

5.4.3.3 Comparison between Nelson-Siegel and Principal Components

Despite the different methods, the factors and components extracted by the Nelson-Siegel model and PCA correspond closely for the cocoa market. Reviewing the correlation matrix of all scores, the close relationship between the level, slope, curvature and wave factors and the respective component scores is clearly visible (Figure 5.7).

Table 5.7: Correlation Matrix for Cocoa Component and Factor Scores

	L	S	C	W	PC1	PC2	PC3	PC4
L	1.00							
S	0.04	1.00						
C	-0.27	0.66	1.00					
W	0.35	-0.49	-0.84	1.00				
PC1	**-0.92**	-0.39	-0.06	-0.10	1.00			
PC2	0.16	**-0.60**	0.06	-0.09	0.00	1.00		
PC3	0.17	-0.28	**-0.45**	0.03	0.00	0.00	1.00	
PC4	-0.15	0.36	0.49	**-0.71**	0.00	0.00	0.00	1.00

The correlation matrix for the coffee market differs for the wave component from what is found for the cocoa market. The remaining three components correspond similarly well to the respective factors. Instead of correlating with the wave factor, the fourth component is strongly correlated with the level factor (Figure 5.8).

Table 5.8: Correlation Matrix for Cocoa Component and Factor Scores

	L	S	C	W	PC1	PC2	PC3	PC4
L	1.00							
S	-0.02	1.00						
C	-0.46	0.68	1.00					
W	0.74	0.10	-0.61	1.00				
PC1	**-0.89**	-0.41	0.05	**-0.61**	1.00			
PC2	0.26	**-0.69**	-0.24	-0.21	0.00	1.00		
PC3	0.16	-0.31	**-0.46**	0.09	0.00	0.00	1.00	
PC4	-0.07	0.06	0.20	-0.25	0.00	0.00	0.00	1.00

The missing correspondence between factors and components in the coffee market is also visible from autocorrelation functions (Appendix 5.8). For the cocoa market these behave similarly. The levels exhibit strong autocorrelation which only slowly decays. Autocorrelation for the slope component scores is slightly stronger than for the slope factor scores, but in both cases autocorrelation decays quicker than for the level. For the curvature, no autocorrelation is present, while for the wave, both component and factor scores show seasonality over four to six months periods (Figures 5.8.1–2).

For coffee this is where the strongest difference appears. While for the wave factor scores no seasonality is visible and the scores show great persistence, the wave component scores show no persistence. This means that wave forms, as picked up by the Nelson-Siegel factor scores, in the coffee futures curve might stem from factors other than seasonal patterns (Figures 5.8.3–4). These differences might be linked to abrupt changes in the coffee futures curve in mid-2008 and 2011, which are picked up by the factors but not by PCA. These shocks are puzzling and demand further investigation.

5.4.3.4 Empirical Results

Components and factors do not resemble the slope between consecutive contracts but common variation in simultaneously traded contracts. However, the previously derived relationship (Equations 5.8) still provides indication of which explanatory variables are expected to drive which components. The level captures the common underlying price trend. Dynamics in level scores should hence be linked to physical demand and supply and, following the financialisation hypothesis, traders' positions. Of greater interest regarding previously reviewed theoretical considerations are the slope and the curvature scores. Both capture dynamics, which affect the price level of simultaneously traded contracts differently, that is, they capture the different shapes of the futures curve. Firstly, differences can arise due to expectations about future developments in market fundamentals. These include differences in storage costs, interest rate and convenience yield. Secondly, differences can be caused by distinct trader-positions in certain contracts. If the differences in traders' positions arise due to expectations about market fundamentals, this would be equivalent to the first reasoning. If traders' positions are however motivated by factors unrelated to market fundamentals, as hypothesised, these become driving factors in their own right. Thirdly, risk premium, which is linked to idiosyncratic risk, systematic risk or hedging pressure, can affect individual futures contracts differently.

Before conducting regression analyses, all factor series are tested for unit-roots. Test results are reported in Appendix 5.9. For cocoa, all but the level factor scores, are found to be stationary. For the coffee market results differ in that all, but the slope factor scores, are found to be non-stationary and integrated to the order one. Given the presence of a unit root in one cocoa and all, but one, coffee factor, AR(i) models with the first difference of the factor scores as the dependent variable are run. The order i is determined by downward testing from a maximum lag length of 12. In the presence of heteroscedasticity in the residuals, White robust standard errors are used. In a second step, the same models are run in levels. Residuals for those regressions involving non-stationary factor scores are tested for a unit root using the ADF test procedure. For residuals of all regressions the null hypothesis of a unit root can be rejected at the one per cent significance level. Estimated values for cocoa are summarised in Table 5.9 and for coffee in Table 5.10. Full regression results and residual diagnostics are reported in Appendix 5.10 for cocoa and Appendix 5.11 for coffee.

A positive coefficient in the level regression means a higher value of the explanatory variable is associated with a higher price. A positive coefficient for the slope regression indicates that a higher value for the explanatory variable is associated with a (more) inverted market, and a lower value is associated with a (more) normal market. A positive coefficient in the curvature regression indicates an association with a more convex (higher at the tails and lower in the middle) futures curve while a negative coefficient indicates an association with a more concave (higher at the middle and lower at the tails) futures curve. For the wave regressions, a positive sign of a coefficient means that a higher value for the independent variable is associated with an N-shaped futures curve. A negative value indicates an association with an inverted N-shaped futures curve.

5.4.3.4.1 Results for Cocoa

Regression results for the cocoa market are reported in Table 5.9. As predicted by hedging pressure theories, the hedging pressure variable is found to be significantly negatively related to the price level.

Table 5.9: Futures Curve Factor Regression Results Cocoa

	First Difference				Levels			
	Level	Slope^	Curvature^	Wave^	Level	Slope^	Curvature^	Wave^
I	64.51	26.99	-32.92	-3.00	-13.50	-4.69	-36.85	-1.69
DI	-22.40	35.01	111.66	2.40	6.91	**71.44	96.48	-1.17
DI_1	7.57	0.86	20.34	0.46	41.51	8.27	-21.24	-0.49
SLIBOR	-0.47	-0.42	-0.12	-0.02	**-2.16	0.55	***-3.84	-0.06
VAR	-0.38	***6.37	5.15	0.25	-0.14	***1.70	***2.70	-0.01
COR	688.04	217.20	**-2013.9	-81.94	-249.945	***417.89	**-526.48	*-19.06
WEIGHT	0.10	-0.19	*9.46	0.40	**11.26	1.00	**11.67	*0.50
COM_H	***-4.90	**-2.34	-1.50	-0.08	***-3.54	-0.67	***-4.54	*-0.14
IND_H	-4.33	-3.32	2.14	0.33	-1.78	-1.61	*5.13	**0.36
NCOM_EX	2.40	***7.20	***-18.14	*-0.50	-7.60	2.57	-4.05	-0.17

Note: * indicates significance at the 10 per cent level, ** indicates significance at the 5 per cent level, *** indicates significance at the 1 per cent level. ^ White robust standard errors used.

Both, idiosyncratic and systematic, risk variables are significantly and positively related to the slope of the futures curve. This indicates that higher risk is associated with an inverted market, which is predicted by the theory of normal backwardation or risk premium. Current changes in inventories are also found to be significantly positively related to the slope factor. This is in contrast to the theory of storage, but, as for the calendar spread regression results, might be explained by seasonal cycles, which cause the cocoa market to oscillate between inverted and normal market regimes. Further, for the first difference equation, a significantly positive relationship is found between the slope of the futures curve and excess speculation. This means that speculative positions are associated with a more inverted market regime in the cocoa market. The negative association between the hedging pressure variable and the slope is puzzling, since hedging pressure should be associated with an inverted market or a weaker carry. The negative sign, although insignificant, for the index pressure variable indicates, as predicted, that index positions are associated with a larger carry or normal futures curve.

Importantly, results for the curvature give an indication of the allocation of index traders and hedgers across contracts. Hedging pressure is associated with a more concave futures curve—that is, loads more heavily on the medium term—and index pressure is associated with a more convex futures curve—that is, loads more heavily on the short- and long-term. This supports findings obtained in the previous section and supports assumptions made in Chapter 4 that while commercial traders dominate in the medium term (throughout a contract's life cycle), index traders have a particular price impact when they rollover (at the tails of the futures curve).

This is further confirmed by a significant and positive coefficient for index pressure in the wave factor regression, which suggests that index pressure is associated with an N-shaped futures curve. In other words index pressure is associated with a suppressed price level of maturing contracts and boosted price level of deferred contracts in line with Figure 2.4. Another interesting observation is that idiosyncratic risk is stronger for the medium-term contracts (positive coefficient in the curvature regression), while systematic risk is stronger for the near to maturity and deferred contracts (negative coefficient in the curvature regression), coinciding with what is found for hedging and index pressure respectively. The finding that index pressure coincides with increased market covariance supports the excessive co-movement hypothesis.

5.4.3.4.2 Results for Coffee

The same regression equations have been estimated for the coffee market and results are reported in Table 5.10. As for cocoa, hedging pressure is found to be significantly negatively related to the level, which is in line with the hedging pressure theory.

Surprisingly the slope factor is negatively associated with systematic risk which means higher risk is associated with a normal market. This is in contrast to the theory of risk premium and findings for the cocoa market. Findings regarding traders' positions, however, conform more closely to findings for the cocoa market. Hedging pressure is negatively related to the slope factor and is significantly and negatively related to the curvature, which means it is associated with a stronger weight on medium-term contracts. In contrast to the cocoa market case, index pressure and speculative demand variables remain insignificant throughout.

Table 5.10: Futures Curve Factor Regression Results Coffee								
	First Difference				Levels			
	Level^	Slope^	Curvature^	Wave^	Level^	Slope^	Curvature^	Wave^
I	-0.0101	*-0.0120	-0.0058	0.0079	*-0.0057	-0.0020	0.0026	-0.0001
DI	*0.0405	-0.0073	-0.0462	0.0667	0.0181	*-0.0259	-0.0345	0.0063
DI_1	-0.0077	0.0111	0.0741	*-0.0900	0.0007	0.0012	0.0539	-0.0087
SLIBOR	***14.6545	-2.7225	**-10.2570	0.8698	-1.0358	0.7701	1.6549	-0.1639
VAR	0.0623	0.0392	-0.0269	0.0285	*0.0385	-0.0010	-0.0167	0.0029
COR	99.5802	-120.8280	-45.1602	-19.3944	68.9598	**-59.5308	-75.7106	-2.8467
WEIGHT	**-0.3869	-0.0084	***1.4824	***-0.1307	-0.1619	0.0130	0.5382	-0.0296
COM_H	0.0495	***-0.3455	***-0.7940	0.0196	**-0.4867	-0.1348	-0.3608	-0.0215
IND_H	-0.3650	-0.2919	-0.2389	-0.0094	-0.5040	-0.1330	-0.2803	-0.0583
NCOM_EX	1.3817	2.4652	4.1653	0.1714	0.9043	-1.5898	1.9655	0.8270

Note: * indicates significance at the 10 per cent level, ** indicates significance at the 5 per cent level, *** indicates significance at the 1 per cent level. ^ White robust standard errors used.

At large, result for the coffee market remain less clear than for cocoa, while results for the cocoa market seem to support previous hypotheses on the positions of index and other speculative traders and their impact on the shape of the futures curve.

5.5 Conclusion

Against the evidence presented, it can be concluded that over recent years in both cocoa and coffee markets, the influence of fundamental factors has weakened. Further, futures contracts which are dominated by hedgers—mostly the medium-term contracts—tend to be driven by market fundamentals and those dominated by index traders—mostly the short- and long-term contracts—tend to be driven by risk variables. This is particularly pronounced for the cocoa market. However, not much can be said about the direction of causation since the data frequency is too low to determine a lag structure. This is caused by limitations stemming from the availability of inventory data. Reverse causality would mean that contracts, which are driven by fundamentals might attract hedgers, while those associated with risk are attractive to speculators. However, results presented in Chapter 3 reject this conjecture for index traders. Index traders are found to not react to market specific factors including idiosyncratic risk.

At the same time, the significance of index pressure at the tails of the futures curve strongly supports the conjecture that index traders' passive rollover of contracts has a significant price impact. It is likely that index pressure and other speculative positions have entered the term structure of futures markets especially through the tails. Short-dated contracts are known to serve a price discovery function for the physical market, while long-dated contracts provide guidance over storage level to market practitioners. Identified speculative influences are likely to undermine these core functions.

Chapter 6 Price Formation in Commodity Sectors

6.1 Introduction

Two major welfare enhancing functions are attributed to commodity futures markets: price discovery and risk management (Chang 1985). Evidence presented in the preceding two chapters suggests that these two critical functions have been undermined by structural changes in global commodity futures markets. These changes have ramifications not only for price discovery, but also for price risk exposure of commercial traders and, depending on the organisational structure of commodity trade, other stakeholders in the sector including commodity producers.

Considering asymmetric power relations, especially in agricultural commodity sectors, it is reasonable to assume that risks, and associated costs, are passed on to the weaker end of the sector (Kaplinsky 2004). This is presumably constituted by farmers in the case of smallholder crops like cocoa, which will serve as a case study in the following Chapter 7. In order to fully assess the impact of changes in commodity price dynamics at the futures market on smallholder producers and cocoa producing countries, it is essential to gain a better understanding (1) about the role of the futures market in the price formation mechanisms across the sector, and (2) about the nature of risk allocation and management within the sector

As previously discussed in Chapter 2, price impulses, whether speculative or based on fundamentals, potentially spill-over from commodity futures markets to the respective physical markets. While economic theory does not provide guidance on the direction of causation between futures and physical markets, empirical studies present some case sensitive evidence. For instance, the analysis in Chapter 4 reveals a bidirectional effect for the wheat market, whereas, for the cocoa market, the futures price is found to lead the physical price. However, such econometric exercise is limited as it does not allow inference on what causes a particular lead–lag relationship.

In this Chapter 6, it is argued that the interrelationship between futures and physical markets and its implications can only be understood by examining the underlying institutional structure, which governs price formation mechanisms at all stages of the cocoa sector. The focus on institutional structure instead of general equilibrium theory is encouraged by the observation that cocoa beans are mostly traded outside a competitive market environment.

For an analysis of the institutional structure of the cocoa sector and its implications for price formation and risk allocation, two strands of literature are consulted. Firstly, the global commodity and value chain literature (jointly referred to as chain literature hereafter) provides a method to reveal the different segments of the commodity sector, and that way to identify main stakeholders and their linkages. Despite the chain literature's focus on institutional structures and associated power relationships, the literature falls short of providing a discussion on implications for price formation and risk allocation (Gilbert 2008b). A second strand of literature fills this gap, which is, institutional theories of price, which in particular draw on the transaction framework by John R. Commons (1934). The latter strand of literature provides a framework within which price formation and risk allocation can be jointly understood.

The remainder of this chapter proceeds as follows. Section 2 reviews the chain literature and the role of institutions within different approaches of the literature. Contributions from empirical studies on cash crops like cocoa are reviewed alongside the theoretical literature. Section 3 discusses institutional theories on price with reference to Commons' transaction theory. Section 4 combines the two approaches towards an institutional theory of price and risk following Palpacuer's (2009) call for an institutional view on chain analysis. Section 5 discusses the empirical applicability of this approach.

6.2 Commodity Chains and Governance

Cocoa beans are bought, sold, and transformed multiple times before being consumed as ingredient in a chocolate bar, other confectionary products, foods or beverages. Along this process the bean, raw or processed, is transferred between different actors in different settings. These modes of transfer are institutional. According to Gibbon and Ponte (2005, 93) chain analysis "sees trade not only as being embedded in, but to a considerable extent determined by, specific (but changing) institutional structures". However, with the literature evolving, the concept and role of institutions saw substantial transformations, which can be summarised in the three conceptualisations of governance as 'driveness', 'coordination', and 'convention' (Gibbon, Bair and Ponte 2008).

Since this has been done in great detail elsewhere (Bair 2005; 2009; Kaplinsky 2013), I eschew a full review of the chain literature and only summarise core ideas on institutions. Further, I follow Gibbon, Bari and Ponte's (2008) selection of the main strands of the literature. This selection is necessarily narrow and excludes other traditions, as for instance Marxist inspired system of provision (Fine 1994; 1996) and commodity system analysis

(Friedmann 1982). However, since the chosen chain tradition draws heavily on concepts in institutional economics, it is critical to evaluate the chain literature in relations to institutional theory and amend it by institutional theories of price formation and risk allocation envisaged later in this chapter.

Despite its popularity, the chain framework has been criticised for being a method rather than a methodology (Gilbert 2008b; Sturgeon 2009). The nature of the criticism is closely linked to the evolution of the literature. The commodity chain concept has originally been developed explicitly as an analytical tool, and not a methodology, within the tradition of the world system theory of the 1980s (Hopkins and Wallerstein 1986; 1977; 1994). Later authors picked up the chain analogy, but dropped the theoretical underpinning of the world system theory. The first adaption of the chain analogy is based on the empirical observation of new modes of production, which emerged in the East Asian Newly Industrialised Countries (NICs) (Gereffi 1999). The evolving literature hence started off inductively and the focus shifted from the world as a conceptual whole towards power asymmetries embedded within single industries (Bair 2005).

The second transition into what is referred to as global value chain (GVC) analysis is born out of a merger between different theories from management, business and the political economy literatures (Bair 2005). Due to the interdisciplinary nature, some key terms remained undefined and confused. The notion of 'value chain' was favoured over other suggestions as it was perceived as most inclusive of possible chain activities[80]. The terminology was foremost inspired by international business scholars and in particular Porter's (1985) work on competitive advantages (Gereffi, Humphrey and Sturgeon 2005). Thereafter, the concept of 'value-added' entered the research agenda together with the notion of chain upgrading, which describes the process of moving into more profitable industry sections (Humphrey and Schmitz 2004b).

However, as argued by Kaplinsky (2013), although the plot of the value chain is a descriptive construct, later contributions to the literature started providing an analytical structure. One element of analytical structure can be linked to the notion of 'governance' and is, as shall be argued in the following, closely linked to institutional economic theories.

[80] Also because of the confusion caused by the term commodity, since the chain literature encompassed primary commodities, indifferentiated factors, products and services (Kaplinsky 2013).

6.2.1 Driveness and Lead Firms

Gereffi (1994, 96-7) adds the concept of 'governance structure' to the commodity chain framework of the world system approach, which became a core theme in the evolving literature. He defines governance as 'authority and power relations that determine how financial, material, and human resources are allocated and flow within the chain' (ibid.). Power is exercised by what Gereffi (1999) calls the 'lead firm' in the chain, which controls access to major resources that generate the most profitable returns. These lead firms further have the ability to decide over the inclusion (or exclusion) of less powerful actors to perform lower value added activities (Raikes, Jensen and Ponte 2000). Against this background, Gereffi (1994, 97) distinguishes between 'buyer-driven' and 'producer-driven' commodity chains, representing different governance structures and modes of organisation[81]. Buyer-driven commodity chains are defined as those where brand-named merchandisers and large retailers play the central role in organising decentralised production networks. Producer-driven commodity chains, are those where transnational corporations control the production system with a high degree of vertical integration.

Especially in the context of agricultural and soft commodity chains, Gereffi's framework was repeatedly criticised for being too narrow. Cramer (1999) is first to point out the necessity of broadening the focus from labour-intensive manufacturing only to include also primary commodities. Gibbon (2001a), with reference to Cramer (1999), aims to fill this gap by developing the concept of international 'trader-driven' commodity chains. In such chains, international trading companies play a 'coordinative role'. A position of economic power is achieved and maintained by those firms through high entry barriers due to high levels of working capital needed. Working capital is not only needed to exploit scale economies through large trade volume, but also to hedge effectively via financial futures markets and, at the same time, be able to benefit from market knowledge by outright speculation. Market knowledge is acquired though vertical integration and close linkages with the producer side, which is, particularly in developing countries, not easily established (Gibbon 2001a; 2001b).

Talbot (2002) criticises Gibbon's trader-driven chain for ignoring the part of the chain beyond the traders. Talbot (2009) further stresses path dependency of the chain evolution and, with reference to tropical chains, their colonial history. Fold (2002) suggests a bipolar governance structure for cash crops like cocoa, where both grinders and branders are main

[81] In his later work he adds 'informedary-driven' commodity chains, in which he accounts for the emergence of the internet (Gereffi 2001a; 2001b).

drivers. While grinders are working in the processing sector of raw cocoa beans, branders engage in the manufacturing of consumer chocolate and marketing of the final product. The interplay between both chain drivers then shapes complex power relationships between lead firms, which remain unacknowledged in Gereffi's framework. Fold and Larsen (2011) later complement the dual structure by acknowledging the importance of multinational retailers. The power struggle then involves three groups of lead firms—buyers, branders and retailers—which compete at the vertical and horizontal chain level.

Besides particularities arising from agro-commodity chains, Gereffi's concept was criticised on more general terms for several reasons. Firstly, it cannot account for different forms of transactions at different nodes of the chain (Raikes, Jensen and Ponte 2000). Secondly, despite the institutional focus, which presents the chain as socially constructed and historically determined, the core concept of 'driveness' is used in a rigid manner and it is unclear whether the chain can switch between the governance structures (Gibbon, Bair and Ponte 2008). Thirdly, the concept does not provide an analysis of the horizontal power structure and leaves open the question whether different players at a lead firm segment have the same influence than their neighbours (Kaplinsky and Morris 2000, 24).

6.2.2 Coordination and Standards

The observation of an increasing level of specialisation and product differentiation necessitated a framework for more complex arrangements of chain governance, as has empirically been shown by Sturgeon's (2002) work on turn key suppliers, as well as studies on the changing role of standards from product to process standards. Further, with a shift from tangible to non-tangible factors of value addition, the buyer driven chain structure became dominant, accompanied by an increasing importance of branding, marketing, product development and coordination of inter-firm relations (Palpacuer 2000; Kaplinsky and Morris 2000). In this context, the discussion transitioned from the overall governance structures of the chain, to chain coordination at a more disaggregated level. Authors implicitly and explicitly turned to transaction costs economics in order to explain the growing importance of process standards and the resulting complexity of intra-chain power relationships embedded in different modes of chain coordination.

Messner (2004, 23) identifies three different layers of governance regarding standards, which is local and regional governance, private and public-private governance, and international global governance. He argues that international lead firms adopt global standards set by international organisation in order to reduce chain governance costs, while the adoption of such standards at the local and regional level functions as a 'ticket' into the chain. He puts forward three reasons for the growing importance of standards: (1) lowering transaction costs in a world with limited information, (2) creating and safeguarding stable expectations, and (3) providing an orientational and sense-giving-dimension (ibid, 36-7). Nadvi and Wältring (2004, 54-6) add the use of standards as a marketing tool. The challenge for newcomers in such system is not how to compete in a global competitive world market but how to engage with private 'rule systems' and exploit or transform those to their own advantage (Messner 2004, 32).

Humphrey and Schmitz (2004a, 97) define governance as inter-firm relationships and institutional mechanisms through which non-market, or 'explicit', coordination of activities in the chain is achieved. In this context, the term governance is used "to express that some firms in the chain set and enforce the parameters under which others in the chain operate" (ibid, 96). They focus on motives behind degrees of vertical integration or disintegration which, according to them, is driven by four trends: (1) concentration at the retailing segment which results in economies of scale and makes inclusion increasingly difficult; (2) the increasing importance of branding and a focus on core competences; (3) the risk of supplier failure when outsourcing; and (4) transaction costs. They further develop a typology of inter-firm relationships including arm's length, network, quasi hierarchy, and hierarchy to which market is added as the baseline (Humphrey and Schmitz 2000; 2001). The form of firm relationships has particular ramifications for upgrading opportunities by different actor (Humphrey and Schmitz 2000; 2004b).

These approaches to governance, standardisation and organisation have led Gereffi, Humphrey and Sturgeon' (2005) to suggest a fivefold classification of modes of chain governance, which is often accredited for marking the beginning of the GVC literature (Bair 2005). Their modes of chain governance represent variations between the two extremes of market and hierarchical organisation. The former presents the most flexible with the lowest level of explicit coordination and power asymmetry. The latter presents the least flexible with the strongest form of explicit coordination and power asymmetry. The intermediate forms are, from most to least flexible, modular, relational and captive. The authors argue that the organisational form is determined by three variables: (1) the complexity of the transactions involved; (2) the ability to codify transactions; and (3) capabilities in the supply base. While the market relationship is characterised by a low complexity, but high ability to codify a transaction and high capabilities in the supply-base, the reverse is the case for hierarchical chain governance. Captive governance structures arise if the capabilities in the supply-base are low and relational governance structures emerge if the ability to codify a transaction is low. For modular governance structures to emerge, the complexity of the transaction has to be relatively high—like for all but the market structure—while codify-able and with a capable supply-base.

Three main points of critique have been raised. Firstly, although authors appear to agree on the idea that, through division of labour, benefits are unequally distributed across a production process, the question how value is created and unequal distribution achieved is not well understood (Gibbon, Bair and Ponte 2008). Indeed, the concept of value and its measurement is highly contested, and so are theories about how value is appropriated by different stakeholders. In this context, Gilbert (2008b) cautions against the common 'value division fallacy' which arises from the cake analogy of a total of value created along the chain—measured as the price fetched by the end-product—and divided among different stakeholders. He stresses that value creation/loss at one stage does not necessarily come at the expense/gain of value at another stage. For instance, a decreasing share of value accrued by one stakeholder in the chain might be due to an increase in production costs for another stakeholder and not increasing profit margins. In the context of the same debate, Kaplinsky and Morris (2000) suggest to focus on incomes[82] at different parts of the chain, rather than profits or prices, for unveiling the distributional outcome of global production systems.

Secondly, with the transition to GVC, the focus of analysis has shifted from a clear macro focus of the 'world' understood as a 'social whole' (Hopkins and Wallerstein 1977), towards the meso level of particular commodity chains, and further towards the micro level of intra-firm relationships. With this shift in the unit of analysis, the chain framework has arguably lost its capacity to embed the interrelationship of single firms into a contextual whole (Bair 2005). This critique is carried to the extreme by Gibbon and Ponte (2005), who argue that the chain metaphor becomes obsolete if turning towards modes of governance at single nodes of the chain.

Thirdly, with the shift from driveness to coordination, the understanding of governance is narrowed down to transaction cost economics where organisational forms are assumed to reflect the efficient solution to some sort of market imperfection. Asymmetric power relationships and strategic interactions of chain participants are excluded (Gibbon, Bair and Ponte 2008), and the social or political dimension of governance is no longer considered (Gibbon and Ponte 2008).

[82] Income is defined as output value minus input cost and employment (Kaplinsky and Morris 2000).

6.2.3 Conventions and Systems of Justification

From this critique, an alternative but related literature evolved, which turns to convention theory. Conventions are either formalised rules or simple agreements regarding the expected frame of action (Rosin 2008). Governance, in this context, is understood as normalisation (Gibbon, Bair and Ponte 2008). Convention theory originates in the work of Boltanski and Thevenot (1991; 1999), who argue that any social action, and with this economic action, is framed by 'systems of justification'. These systems are multiple[83] and can be in conflict. The assumption of conflicting systems of justification is in contrast to the notion of rationality refered to by transaction cost economics, which allows for only one superior system of justification leading to one optimal solution.

Systems of justification can serve as coordination or become conventions as long as there is objectivity. However, when the identity of the object, i.e., the nature of a commodity, is questioned over for instance quality, the market form of coordination is undermined and other systems of justifcation set in, which might or might not be in conflict (Thevenot 2002). If objectivity is questioned, 'critical uncertainty' arises, which is uncertainty that cannot be dealt with in the particular system of justification, and a new convention arises (Boltanski and Thevenot 1999).

The concept of conventions resembles the idea of standards in the previous literature. However, the concept is richer as it entails formalised product and process standards, as well as informal frameworks in which transaction takes place. It encompasses international trade agreements, contracts, standards or general practices (Rosin 2008). Further, convention theory focuses on the sense giving component to actions, with transaction costs being one justification among others. Governance is hence not only linked to economic and technical attributes, like market concentration and complexity, but to dominant normative paradigms that provide legitimacy (Ponte and Gibbon 2005).

The theory has been used to explain the role and emergence of standards and tendencies of outsourcing. Ponte and Gibbon (2005) relate the change in the use of standards to a transition from mass consumption to market saturation in industrialised economies, coupled with a rising awareness of consumer safety and environmental and social concerns, which pose conflicting systems of justification (Ponte and Gibbon 2005). Daviron and Ponte (2005, 33-6) apply the convention theory to standards in the coffee industry. They argue that if there is uncertainty over the quality of the product, actors set up conventions,

[83] For instance, 'market' follows the logic of price, 'industry' follows the logic of efficiency, 'domestic' follows the logic of status, 'civic' follows the logic of the common good.

which are linked to three different forms of coordination outside the market. These are domestic, industrial and civic. In the first form, uncertainty is solved through a long-term relationship of trust. In the second form, common norms and standards are enforced via certification. In the third form, a collective commitment ensures quality. Similarly, Ponte (2007), on the example of South African wine, links different modes of coordination to systems of justification for different wine qualities, while Raynolds (2002) uses the concept to explain the emergence of Fair Trade coffee.

Rosin (2008) suggests linking chain governance to the capacity of agents to influence the conventions of exchange to their advantage. He argues that agents engage strategically in the formation of conventions, that is, agents actively negotiate conventions in order to improve their relative economic position. On the example of yerba mate in South America, Rosin (2008) studies the change in production conventions for small-scale yerba mate producers as a reaction to a change in the macroeconomic environment, brought about by the MERCOSURE trade agreement.

Ponte and Gibbon (2005) explain the evolution of the shareholder value doctrine as a new legitimate corporate strategy with convention theory. The authors argue that this new convention has direct implications for the restructuring of the respective commodity chain. Most symptomatic of this restructuring is the outsourcing of inventory management, regardless of the potential risks of stock-outs attached to it. Further, it is argued that the financial justification system has won over the industrial justification system especially in the US (Palpacuer, Gibbon and Thomsen 2005).

The convention theory successfully introduces a social component to the chain analysis and makes leadership dependent, not only on economic attributes, but also legitimacy and normative paradigms, which are actively shaped for competitive purposes (Ponte and Gibbon 2005). Convention theory is also more flexible regarding the unit of analysis and importantly considers consumers as active participants in the chain (Ponte and Gibbon 2005; Raynolds 2002). However, an obvious shortcoming is the indeterminacy of different systems of justification (Ponte and Gibbon 2005).

My review shows an evolving shift in emphasis in literature: the early literature focuses on economic power relationships in its emphasis of driveness. The later literature shifts towards standards and understands governance as coordination or rule giving. The convention theory puts emphasis on the sense giving and ethical component of governance. An institutional theory for price that combines all three components—

economic, law and ethics—of the chain literature, without subordinating one over the other, is reviewed next.

6.3 Institutional Theory for Price

The chain literature appears to agree on the fact that linkages between different stakeholders in a chain can take on different forms, which embed different power asymmetries. However, the literature lacks an assessment of implications of the particular governance structure for price formation mechanisms (Gilbert 2008b). Given the different concepts of governance, an intuitive starting point appears to be an 'institutional theory for price' (Kaufman 2007). Markets as well as other modes of transaction are social constructs, whose evolution is shaped by a unique historical trajectory. Seen as an institution, the price mechanism is both a result of the intentional action of individuals as well as shaped by rules of everyday human interaction (Gloria and Palermo 1996). The market-structure "is a central determinant of the process of price formation and of the division of benefits of trade" (Maizels 1992, 162) and agents continuously try to change the structure as markets evolve (Callon, Meadel and Rabeharisoa 2002). The power of agents to shape the market structure, as well as the transaction within a given structure hinges on their relative bargaining strength (Maizels 1992, 166). Kaufman (2007) argues that each agent's relative bargaining power is determined by a specific regime of working rules. These working rules are set by some people in power to do so. He concludes that "therefore, it is political power, not the impersonal forces of supply and demand, that determines […] who reaps the rewards and bears the costs of economic activity" (Kaufman 2007).

Both Gloria and Palermo (1996) and Kaufman (2007) explicitly link their institional theory for price to the work of John R. Commons and his concept of transaction. Commons (1934) presents his work as an antithesis to 19th century economists, which he accuses of focusing narrowly on exchange, which places the price formation mechnism into a mechanical harmonic relationship (equilibrium) between man and nature (Gloria and Palermo 1996). By focusig on exchange rather than transaction, those economists fail to account for the legal transfer of property rights, which is a process characterised, quite differently, by conflict, in a relationsip between man and man.

For Commons (1934) transactions are the smallest unit of institutional economics, which he defines as:

> "the alienation and acquisition, between individuals, of the *rights* of future ownership of physical things, as determined by the collective working rules of

society. The *transfer of these rights* must therefore be negotiated between the parties concerned, according to the working rules of society". (Commons 1934, 58)

Four aspects are immediately striking with Commons' definition: (1) his focus on property rights as the matter of the transfer, (2) his emphasis on 'futurity'—not immediate but future physical ownership is transferred which brings in uncertainty, (3) the working rules which determine the mode of the transfer, and (4) his emphasis on negotiation of mode and matter of transfer within the boundaries of the working rules.

According to Commons, the focus on exchange neglects the legal and ethical component of economic activity (Commons 1934, 56). He argues that transaction and exchange are only congruent when contracts are complete, which means when there is no uncertainty involved. However, inspired by Keynes, he maintains that uncertainty is a reality, which implies that contracts are incomplete by nature. This leads to the differentiation between legal and physical control that is between transfer of property rights and transfer of a physical good (Kaufman 2007).

Since a transaction is an interpersonal relationship, it is characterised by conflict, mutuality and order. The first two characteristics are regarding the interest of ownership of the parties involve, which are conflicting and mutually dependent. The latter characteristic is about security of expectations. Security of expectations is a necessary characteristic because of the true uncertainty of the future. Commons argues that the future must, to some extent, be reliable in order to facilitate action in the present (Commons 1934, 58). The security of expectations is guided by the working rules of society, which are subject to negotiations. Working rules "work as a limiting factor on behaviour" and guide what is legally and ethically accepted (Commons 1934, 140).

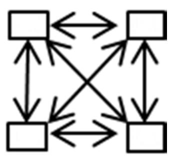
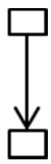
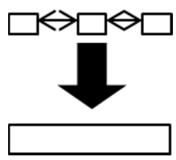
Because working rules "define each economic agent's opportunity set, endowments, and rights and conditions for exchange of property" (Kaufman 2007), the enforcement is the gain for one which comes at a loss for the other. When it creates liberty for one party, it results in exposure for the other. When it creates security for one party, it demands conformity from the other. In this sense, working rules set the limits of the three dimension of behaviour: (1) performance, that is the power exerted in an act or the attempt to persuade and coerce; (2) avoidance, that is the choice of one performance over another; and (3) forbearance, that is the difference between the potential power and the actual power exerted in a transaction. The distinction can be summarised as actual performance, alternative performance avoided, and the limit placed on performance (Commons 1934, 88). These three dimensions of behaviour are linked to the doctrine of reasonableness or ethical and legal legitimacy. Each actor involved in a transaction seeks to influence the other towards these three dimension, which is the 'social psychology of negotiations' (ibid, 91).

Commons (1934, 58) distinguishes between three types of transactions based on the manner in which ownership rights are transferred, resulting in different power relationships. These are *bargaining* transactions, *managerial* transactions, and *rationing* transaction.

A *bargaining* transaction is one between legal equals, but not necessarily economic equals. Whether the agents are economic equals or not has an impact on the negotiation psychology, which is one of persuasion for economically equal agents, and one of coercion for economic unequal agents. Since such relationship is always one of conflict, working rules are required to introduce limits to the ability of parties to exercise power. If a dispute arises, some legal authority is needed to decide the dispute and the outcome of this decision enters future expectations and in that way becomes a custom.

Managerial transactions are guided by working rules as well, but the relationship is one between economic and legal unequal agents. The negotiation psychology is one of command by the legal superior and obedience by the legal inferior. The terms of a managerial relationship can be negotiated and agreed upon between two legal equals before entering into the relationship of legal hierarchy. While the purpose of the bargaining relationship is the voluntary transfer of ownership over wealth, the purpose of the managerial transaction is wealth creation. The former is driven by the principal of scarcity, while the latter is driven by the principal of efficiency (Commons 1934, 64).

Table 6.1: Transaction Typology under Commons

	Bargaining	**Managerial**	**Rationing**
Legal	Equal	Unequal	Unequal
Economical	Equal Unequal	Unequal	Unequal
Psychology	Persuasion Coercion	Command/Obedience	Enforcement
Type of Parties	Individual	Individual	Collective
Number of Parties	4	2	2
Purpose	Transfer of ownership of wealth	Production of wealth	Allocation of burdens and benefits of wealth creation
Structure			

Source: Author.

A *rationing* transaction is one where a working rule is enforced by a superior collective. The enforcement of the working rule depends on the negotiation of those in power. Agents with power are part of the superior collective and have the authority to allocate the benefits and burdens of wealth creation. The negotiation is hence a collective bargaining. The rationing transaction can take the form of output-rationing or price-rationing (Commons 1934, 68). Table 6.1 summarises the transaction types.

A network of all three transaction types is a 'going concern'. A going concern, with the working rules that keep it together, is Commons' definition of an institution (Commons 1934, 69). In this framework, institutions can be firms, markets, families or commodity chains. The performance of such institutions has to be "understood in terms of the rules that structure them and the goals of the people who develop and enforce the rules" (Kaufman 2007). While in Commons' theory, transactions make the smallest units of economic activity, the going concern is a larger unit of economic activity (Commons 1934, 71).

The organised collective action is distinguished from the unorganised collective action, which is a custom. Since customs are subject to change and lack precision, they cause dispute. Customs can be variable practices as well as mandatory customs which have a binding effect. A custom being mandatory does not necessitate it being precise or organised, but that the consequences of neglecting it are binding. These different types of customs are subsumed as working rules (Commons 1934, 80).

The outcome of a bargaining relationship hinges on the relative economic power of the agents involved in the transaction as well as the working rules that limit the exercise of power. The outcome of a managerial transaction and rationing transaction hinges on legal as well as economic power. In this context, Commons defines bargaining power as "power over others as contrasted to power over nature" (Commons 1934, 302-3). This differentiation is linked to his distinction between physical and proprietary meaning of procession. Only the latter meaning entails the power of individuals to withhold from others what is demand by them for their own use, which is bargaining power.

With the notion of 'futurity', risk is an integral part of Commons' theory. As stated before, the enforcement of a working rule creates liberty and security for one, and exposure and conformity for the other. Hence, the institutional framework, in which transactions are embedded, determines not only the allocation of wealth, but also the allocation of the burdens and benefits of wealth creation. This entails risk, which is allocated according to security and conformity, liberty and exposure. Legal control or legal power is the control over agents' future behaviour (Commons 1934, 86).

Institutional change is initiated by limiting factors, which turn a bargaining transaction into a *strategic* transaction. Strategic transactions aim at changing existing working rules. Limiting factors could, for instance, arise due to the ownership of others over scarce resources. Along these lines Medema (1992) uses Commons' framework to explain the decision of firms to vertically integrate, that is, to enter into a managerial transaction. The arising governance structure of a chain is the product of "the evolutionary process which is worked out over time, a many period game characterised by power play" (ibid.). This power play is guided by working rules that determine to what extent, and in which manner, power can be exercised, and to what extent working rules can be challenged and modified by actors.

6.4 Governance, Transactions and Institutions

Following Commons' notion of going concerns, the commodity chain as a whole can be understood as an institution, guided by existing working rules, and so can each individual firm in the chain. Since a going concern, constituted by a set of transactions, can be embedded into a larger going concern, the struggle over the unit of analysis is overcome. Further, the shareholder value doctrine can be understood as changing power relationships within a company. Shareholders gained legal power due to changes in regulations, and financial capital gained economic power in saturated consumer markets. Shareholders transform existing working rules in their favour, which results, inter alia, in outsourcing of non-core competences.

Different types of standards can be explained by linking those to Commons' categories of customs, which are differentiated into organised or unorganised, binding or non-binding. Private process standards for instance can be unorganised (not written into law), but binding. A producer might not find a buyer if discarding private production standards, and is consequently excluded from the chain. Raikes, Jensen and Ponte's (2000) argument that branders increasingly control market access through coordination, can hence be understood as an increasing economic power of branders (due to for instance market concentration), which enables them to shape working rules through the enforcement of binding customs.

Moreover, the fivefold typology of governance structure by Gereffi, Humphrey and Sturgeon (2005) can be translated into Commons' transaction concept. Market and hierarchy are the opposite ends of the typology. These are translated into bargaining transactions with equal economic power and managerial transactions. The intermediate stages of modular, relational, and captive are bargaining transactions with increasing economic power asymmetry, which enables one agent to shape the working rules in his favour. Unequal economic power has different origins, for instance asset specificity, informational asymmetry, and market dominance. It becomes immediately apparent that Commons' rationing transaction is not accounted for. This relates back to the previous critique that GVC analysis only targets one node at a time but not the wider institutional context. For instance, product and process standards set far away from the actual point of exchange, as in Messner's (2004, 23-37) network analysis, are not easily understood in the framework proposed by Gereffi, Humphrey and Sturgeon (2005).

The notion of transaction provides a framework in which price formation as well as risk allocation process can be jointly understood. A transaction encompasses the terms at which a transfer takes place (mode of transfer) as well as the subject of transfer (matter of transfer). Both the mode and matter of transfer embedded in a particular contractual arrangement are negotiated. The negotiation process is determined by the relative legal and economic power of the agents involved as well as existing working rules. Given the specificity of a particular negotiation, different outcomes are possible which explains the diverse forms chains can take on. Contractual arrangements do not only specify a particular price and quantity, but also the terms at which the physical exchange is conducted. These terms are linked to uncertainty involved in a transaction, which means they are linked to the allocation of risk.

Power is linked to economic and legal attributes. Asymmetric bargaining power arises from unequal economic power due to the presence of limiting factors, that is, ownership over scarce resources. Resources can be tangible (e.g., commodities) or intangible (e.g., information). Such limiting factors can motivate an actor to engage in strategic transactions in order to change existing working rules. Further, asymmetric power in managerial and rationing transaction arises due to both asymmetric economic and legal power. In the managerial transaction, inferior legal power can be voluntarily (e.g., entrance in an employment relationship) or non-voluntarily (e.g., vertical integration through hostile takeover). Governance understood as the power to appropriate the main share of value creation is the execution of economic power, while governance understood as the power to set standards and decide over the modalities of production is the execution of legal power.

However, Commons does not elaborate further on the nature and sources of economic or legal power. Two concepts, which have been used in the context of chain analysis are useful extensions. These are different economic rents as a source of economic power (Fitter and Kaplinsky 2001; Kaplinsky and Morris 2000, 25-8) and the differentiation between executive, legislative and judicial power as a categorisation of legal power (Kaplinsky and Morris 2000, 29-32). Fitter and Kaplinsky (2001) on the understanding of governance in the chain literature conclude that: "It is this role of coordination, and the complementary role of identifying dynamic rent opportunities and apportioning roles to key players which reflects' an important part of the act of governance". By combining Commons' framework and the above statement, governance is in the hands of those who hold economic (identifying dynamic rents) and legal (coordination) power and the resulting ability to shape working rules and consequently allocate the burdens and benefits of wealth creation (apportion roles to key players).

Several sources, linked to economic rents, have been associated with economic power or bargaining power. Kaplinsky and Morris (2000) present a comprehensive list of sources of economic rents which fall under certain categories: (1) rents can be endogenous to the chain and constructed by a single actor (e.g., technology rent) or a group of actors (e.g., relational rents), and (2) rents can be exogenous to the chain and be constructed by external parties (e.g., financial rents) or nature (e.g., resource rent). They further stress that rents are dynamic, which means that economic power is in constant shift. This implies that existing working rules are challenged and transformed by shifting power imbalances. Importantly Kaplinsky and Morries (2000, 42) stress that while economic rents result in surplus generation, one has to look at the income of different labour involved in the production process in order to identify the distributional effect of a particular institutional structure.

Maizels (Maizels 1992, 165-73) distinguishes between three different sources of bargaining power held by developing host countries or governments vis-à-vis transnational corporations. These are factors specific to the commodity, factors specific to the host country and factors of international action. His selection of commodity specific factor is inspired by Labys (1980). The latter lists export dependence, magnitude of fixed investment, nature of technology (e.g., for extraction), control over reserves and production, opportunities for processing, material share in product price, obsolescing bargain[84], nature of competition, and government learning process. To this list, Maizels (1992, 169) adds transparency of world markets, control of marketing and distribution, and competition among transnational corporations (TNCs). Factors of international action would be either joint action by developing countries (like commodity agreements) or joint action by TNCs (like collusion over price or quantity). Country-specific factors involve macroeconomic position and degree of corruption. These factors of asymmetric bargaining power can be linked to economic rents like information rents (transparency of markets), technology rents (nature of technology), etc.

Kaplinsky and Morris (2000, 31) further contribute to disentangling the complexity of legal power. They firstly distinguish between three dimensions of governance which are: *legislature,* i.e., making the law or working rules, *executive,* i.e., implementing the law or working rules and *judiciary,* i.e., monitoring the conformance to the law or working rules. Secondly, the authors stress that these dimensions of governance can be exercised by parties internal as well as external to the chain. Thirdly, they assess the strength of governance by its depth that is "the extent to which it affects the core activities of individual parties in the chain" and pervasiveness that is "how widely over the chain its power is exercised, and related to this, whether there are competing bases for power" (ibid, 32). Who holds these forms of governance or legal power determines not only the particular organisational structure of production, but also the terms at which transactions take place, the functional division of labour between the segments of the chain, and the structure of the price formation and risk allocation process.

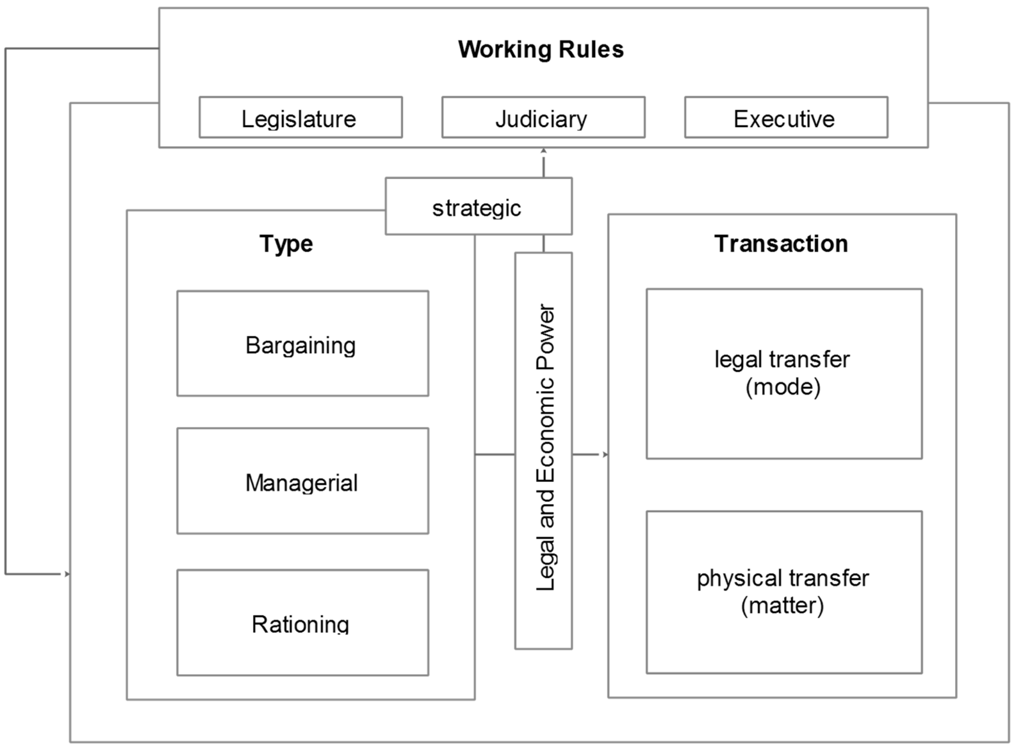
Institutional change for Commons emerges due to limiting factors, which cause agents to engage in strategic transaction aimed at changing the existing working rules. Kaplinsky (2013) stress the importance of dynamic rents and core competences through for instance innovation as the driving forces that shapes and reshapes the organisation structure of production chains. Another approach links chain organisation to the financialisation literature and 'shareholder capitalism' (Palpacuer 2009; Gibbon 2002; Raikes, Jensen and Ponte 2000). According to this literature industry restructuring is driven by the increasing dominance of shareholder value and relative return on capital employment ratios. In both instances, it is economic and legal power that enables agents to shape existing working rules and consequently change the organisation structure of the chain. Such institutional changes affect both the matter and mode of transaction. Hence not only the subjects of

[84] Obsolescing bargaining refers to a shift in bargaining power as for instance after a huger investment by a TNC is made. While before the investment the TNC might have had the superior bargaining position, the government gains bargaining power after the investment due to the risk attached to it (Maizels 1992, 170).

transaction, which are quantity and price are altered, but also the terms of transaction, which include risks. For instance, Palpacuer (2009) argues that financialisation leads to the transfer of risk from the shareholder to the corporation, which promotes incentives to shift risk to employees and suppliers via outsourcing.

Figure 6.1 combines Commons' transaction framework with the concepts of economic and legal power. The institutional structure is made of different types of transaction, which entail different legal and economic power relationships. Asymmetric power relationships determine negotiation psychology and strength in influencing both the matter and mode of a transaction as well as existing working rules. A change in working rules appears in the presence of limiting factors which motivates agents to enter into strategic transactions. The working rules in turn determine the limits to the power exerted in negotiation processes. Legal power with reference to working rules can be differentiated into power to make working rules, power to supervise the conformance to existing working rules and power the enforce existing working rules. This complex interplay between different legal and economic power relationships defines, not only the mode and matter of a transaction, but also the boundaries by which the mode and matter of a transaction can be negotiated.

Figure 6.1: Transactions, Governance and Economic Rents



Source: Author.

6.5 Concluding Remarks

Commodity and value chain approaches provide a useful framework to understand linkages and embedded power relationships within a commodity sector. However, the literature struggles with the appropriate unit of analysis and further, does not provide any insights in implications of different power relationships for price formation and risk allocation processes. In order to compensate for this shortcoming, an institutional theory of price and, following existing theoretical contributions, Commons' concept of transactions is used.

By focusing on transactions instead of exchange, the price formation process is embedded into an institutional context, which makes an analysis of price formation outside the market possible. Further, the notion of transaction is inherently linked to uncertainty or what Commons calls 'futurity', which makes risk an essential component.

Against this background, the price formation process within a commodity chain has to be understood in terms of different forms of transactions. Prices can be administered or negotiated in a single or repeated bargain among economic equals or non-equals. In order to gauge the unequal distribution of economic benefits across the chain, one has to consider the distribution of legal and economic power which shapes the modality of transactions established in contractual arrangements (formal or informal). In the following, we will show on the example of the Ghanaian cocoa sector that price formation and risk allocation mechanisms essentially hinge on the institutional setting in which transactions take place.

Chapter 7 The Case of Ghanaian Cocoa

7.1 Introduction

While the literature on cocoa chains is rich, focusing on governance structure and bean quality after liberalisation, few studies investigate price formation and risk allocation mechanisms. This is despite the fact that price risk has been identified as the most substantial risk faced by cocoa farmers across producing countries (WB 2008; 2011). Gilbert (2008b) is among the few to consider price formation mechanisms. He notes that the futures market plays a decisive role in determining values and value shares in the cocoa sector. However, his analysis focuses on the accountancy tasks of calculating value shares across the chocolate sector and not on price formation mechanisms in particular. Dana and Gilbert (2008, 209-12) investigate price risk management techniques in soft commodities including cocoa. Although they provide a comprehensive typology of price risk factors to which different stakeholders are exposed to, they fail to account for the role of the institutional framework guiding risk allocation and management.

Therefore, this Chapter 7 provides a systematic analysis of the Ghanaian cocoa sector, which links price formation and risk allocation to the evolution of the institutional structure of global, regional and national cocoa trade. The analysis is based on semi-structured interviews conducted during a three month fieldwork in Ghana, as well as in-person and phone interviews with stakeholders in the US, Germany, and the UK. Appendix 7.1 provides an overview of interview partners. Where reference is made to information obtained in an interview or an interviewee is quoted, the reference is indicated in the form: ['letter' 'number']. The 'letter' refers to the particular sector, for instance chocolate manufacturer or farmer, and the 'number' is a serial number in the order of the dates when the interviews were conducted.

The Ghanaian phrase 'Cocoa is Ghana and Ghana is cocoa!' is exemplary for the status of cocoa as a commodity not only in Ghana's economy but also in the social and political realms. About one Million farmers [I2, L4] and their families, together with employees of Cocobod, processing companies, hauliers and LBCs—about one third of Ghana's entire population—directly depend on cocoa income [B2, G8, L4]. Further, cocoa constituted 30 per cent of Ghana's exports in 2013 and only lost its dominance due to the increasing importance of gold and oil exports (Figure 1.5). Until today the cocoa sector remains the single most important sector for Ghana in terms of employment, foreign reserve provision and revenue generation for the government.

The introduction aside, the chapter is structured into four sections. Since institutional structures are path dependent, Section 2 commences with the history of the Ghanaian cocoa sector and the evolution of its institutional structure. The historical trajectory is constantly linked to developments in the global cocoa sector and neighbouring cocoa producing countries. Section 3 outlines the methods used for the fieldwork and provides a map of today's cocoa–chocolate chain structure from Ghana's perspective, in which key stakeholders are identified. Section 4 provides a detailed analysis of the mechanisms of price formation and risk allocation across the cocoa sector. Towards this aim the different settings in which transactions take place and the working rules that shape them, as well as asymmetric economic and legal power relationships among stakeholders are unveiled. Section 5 concludes by assessing Ghana's unique institutional structure and ramifications for price formation and risk allocation among stakeholders in the cocoa–chocolate industry.

7.2 The History of Cocoa in Ghana

In the context of cocoa Talbot (2002) argues that the colonial past has shaped the way in which cocoa chains are organised. In order to understand the evolution of the Ghanaian cocoa–chocolate chain, the following section reviews the history of cocoa in Ghana from the arrival of the first bean to the current state of the sector against the background how the global cocoa sector has been evolved. The time period under review covers the colonial times, the pre-independence period and the aftermath, and the era of structural adjustment until today.

7.2.1 Cocoa under Colonial Power

According to the most common narrative, cocoa has been brought to Ghana from Fernando Po by Tetteh Quashie, a Ga blacksmith, in 1878 (Mikell 1989, 70). However, the historical truth of this claim remains unconfirmed as of today and alternative versions have been promoted. Indeed, evidence suggests that European Missionaries attempted to cultivate cocoa in Ghana in 1857 already, but with limited success (Acquaah 1999, 16-7, Gunnarsson 1978, 29). Nevertheless, Quashie, although he might not have been the first, is rightly celebrated as the 'Father of the cocoa Industry in Ghana' (Acquaah 1999, 21) and his farm in Mampong-Akwapim is open to the public with a small museum attached to it[85]. With its second arrival, cocoa was quickly taken up by farmers within the State of

[85] At the time of visit the museum was closed due to quarrels with Cocobod.

Akwapim[86] and moved North-West, reaching Kumasi in 1903. Between 1905 and 1930 'cocoa spread like wildfire' and by 1911 surpassed rubber, timber and gold as the main export good (Mikell 1989, 83).

The rapid expansion of cocoa in Western Africa was accompanied by the emergence of large-scale chocolate factories and mills in late 19th century Europe and North America. In the early days, cocoa was auctioned in London or Liverpool (Dand 1995, 82). Since overseas shipping took time and was associated with great risks, cocoa could only be sold at the European ports on arrival. For small drinking chocolate manufacturers this spot sale system was sufficient, but larger chocolate factories required more stable supply. Improvements in speed and safety of shipping, not least with the development of steam engine power, and an increasing supply from the Gold Coast facilitated such stable supply.

With the new era of cocoa trade, another innovation reached the trading centres in Europe and North America; the forward sale. The forward contract system was favoured not only because forward contracts mitigated price and supply risk, but also because such system was less transparent than the auction system and competitors were left with uncertainty over price and volume of trading deals (Dand 1995, 83). With increasing trade volume and a demand for standardisation of contracts, three trade associations were formed between 1924 and 1935. The CMAA in New York, the Cocoa Association (CAL) in London and the Association Francaise du Commerce des Cacaos (AFCC) in Paris. All three organisations provide standardises contracts as well as arbitration services (ibid, 84). From standardised forward contracts, the step towards the first cocoa futures exchange in 1925 in New York was small. With the new institution in place, the focal point of price formation shifted towards New York and even price notations at later founded exchanges in London, Liverpool, and Amsterdam followed the American price (Ehrler 1977, 26).

Since production of cocoa was in the hand of indigenous people, the West African cocoa trading system relied to a great extent on middlemen, referred to as brokers. European companies never took an active part in cocoa production (Gunnarsson 1978, 51-2)[87]. Nevertheless, the European companies were vital for the rising cocoa sector. Firstly, they established the necessary link between the farmer and overseas cocoa markets, and secondly, they provided producers with manufacturing imports and capital. Their interests were twofold: securing cocoa supply and establishing new markets. The two largest players

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[86] This is the area around Aburi in Figure 7.5.

[87] An exception was Governor Sir William B. Griffith, who experimented with cocoa plants himself at the Botanic Gardens of Aburi, next to Mampong-Akwapim and expanded those to the Aburi Agricultural Station which from 1891 sold seeds, pods, and seedlings to farmers. In 1898 Aburi turned into a marketing centre which introduced advanced payments for sales of cocoa (Acquaah 1999, 33-8).

at the time were the United African Company (UCA), later owned by the Lever Brothers (Unilever), and Cadbury (later Cadbury and Fry) owned by the Cadbury Brothers (Acquaah 1999, 99-100). UCA entertained an import-export business and was the major buyer of cocoa in the 1930s with over one-thousand buying points and merchandise outlets. Between 1920s and 1930s, 13 foreign firms entered the cocoa trade and went into fierce competition with local independent traders (ibid.).

Beans were brought from the farmers by sub-brokers, who were small petty traders, and then sold on the larger brokers, who were large merchants or large farmers themselves. The larger brokers then sold the crop on to European firms (Commission on the Marketing of West African Cocoa (CMWAC) 1938, 26-8). The brokers were responsible for the transportation from the farm to the ports and, in their role as merchants, were supplying imported consumer goods to the farmers (Gunnarsson 1978, 52-3). Due to the seasonality of the crop and the dual function of the European trading companies, a system of cash advances developed. Crop income was condensed into the harvest seasons from October to March, which meant that farmers were short in cash during the remaining months. In this emerging system, brokers were contracted by the European firms to buy a certain amount of cocoa and given cash advances in order to contact sub-brokers and farmers. Thereby, European firms bought forward a large amount of cocoa in order to secure supply during harvest season.

The emergence of the advanced cash system and the increasing commercialisation of cocoa trade led to an increasing stratification among cocoa farmers, with brokers and larger farmers arising as new wealthy strata. Brokers established themselves as money lenders and often brought a considerable amount of farms under their control (Ehrler 1977, 57). Further, since brokers were the sole link to the overseas market, they had considerable power over farm-gate prices (Gunnarsson 1978, 110-2). This increasing power of brokers rose to the concern of European firms and was a source of conflict in the 1930s.

By the 1930s more than 25 per cent, at some locations even up to 50 per cent, of the crop was bought forward (Gunnarsson 1978, 117; CMWAC 1938, 31). The respective overseas principal informed the European buyer about the price at the exchange. The buyer then fixed limits to which he allowed his brokers to buy. These limits were decided upon by considering the world price, existing contracts and in-country competition (Ehrler 1977, 56-7; CMWAC 1938, 33). The broker then received cash advances from the buyer, which he passed on to his sub-brokers. The maximum price given to the sub-broker did not necessarily match the price given by the buyer. Should the price change, the broker was immediately informed by the buyer and he had to declare the amount of cocoa already bought to the former price. However, since he had to inform his sub-brokers, this would take time—a variable which could be played by the broker. By pretending he did not reach his sub-broker, he could continue to sell the cocoa to the buyer at the previously high price. This way brokers would accumulate income during the early time of the season and often bought cocoa with their own cash later in the season to sell it to buyers at a higher price (Ehrler 1977, 62).

While local brokers had a substantive influence on prices at farm-gate, world prices could at least to some extent be influenced by the large commercial traders. Speculation in London and New York, the two leading cocoa futures exchanges, was likelier than in other crop markets due to the nature of production and marketing in West Africa. Since cocoa was not produced on large European-owned estates, information about the state of the cocoa sector was scarce among European firms. As a result, traders often relied on guesswork and extrapolation. Gunnarsson (1978, 23-4) argues that the separation of producers from European merchants contributed crucially to price fluctuations. The only report on cocoa crop forecasts available published by Gill and Duffus—the worlds' largest cocoa dealer at the time—had a decisive and often intended influence on exchange traders' expectations (Kofi 1974, 458-9). Active market manipulation, as for instance in January 1937, when Hershey Chocolate Corporation attempted to peg the market, was another way to influence prices (CMWAC 1938, 8-10).

The rising power of the middlemen, the increasing importance of the futures market and the concentration of the export segment in the hands of a few European and North American companies characterised the situation of cocoa trade in the 1930s. Against increasing concerns over the quality of the exported cocoa (De Graft-Johnson 1974, 352), as well as the growing power of the middlemen, co-operatives were introduced in 1931 (CMWAC 1938, 40-2). Co-operatives would sell directly to European buyers and receive a premium for ensured bean quality. The amount of cocoa marketed through co-operatives was minimal in the early days. However, those should play an important role in the days prior to independence (Beckman 1974, 368).

The 1930s marked a time of particularly low cocoa prices. The emerging recession in cocoa consuming countries resulted in distress for the cocoa–chocolate industry and European buyers respectively. The decreasing farm-gate prices and the oligopoly of European buyers' sparked suspicion among farmers over European buyers colluding to artificially supress prices (Mikell 1989, 97). Anger among farmers was further aggravated by the fact that foreign firms, due to their dual role in the economy, not only administered export prices but also prices for imported manufactured goods (Acquaah 1999, 100; Ehrler 1977, 142). Indeed, during the 1930s, foreign exporters agreed on quota systems and prices among them (Gunnarsson 1978, 125-6). The unmasking of the collusion led to a succession of cocoa hold ups, which found their climax in 1937 with a boycott of the import stores owned by cocoa shippers in addition to a cocoa hold up (Acquaah 1999, 108)[88].

As a response to the hold up, the Nowell Commission—a Parliamentary committee—was set up. The commission later condemned the buyers' monopoly and the unethical action of the inland middlemen (Mikell 1989, 99). However, recommendations made were never implemented. A few months later, with the outbreak of the Second World War, the British government, in need of revenues to finance its war expenses, decided to purchase all cocoa beans from its colonies at a fixed price. In 1940 the West African Producer Control Board was established to undertake overseas marketing (Acquaah 1999, 111). The local Government was empowered to fix prices in consultation with the London authorities (Wickizer 1951, 330-1). The handling of the cocoa was divided between those firms already in business, referred to as Licenced Buying Agents (LBA), and quotas were allocated depending on the firm's previous performance. LBAs acted as agents for the government and were reimbursed for their services (Acquaah 1999, 112). The price paid to the farmers was figured by deducing transportation, brokerage and other costs according to a published schedule from the controlled price (Wickizer 1951, 330-1).

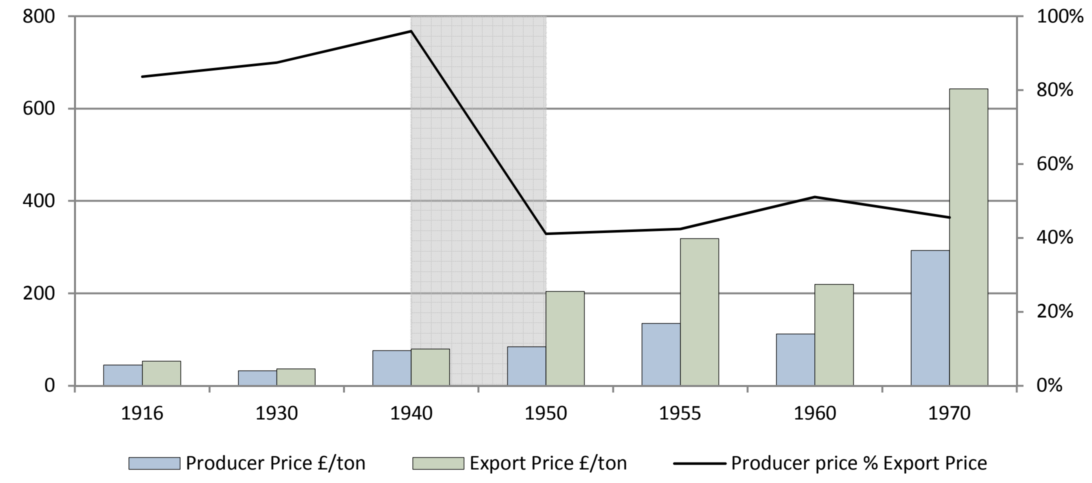
After the war, the composition of the board was changed to allow greater producer participation and it was renamed into Cocoa Marketing Board (CMB) (Acquaah 1999, 144). However, the price setting mechanisms sparked controversies, since the controlled price remained conservative. While during the war years the argument that low prices were needed in order to compensate for the risk incurred by the CMB was accepted, farmers became increasingly vocal against the arrangement thereafter (Wickizer 1951, 335-6).

The introduction of the CMB was not the first attempt to tap the cocoa industry for revenues and the British introduced export duties in 1916 already (Acquaah 1999, 41). However, for the first time, the bargaining process between farmers, intermediaries and exporters was taken out of the hands of the agents involved and revenues were extracted by administered prices. The transaction turned into a rationing transaction between farmers and CMB and into a managerial transaction between LBAs and CMB. The introduction of this new institutional setup had lasting consequences for the West African cocoa industry.

[88] For a detailed report on events see Ehrler (1977) and CMWAC (1938).

While farmers received up to 90 per cent of the free on board (FOB)[89] price in the 1940s, the share decreased to 40 per cent after the introduction of the CMB as depicted in Figure 7.1. The structure of this institutional setup remained until today. However, power relationships constantly changed and, so too, working rules.

Figure 7.1: Export Prices and Producer Price Share in Export Prices (in £ per ton (left scale) and in % (right scale), 1916–1970)



Source: Acquaah (1999, Table 5.2, 126); Western Africa Programmes Department (WAPD) (1983, Appendix VI, 36).

7.2.2 Cocoa under Independence

Pressure towards higher political self-determination emerged in the Gold Coast in 1941 and a new constitution came into force in 1946 (Gocking 2005, 79-81). This development was a stepping stone towards parliamentary democracy and the first large scale election of a Legislative Council was held in 1951. Kwame Nkrumah, founder of the socialist Convention People's Party (CPP), became the first elected prime minister (Gocking 2005, 99).

The development towards a 'semi-responsible form of government' was propelled by the passing of an ordinance that made the cutting-out of cocoa trees infected with the swollen shot virus obligatory in 1946 (Gocking 2005, 93). The virus spread rapidly in the 1930s, not least because of the neglect of cocoa farms during the war and chronically low prices. However, the ordinance came at a time when prices were finally rising again and hence resulted in protests and violent clashes between farmers and cutting-out gangs (Gocking 2005, 81-2). The revolt quickly spread to urban areas and resulted in similar violent protests

[89] FOB stands for free on board which means the seller pays for the loading and transport of the commodity to a designated port.

that had erupted a decade earlier during the cocoa hold-ups. The colonial government reacted by opening up to democratisation embedded in a new constitution.

While previously the CMB was serving as a tool for revenue extraction, it was heavily politicised under Nkrumah. In 1952, right after the election of the first pre-independence government, the Cocoa Purchasing Company (CPC) was set up as a state owned buying company competing with co-operatives and other LBAs. Especially in the run-up of the second election, the CPC provided favours, like inexpensive loans, for those in support of the CPP (Frimpong-Ansah 1991, 86).

All time high cocoa export prices between 1952 and 1955 bestowed a period of unprecedented growth on the newly elected government. However, through the action of the CPC, the price for cocoa famers was not raised proportionally (Mikell 1989, 162). Nkrumah's early plan was to use the country's economic resources to create an industrial base, which would serve to promote development, but chiefs and farmers in the cocoa belt complained that the new state of Ghana was being built on the backs of cocoa farmers. Despite rising opposition, Nkrumah and the CPP won the third election in 1956, not least because CPP had an advantage in financing and reach through CPC (Mikell 1989, 163). After the third election cycle, Ghana won independence as the first West African colony on March 6, 1957.

The same year, the CPC was liquidated due to concerns over corruption. This, however, did not end the politicisation of the cocoa sector (Williams 2009). In its place stepped the United Ghana Farmers' Council Co-operative (UGFCC), which was granted a monopoly position in cocoa buying in 1961. In the famous Dawn Broadcast, Nkrumah explained that all foreign LBAs were expelled and that the UGFCC, which entertained close political ties with the CPP, was to become the only recognised farmers' organisation in the country (Mikell 1989, 176-8). As foreign firms increasingly focused on processing they did not mind the surrender of their sourcing operations. Their main concern was securing enough cocoa at sufficient quality and towards this aim they offered their close collaboration to the government (Beckman 1974, 372). Indeed the quality of the cocoa increased under the new arrangement (Kotey 1974, 382).

While to the satisfaction of overseas buyers, farmers were squeezed and their standard of living decreased under the new arrangement. The cocoa sector lost attractiveness and children from cocoa farmers, who benefitted from schooling, were migrating towards urban areas. In 1964 world cocoa prices plummeted, loans could not be repaid, and the producer price had to be lowered the following year (Mikell 1989, 186-7). The cocoa sector entered into crisis as many farmers abandoned their farms. A food crisis emerged and when foreign lenders refused to issue new loans, Nkrumah's reign ended in a military coup in 1966. From 1947, the year the CMB was established, to the end of the 1964/65 crop season, the government collected about 30 per cent of the cocoa export proceeds in export duties and other levies (Beckman 1974, 277).

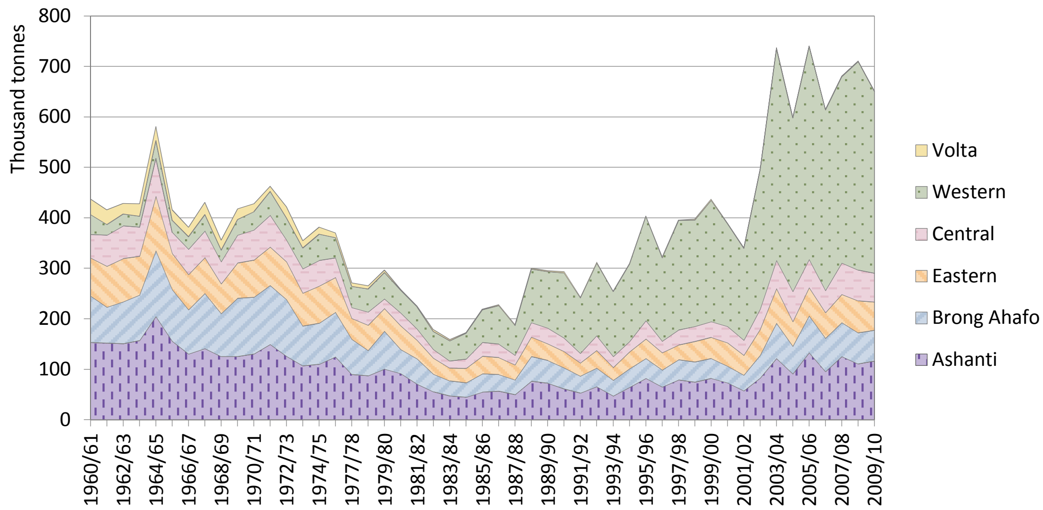
The coup in 1966 was followed by a general distaste for socialism and negative sentiments towards foreigners, which forced migrant wage labour working at cocoa plantations to leave the country. Increasing wage labour costs led to further abandonment of cocoa farms. The former CMB administrative apparatus was dissolved since associated with socialism, the monopoly of the UGFCC lifted and the co-operative system revived (Mikell 1989, 193). However, debt issues and fierce competition among co-operatives, as well as delayed payments, forced many farmers to turn to the state owned Producer Buying Agency (PBA) and the monolithic structure was re-established in 1977, when PBA became the sole buyer (Laven 2010, 80).

The turn away from socialism opened the door for the IMF, who provided loans to the new government under forced devaluation of the currency and strict austerity conditions which included cutting back on subsidies for fertilisers and other cocoa inputs. In 1969 Ghana returned from its military government to party politics. However, the country still struggled and, with the decrease in world prices, the IMF was invited again in 1971, enforcing another round of currency devaluation and austerity (Gocking 2005, 158). Another coupe took place in 1972, but the economy remained in severe distress. The smuggling of cocoa to Ivory Coast and Togo, where producer prices were up to five times higher than in Ghana, became a problem. With the decline of the rural infrastructure also food production suffered and urban food prices rose. Inflation soared between 1974 and 1977. Foreign exchange was lacking and imports could not be paid for (Mikell 1989, 202). The 'Operation Feed Yourself' introduced by the new military regime in order to handle the food crisis further incentivised cocoa farmers to turn their back on the cash crop (Gocking 2005, 168). Farmers either returned to the home villages, searched for alternative wage labour (e.g., in the Nigerian oil sector), or used cocoa plantations for subsistence farming.

A third coup followed in 1979, initiated by Jerry Rawlings (Mikell 1989, 211-3). Rawlings pushed for fixed prices to curb inflation, burned down market places which, in his eyes, were breading beds for corruption, jailed and executed corrupt civilians, entrepreneurs and military officers alike, and dismantled the CMB (Gocking 2005, 180). Later the same year he turned to the revival of party politics and the People's National Party (PNP) under Hilla Limann was elected. The PNP raised the cocoa producer price beyond the international market price to encourage production. However, rural infrastructure bottlenecks and shortage in wage labour made this policy unsustainable (Mikell 1989, 213). With the elected government failing, once again, to manoeuvre the country out of its economic struggle, Rawlings, in another coup, took over in 1981.

By then the cocoa sector occupied more than 50 per cent of the area under cultivation, provided employment for 24 per cent of the labour force and accounted for over 60 per cent of the total export in Ghana (WAPD 1983). However, the sector was in despair with sharply declining real prices since the mid-1950s and subsequently falling production from 400,000 tonnes to 200,000 between mid-1960s and early 1980s (Figure 7.2).

Figure 7.2: Ghana Cocoa Production Per Region and Crop Year
(in thousand tonnes, 1960–2009)



Source: Cocobod Statistical Division.

Not surprisingly, the impact of the Second World War on the cocoa–chocolate industry in Europe and the US was significant. Europe, and also the US, maintained a rationing system in the post war period for many commodities including cocoa and chocolate (Wickizer 1951, 347-8). This made the task of marketing boards during the early post-war years easier.

With former colonies gaining independence, the difficulties faced especially by developing countries due to commodity price instability found discussion in the international community. During the 1950s and 1960s many countries saw their development plans undermined by adverse changes in world commodity prices and repeatedly declared their frustration with the General Agreement on Tariffs and Trade (GATT), which was pushed through foremost by the US as an advocate for free trade (Maizels 1992, 102-5).

This frustration resulted in the first convention of the United Nations Conference of Trade and Development (UNCTAD) in 1964, which openly questioned the benefits of free trade for commodity exporters with reference to Prebisch (1950). A decade earlier, negotiations about commodity price stabilisation schemes already began under the auspice of the United Nations Food and Agricultural Organisation (FAO) (Ernst 1982, 122-7). The discussion was taken up by UNCTAD, which negotiated the first International Cocoa Agreement (ICA) in 1972. The ICCO was established the following year, in order to put the agreement in effect (Maizels, Bacon and Mavrotas 1997, 28). Several more agreements in 1975, 1980, 1986, 1993, 2001 and 2010 followed.

However, the mandate of the ICCO and the aim of the ICAs changed over the years (Maizels, Bacon and Mavrotas 1997, 45-7). The objectives of the early agreements included stabilisation of volatile prices, a balanced expansion of the cocoa industry, and an increase in income and export earnings for producing countries. The latter point was dropped in the 1986 agreement and the remaining ones were watered down with the 1993 agreement. Thereafter the mandate of the ICCO changed into a consultative board (ICCO 2015). In parallel, the tools available to the ICCO eroded. Price quotas were dropped after the 1975 agreement and buffer stocks were abolished when the 1986 agreement failed only two years after its ratification (Maizels, Bacon and Mavrotas 1997, 28).

The aim of commodity agreements across the board shifted away from the notion of price stability towards "developmental" measures like increasing productivity, efficiency and cost reduction (Maizels 1992, 137-8). At the same time, other sources, dealing with the repercussions of volatile commodity prices, ceased existence as for instance the Compensatory Finance Facility of the IMF. The facility was introduced in 1963 in order to provide counter cyclical funding for the mitigation of short-term income shocks from low commodity prices. In the early 1980s, during a time of particularly low commodity prices, conditionalities were attached, and by the late 1980s the facility became fully integrated into the IMF. As a result of decreasing prices and a discontinuation of institutional support, commodity dependent countries accumulated huge debts.

7.2.3 Cocoa under Structural Adjustment and Beyond

Like many other countries during the 1980s, Ghana, once again, reached out to the IMF for assistance. Forestalling the IMF's austerity program, the government drew up an extensive plan for financial reform, which, among other areas, targeted at the cocoa sector (Gocking 2005, 194). The CMB was dismantled and replaced by todays Ghana Cocoa Board (Cocobod) and the setting of a producer price was passed on from the government to a Producer Price Review Committee (PPRC) in order to avoid conflict of interest (WAPD 1983, 24). Few years later, the Agricultural Services Rehabilitation Project was launched, which aimed at a stepwise increase of the FOB share received by farmers from 30 to 55 per cent (Quartey 2013). By 1989 prices paid to cocoa farmers had increased 14-fold. Meanwhile, Cocobod staff was halved by 1986—nearly 25,000 employees were Ghost workers (Williams 2009)—and further reduced to one-tenth of the staff number of the early 1980s by mid-1990s (Akiyama, et al. 2001).

After reaching a low in mid-1980s, cocoa production increased again under Rawlings' reign (Figure 7.2). The successful revival of the cocoa sector was the result of several policies, like the introduction of new high yielding cocoa hybrids, the provision of mass spraying of trees and the allocation of subsidised fertiliser. Those, together with increased producer prices, propelled farm yields and triggered an expansion of the cocoa belt towards the Western region (Teal, Zeitlin and Maanah 2006).

In 1991 a new constitution was drawn, the ban on political parties lifted and in January 1993 the first elected Parliament of the country's Fourth Republic convened, with Rawlings becoming its first president by absolute majority (Gocking 2005, 217). The same year stepwise liberalisation of the cocoa sector was launched. In 1992/93 Cocobod partly liberalised domestic buying of beans and consequently ceded the PBC's monopoly position and the PBC was privatised in 2000 by listing its shares on the Ghana stock exchange (Ul Haque 2004). Especially in the years after liberalisation, local haulage companies went into bean sourcing and registered as licenced buying companies (LBCs) with Cocobod (Vigneri and Santos 2008).

As part of the cocoa sector reform in 2000/01, private companies were allowed to export up to 30 per cent of their cocoa purchases directly (Akiyama, et al. 2001, 63). However, this opportunity was never taken up and evidence suggests that this rout is still blocked successfully, although not openly, by Cocobod (Laven 2010, 85-7). Further, the government set the new goal for farmers' income to 70 per cent of cocoa export earnings with the intention to link producer prices closer to the world price. Moreover, the trading system entertained by the Cocoa Marketing Company (CMC), a Cocobod subsidiary, was reformed. With the arrival of electronic trading platforms, real-time financial market data became easily available, which enabled the implementation of a forward selling system.

Increasing producer prices, price stability and state provision of extension services resulted in a steady increase in cocoa production. The trend was further supported by the rising competition among LBCs. While those did not compete on prices, they competed over volume through service provision to farmers (Vigneri and Santos 2008; Fold 2008), as well as prompt payment and credit supply (Anang 2011). Zeitling (2006) presents statistical evidence that increased competition among LBCs is associated with output growth. With the new millennium, trees planted on virgin forest land in the Western region in the early 1990s matured, while trees at older plantations were providing higher yields due to improved input provision (Figure 7.2).

Although partial liberalisation promoted productivity, it has also eroded Ghana's quality premium. Since LBCs were motivated to deliver cocoa as quickly as possible in order to turn over their loans, beans were often not properly dried and fermented before export (Gilbert 1997). However, in contrast to fully liberalised West African neighbours, a premium at the world market could be maintained through the strict supervision of Cocobod's Quality Control Division (QCD)—although at a lower level than before (Fold and Ponte 2008). Aside from liberalisation, another force played into the erosion of the premium, which was the decreasing demand for quality from grinders due to technological advances in the processing of cocoa beans (Gilbert 2009).

The restructuring of the Ghanaian and West African cocoa sector coincided with and in many ways facilitated a restructuring of the global cocoa–chocolate industry (Fold 2001). During the 1970s to 1990s the industry experienced both increasing vertical integration and horizontal concentration in the trading, grinding, and chocolate manufacturing segment. Fold (2001) counts more than 200 take-overs among chocolate producers during this time period. The restructuring of the industry precipitated new power relationships and led to Fold's (2002) bi-polar description.

Saturated markets and demographic and social changes in chocolate consuming countries brought about by an aging population, fragmentation of tradition households and cultural diversity, demanded product innovation and differentiation, which led to an increasing focus on branding and marketing by chocolate producers (Fold 2001). Today product differentiation is not only driven by competition among snack food providers, but also from consumers' growing concern over health and social and ethical aspects of the product and production processes. These developments, in several ways, motivated chocolate producers to outsource bean processing.

Cocoa bean processing is associated with dirt and dust from roasting, husking, and grinding beans. Shifting such activities away from chocolate production sides made it easier to obey to stricter sanitation standards. Advancements in process technology further enabled codification of the grinding process even up to the production of chocolate itself (Gilbert 1997). Another factor that played into outsourcing of cocoa processing is the increasing attention towards a firm's financial performance. In particular in the US, a saturated market confined the growth of chocolate manufacturing companies to mergers and acquisitions. Branders were hence motivated to deliver higher returns on capital employment in order to increase shareholder value (Gibbon 2002). As a result, bean sourcing and inventory management, which requires high working capital, was outsourced.

Technological advancements also brought about changes in the trading segment. In search for diversification of their product line, players who originally established themselves as grain trader, entered into cocoa. Those players introduced bulk shipment and flat storage[90], which became relevant for cocoa in the late 1990s and eased transportation and storage costs (UNCTAD 2008; Fold 2001). This method is intrinsically linked to economics of scale. Scale economies arising in transport and storage caused smaller traders to struggle, which resulted in a consolidation of the trading sector (Gilbert 1997). Further, increasing competition reduced trading margins and forced many to attempt unhedged positions in order to increase profitability (International Trade Centre (ITC) 2001, 83). Especially smaller traders which were less well-capitalised than their larger counterparts faced bankruptcy.

Under the dominance of few large trading houses, a transition of commodity trading into distributive and added-service trading emerged (ITC 2001, 84). Such development foremost started in the US with just-in-time delivery under the turn-key system (Sturgeon 2002, Fold 2001). Just-in-time delivery requires large working capital since the time period between buying and selling could be months instead of days as in the previous system. Simultaneously, changing banking regulations enabled trader to source working capital through futures brokers (ITC 2001, 84). The relationship between banks and commodity traders grew closer and today large trading houses have in-house brokers offering hedging services to smaller market actors, as well as clients in the chocolate manufacturing and grinding business.

In a similar manner as for the trading segment, the financial marker played a pivotal role in the consolidation of the grinding segment. Cocoa prices have always been highly volatile

[90] Storage technique where beans are piled up as opposed to beans being stored in jute sacks.

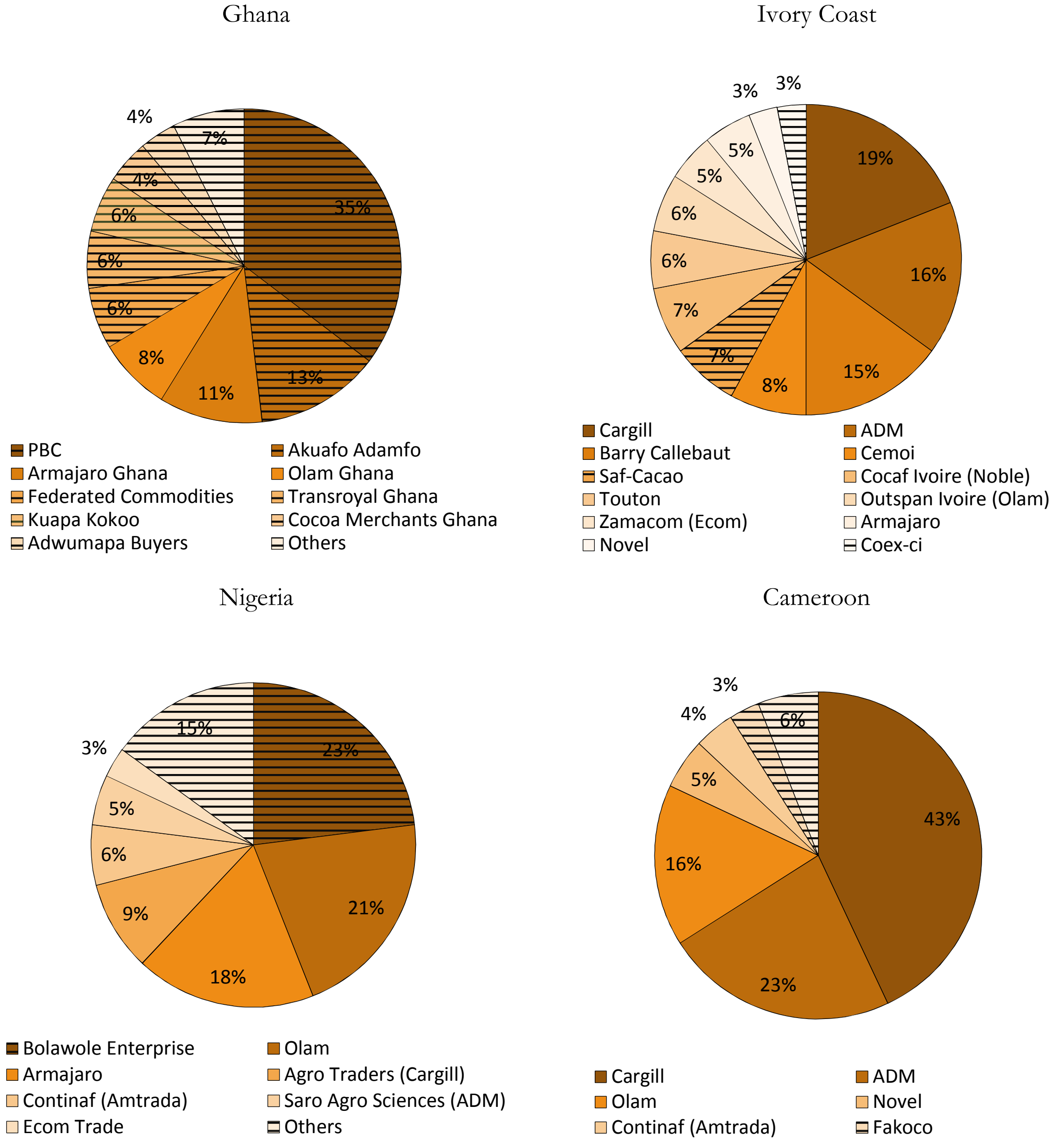
and risk management tools like financial derivatives provided a competitive edge to those able to use them. These were usually large grinders, due to the costs associated with hedging. With their own trading desks in place, these companies were able to manage their risk better than smaller companies, and to make significant revenues on non-hedging activities, as well as offer those products to their clients against a service charge (Murphy, Burch und Clapp 2012). The position of the grinding segment was further strengthened with the growing tendency of chocolate manufacturers to outsource processing. Branders became increasingly dependent on the skills of their processing companies which provided tailor-made intermediate products.

The trading segment became more concentrated and diversified into various service segments including just-in-time delivery, risk management, and ultimately also grinding and processing. Decreasing profit margins from traditional commodity trade paired with the strengthening of the grinding segment led to an increasing integration of trading and processing firms. With the distinction between trading and processing segments blurring, Fold (2002) introduced the notion of 'first-tier suppliers' for both segments. While the trading segment integrated into the grinding segment, traders and grinders alike vertically integrated upstream, sourcing their cocoa via subsidiary companies in producing countries.

The dismantling of trading boards in producing countries and liberalisation of the cocoa sector enabled downward penetration of the local cocoa buying sector. One motive for vertical integration by first-tier suppliers was increasing risk of non-performance and uncompensated losses as well as uncertainty over the quality of the crop after former quality control systems and trading boards were dismantled. A related reason was increasing demand for speciality beans, following the rise of social and environmental standards. Vertical integration enables traders and grinders to secure sufficient supply and to monitor compliance with standards in order to fulfil customers' demands (Fold 2001; Laven 2010, 57). Last but not least, the acquisition of information is an essential motive for vertical integration. Private knowledge about crop outlook is an important advantage in negotiations over trading contracts and further enables grinders and traders not only to manage their risk more efficiently but also to benefit from speculative positions in the financial exchange (Van Dijk, Berntsen and Berget 2011).

However, vertical integration played out differently in West African cocoa producing countries. Although Ghana opened its internal buying segment to private domestic and foreign companies, only few multinational companies entered the sector. In contrast, in fully liberalised neighbouring countries the sector was almost completely penetrated by multinational buyers, which ousted domestic companies over credit and cash advantages. Figure 7.3 shows the market share of different cocoa sourcing companies in Ghana, Ivory Coast, Nigeria and Cameroon. Domestic-owned companies are in stripes. 81 per cent of Ghanaian cocoa beans were sourced by domestic companies, while 90 per cent of all Ivorian beans were sources by foreign firms in the 2010/11 crop year.

Figure 7.3: Share in Total Volume of Purchases by Company
(as of 2011/12 crop year)



Source: George (2012).

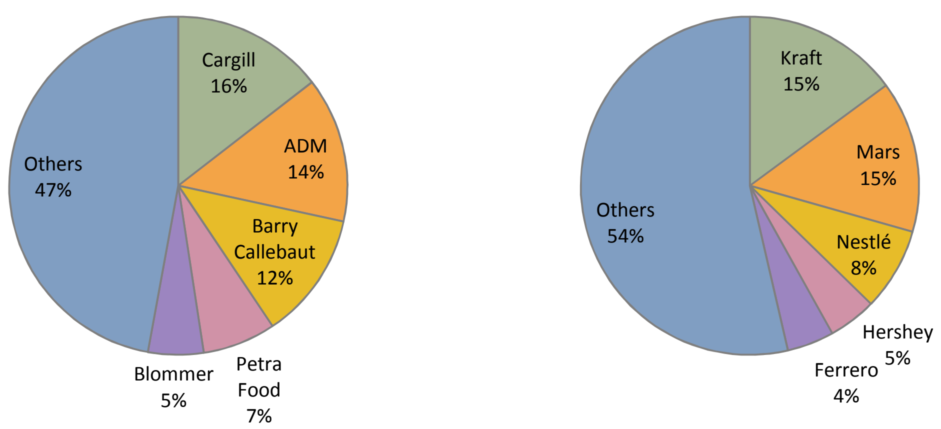
It has to be noted that for Ghana the share by local companies is overestimated as some of the major buying companies are joint ventures between local and foreign firms. Among those are Akuafo Adamafo, which belongs to the Finatrade Group and is partly Lebanese (Sucatrade) owned and Kuapa Kokoo. The latter is a fair trade farmer's cooperation and gets support from the Fair Trade organisation and other stakeholders[91] (George 2012). Further, large local buying companies partner with multinational exporters for certification.

What emerged from this period of horizontal consolidation and vertical integration is a complex system of few large first-tier suppliers, which expand into sourcing, certification, warehousing, risk management, and even chocolate production. These compete over power with multinational branders, that is, large food producers offering a wide variety of brand names and chocolate and cocoa-containing confectionary goods (Fold 2002). This brought about 'co-existing collaboration and intensified rivalry' between large grinders and branders within the cocoa chains. Another dominant player emerged which are retailers with their own standards and requirements (Fold and Larsen 2011).

Given the sensitivity of chocolate consumption to business cycles, the recent economic depression in Europe and the US has put considerable pressure on the industry and contributed to further consolidation through mergers and acquisitions. Today chocolate markets are dominated by five companies, which are Kraft (Mondelez), Mars, Nestlé, Ferrero and Hershey. Kraft increased its share with the acquisition of Cadbury in 2009. The grinding segment is even more concentrated. Until 2010 five companies were producing more than half of the semi-finished cocoa products globally. These were Cargill, Archer Daniel Midland (ADM), Barry Callebaut, Petra Food and Blommer (Figure 7.4).

Figure 7.4: Grinders' and Chocolate Manufacturers' Market Share
(as of 2010)

Grinders' percentage Share in Global Semi-finished Cocoa Products — Chocolate Manufacturers' Percentage Share in Global Confectionary Market



Source: TCC (2010).

[91] Kuapa Kokoo is the only Fair Trade certified co-operative in Ghana. In 1997 the cooperative set up a chocolate company (today Divine Chocolate) in the UK. In partnership with Twin Trading and with support by Body Shop, Christian Aid and Comic relief, the company was formed with Kuapa Kokoo owning a third of its shares.

Barry Callebaut acquired Pertra Food in 2012 and Cargill bought ADM's processing and chocolate business in 2013 (Reuters 2013). This leaves almost half of the global grinding business in the hands of two companies. The trading house Olam entered the grinding segment through the acquisition of ADM's cocoa processing arm in 2014 (Reuters 2014). In the same year, another major trading house, Armajaro, sold its cocoa sourcing unit to the soft commodity trader Ecom in order to focus on its commodity hedge funds (Agrimoney 2014). Olam too stepped up its financial market presence and was fined $3 million USD for exceeding position limits at six occasions between 2011 and 2013 (Financial Times 2015).

Due to innovations in bean processing, most multinational grinding companies depend less on quality and origin parameters of the beans than a couple of years ago and processing became standardised and codifiable. These technological advances paired with the increasing focus of first-tier suppliers on added services and their financial businesses, promoted origin processing. While origin processing still faces the disadvantage of not being able to blend cocoa from different origin, these aspects became less important and the bean processing into cocoa nibs, liquor, powder and butter is now economically viable not least due to the substantial tax exemption offered by respective governments.

Table 7.1: Cocoa Bean Production and Grinding per Country and Region (2000 compared to 2013)

	Cocoa Bean Production (in thousand tonnes)		Grinding of Cocoa Beans (in thousand tonnes)		Percentage Share World Production		Percentage Share World Grinding		Percentage Share National Grinding in National Production	
	2000	2013	2000	2013	2000	2013	2000	2013	2000	2013
Cameroon	115.00	225.00	31.80	30.00	3.74	5.74	1.07	0.74	27.65	13.33
Ivory Coast	1,403.6	1,445.0	235.00	460.00	45.62	34.18	7.94	11.35	16.74	31.83
Ghana	436.90	835.40	70.00	225.10	14.20	17.39	2.37	5.56	16.02	26.95
Nigeria	165.00	225.00	22.00	28.00	5.36	6.47	0.74	0.69	13.33	12.44
Europe			1,335.3	1,574.5			45.14	38.86		
USA			447.60	411.80			15.13	10.16		
Africa	2,155.6	2,813.2	367.50	754.60	70.06	68.40	12.42	18.62	17.05	26.82
Americas*	388.90	617.60	404.00	466.00	12.64	14.18	13.66	11.50	103.88	75.45
Asia & Oceania	532.50	500.10	404.10	845.10	17.31	17.42	13.66	20.86	75.89	168.99
World	3,077.0	3,931.0	2,958.4	4,052.0						

Note: *without US, Figures for 2012/13 are ICCO estimates. Source: ICCO, Quarterly Bulletin of Cocoa Statistics, various volumes.

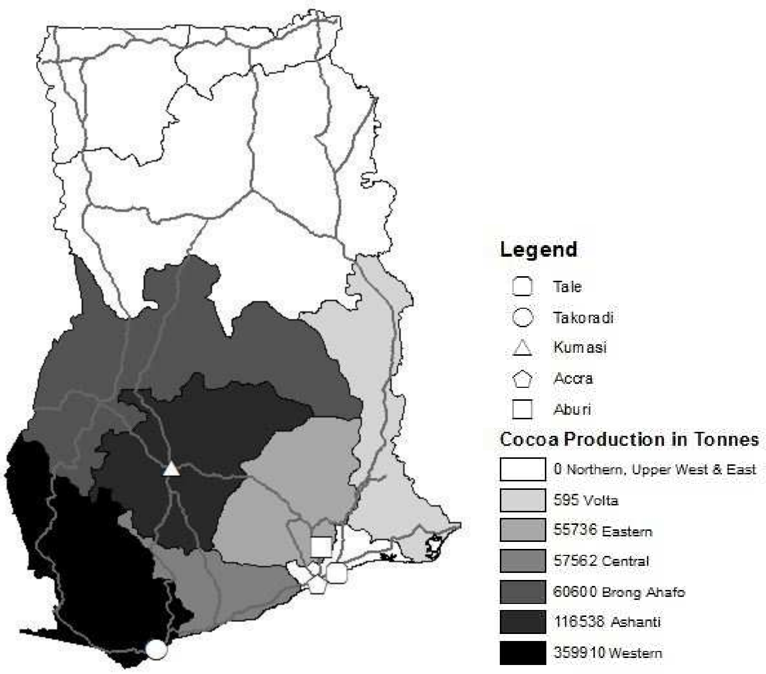
From 2000 to 2013 Ivory Coast and Ghana could increase their share in world grinding from 7.9 and 2.4 per cent to 11.4 and 5.6 per cent respectively. This amounts to 31.8 and 27.0 per cent of domestic production respectively (Table 7.1). Ghana could more than triple its grinding capacity over the same time period. Whether this development will move

West African countries into higher value added and chocolate production viable for the global market is, however, questionable [G8].

7.3 Structure of the Ghanaian Cocoa Sector

Between October and December 2013 semi-structured interviews at different stakeholder levels were conducted in Akra, Tema, Takoradi, Kumasi and cocoa sites around Kumasi. Figure 7.5 depicts the locations of the interview sites and the respective cocoa regions in Ghana. Appendix 7.2 provides a list of all targeted interview partners and those reached. Given the time constraint, only 34 in-depth interviews could be conducted. The interviews were focused on four different subjects: price formation, risk management, the role of financial markets and regional and global chain structure. These together reveal the institutional structure of the chain, mode and matter of transactions within the chain, and existing working rules. Interview questions are provided in Appendix 7.6. All interviews were recorded and transcribed with permission of the interviewee. If not agreed to the recording, hand written notes were taken. Further, each interview partner was asked about the level of anonymity he or she would prefer and an agreement was signed before each interview; a copy of which can be found in Appendix 7.3.

Figure 7.5: Map of Ghana's Main Cocoa Growing Areas and Interview Sites



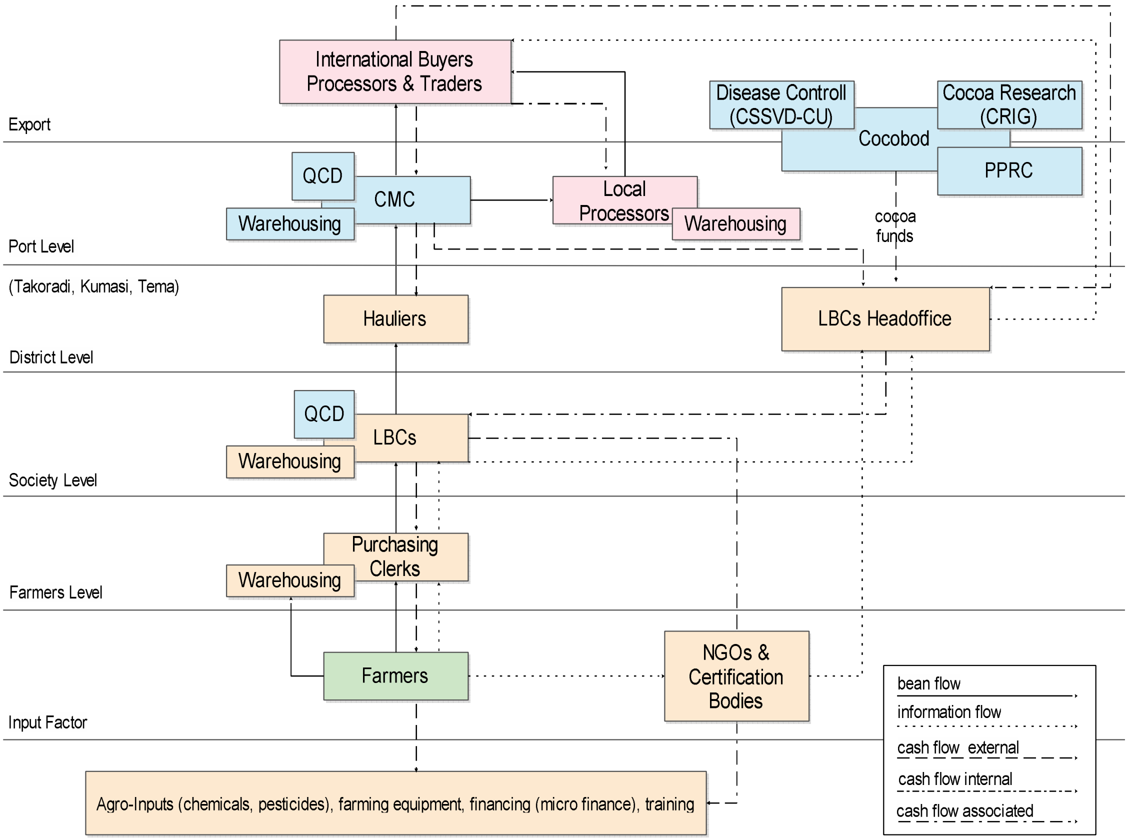
Notes: Cocoa output figures as of 2009/10 crop year. Source: Cocoa output figures were kindly provided by Cocobod Statistical Division, author.

Due to time constraints, only chief farmers, but no other cocoa farmers, were interviewed. Other stakeholders include local processing companies, LBCs, hauliers, warehousing services, extension services, certification officers, and government officials inside and outside Cocobod, which include the finance ministry, port officials, quality control division, statistical division, shipping office and several traders working for CMC. Further, at the international level interviews with chocolate manufacturers, processors and traders in the UK, the US and Germany were conducted in the months prior to the fieldwork in Ghana. Interviews with companies in Germany and the US were conducted over the phone. Private companies were approached via email (see Appendix 7.5) or called on telephone numbers found through internet research. Ghanaian government organisations were reached through a letter of introduction addressed to the Chief Executive of Ghana Cocoa Board (see Appendix 7.4). Further interviews were facilitated via contact established during the stay in Ghana and through interviews with European and US companies prior to the visit to Ghana, as well as personal relationships.

The analysis is divided into three different parts. Firstly, the international level is analysed, including chocolate manufacturers, processors and traders outside of Ghana, but engaging with Ghana for sourcing beans (*global marketing*). Secondly, Cocobod with its divisions and subsidiaries is analysed with a particular focus on CMC, which acts as the trading arm of Cocobod (*external marketing*). Other divisions and subsidies of Cocobod are the Cocoa Research Institute of Ghana (CRIG), the Cocoa Swollen Shoot and Virus Disease Control Unit (CSSVSC), and the Quality Control Division (QCD). Thirdly, other stakeholders in Ghana including hauliers, LBCs, purchasing clerks, and farmers are analysed (*internal marketing*). Here the PPRC—a government associated body—takes a prominent role. The interrelationships of all three parts of the analysis are depicted in Figure 7.6.

Red boxes indicate multinational buyers and processors. Orange boxes indicate local stakeholders, which might or might not be associated with multinational buyers and processors through vertical integration, joint ventures, project funding, finances and other partnerships. Boxes in blue indicate government bodies, which are divisions and subsidiaries of Cocobod. Five different arrows indicate flow of beans, information, external finances, internal finances and finances between independent but associated entities.

Figure 7.6: Ghana's Cocoa Chain Structure



Note: Red indicates multinational buyers and processors, orange indicates local stakeholders and blue indicates government bodies. Source: Author.

The internal chain structure is further subdivided into different levels, which resemble the journey of the cocoa bean from farm to port. Cocoa beans are harvested, dried and fermented at farm level, usually in the cocoa villages, which make the centre of a number of cocoa plantations located in the adjunct bush. The organisation of farmers in co-operatives is rare in Ghana and the overwhelming share of cocoa is recovered by purchasing clerks, who are hired by a particular LBC. Purchasing clerks are members of the cocoa society they are buying from and manage a warehouse in the cocoa village, where the beans are dried, checked for quality[92], weighted and packed (Figure 7.7). Quality checks at this level are mostly concerned with the extent of foreign material and sufficient dryness of the beans. The purchasing clerk then brings the cocoa to the respective LBC's shed at the district level.

[92] Although Cocobod refrains from quality control at the society level, purchasing clerks have their own mechanisms in place as they are incentivised to deliver sufficiently dried and fermented cocoa to the district warehouses [G2].

Figure 7.7: Beans and Scale in a Shed in a Cocoa Village near Kumasi

Note: The cocoa is dried until the shells are crumbly and break easily if squeezing them. In the process the bean colour darkens. When it rains beans are covered with corrugated sheets or foil. Jute sacks are provided by Cocobod and allocated to purchasing clerks via LBCs. Only jute sacks from Cocobod with the print as shown in the picture are accepted by CMC. Source: Pictures taken during a cocoa village visit near Kumasi November, 13th 2013.

Logistically the country is divided into several cocoa districts, which again are constituted by a number of cocoa communities. Cocobod counts 69 cocoa districts [G2]. LBCs split these districts into smaller operational units and the number of LBC districts varies between 80 and 100 [L1-4]. A district might again consist of 30 to 60 farming communities [G2]. LBCs have representatives at the district level (regional depots), which are in charge of appointing their purchasing clerks. There the cocoa is checked for its quality by QCD, reweighted, and sealed for export [G2]. If the cocoa does not meet the required standards, it has to be either redried or is confiscated by QCD without compensation.

Hauliers are hired by LBCs for transportation of the cocoa from the district to one of the three 'ports' which are Tema, Takoradi and Kumasi. The latter one is an inland port, usually receiving the beans for local processing (smaller beans), while the former two are sea ports and beans are usually for export. At the ports the cocoa enters the takeover points, which are CMC owned or rented warehouses from where the cocoa has to be taken up either by the international buyers or local processors. Before the cocoa enters the warehouse it is checked for quality one more time (Figure 7.8). The cocoa samples taken are kept and stored by QCD for insurance reasons in case arbitration is necessary.

Figure 7.8: Cocoa Bean Sacks to be Offloaded Into a Bulk Warehouse at Takoradi Port

Note: The holes in the cocoa sacks are from "horning", which refers to a method by QCD through which a cocoa sample is taken. A "horn mask" is pushed through the jute sack without damaging it. Source: Pictures taken during Takoradi Port visit November, 12th 2013.

LBCs work as agents for CMC and LBCs are obliged to deliver their cocoa to the ports according to a schedule published by Cocobod prior to the start of the season [G2, H1]. Since liberalisation of the internal trading segment, the number of LBCs steadily increased from 4 in 1992/93 to 29 registered and active LBCs in 2012/13[93]. The minimum requirement for an LBC to get registered with Cocobod is a buying capacity of 2,000 tonnes of cocoa. This, at the time of the fieldwork, amounted to cocoa worth $3 million USD. These requirements pose barriers to entry. The former state owned PBC still holds the majority share in sourced cocoa volume and acts as the buyer of last resort for more remote cocoa farms, foremost in the Volta region.

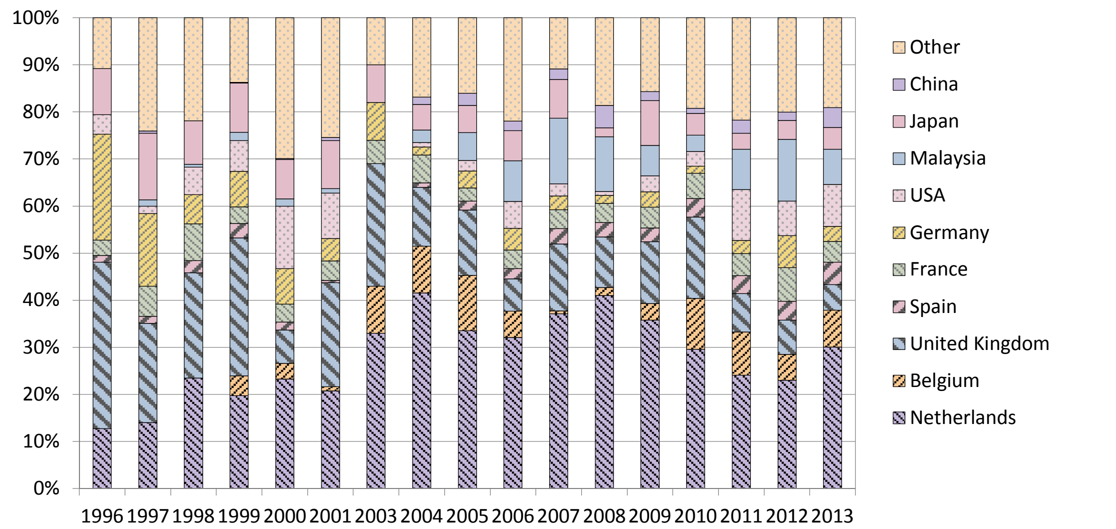
Ghanaian beans, in contrast to beans from Ivory Coast, are still shipped mainly in jute sacks. Only one international company facilitates bulk shipment at Takoradi Port [J3]. The reason for the low demand for bulk shipment is that Ghanaian cocoa still fetches a premium at the global market and buyers are careful not to mix Ghanaian beans with cocoa

[93] According to data kindly provided by Cocobod Statistical Division.

from other origins. Further, as grinders might only buy a few tonnes of Ghanaian cocoa for flavouring, the volume is often too small for bulk shipment.

The great majority of cocoa exports arrive in Europe and the US. Those regions accounted for 65 per cent of Ghanaian cocoa exported in 2013. Two new trading partners under the top ten importers recently emerged which are Malaysia and China. Malaysia has an excess capacity for grinding cocoa[94] while China made a deal with Ghana over 40,000 tonnes of cocoa to be delivered annually from 2005 onwards in return for funding for the Bui hydro power plant on the border between the Northern and the Brong Ahafo Region [J2]. The greatest importer is the Netherlands with Amsterdam harbour processing most cocoa beans globally, replacing the UK as the dominant destination since 2004 (Figure 7.9).

Figure 7.9: Export Destinations of Raw Ghanaian Beans
(annually, in percentage shares, 1996-2013)



Source: UN Comtrade (author's calculation)

All cocoa has to go through CMC, which acts as the sole seller of Ghanaian cocoa to international byers via forward contracts. Smaller beans (referred to as mid-crop[95]) are sold at an up to 20 per cent discount to the local processing sector [G2]. After selling 60 per cent of the projected harvest forward, CMC extends cocoa funds to LBCs below market rate. The funds are allocated by the respective LBC to the different district officers, who then give their purchasing clerks cash advances to buy the cocoa for them. Purchasing clerks are further equipped with weights, cocoa sheds, tarpaulin, and jute sacks by the LBC. After delivery, cash advances are renewed, commission is paid, and the purchasing clerk returns to the society for further purchases. When the LBC delivers the cocoa to one of the

[94] Malaysia holds the largest cocoa processing industry in Asia, which processes eight times its domestic production.
[95] The division follows the bean size and not the harvest period, although these correlate since mid-crop beans are usually smaller.

ports, it is compensated by CMC and loans are turned over. LBCs as well as hauliers receive a set margin for their services to CMC [H1, G2].

Extension services and input supplies are provided by government schemes and increasingly also through non-governmental organisations (NGOs) and private companies [I2]. While the provision of governmental services varies with election seasons, available budget of Cocobod, and changing interests of government stakeholders, NGOs partner with foreign buyers for funding. In return those NGOs assist in the execution and supervision of standards set by international buyers. The close work with farmers does further allow a better information flow towards LBCs and associated multinational buyers regarding the forthcoming harvest and potential bottlenecks.

7.4 Price Formation and Risk Allocation

Following the structure of the cocoa chain, the analysis of price formation and risk allocation is divided into three segments: global marketing, external marketing, and internal marketing. In each section the particular institutional structure with existing working rules, mode of transfer and matter of transfer is revealed and implications for price formation, as well as risk allocation identified.

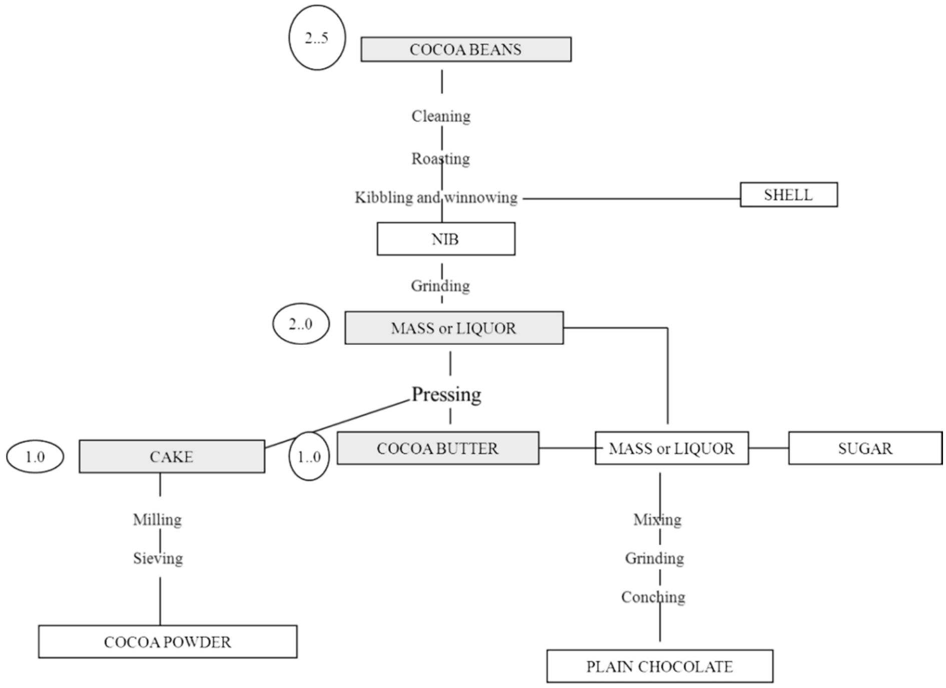
7.4.1 Global Marketing: Traders, Grinders and Manufacturers

Most first-tier suppliers[96] and chocolate manufacturers are in a bargaining transaction. However, existing working rules limit the negotiation process in several ways. Moreover, working rules differ with the matter of transfer. The matter can be raw cocoa beans as well as intermediate products like cake, powder, butter and liquor. The physical transformation process of cocoa beans is described in Figure 7.10.

While the price for cocoa liquor is directly based on the bean price, cocoa powder and butter are traded independently. The trade with intermediate cocoa products is a relatively recent phenomenon and contracts are not as standardised as for cocoa beans (Dand 1995, 103). For raw cocoa beans, existing working rules, in the form of standardised contracts, do not permit much freedom in negotiating prices. With few exceptions in the speciality cocoa segment, the bean price is contractually linked to the futures price.

[96] Since the different segments at the international buyer level became increasingly intertwined, traders and grinders will be jointly referred to as 'first-tier suppliers' where reference is made to both.

Figure 7.10: Cocoa Bean Content in Intermediate Products



Note: The circled numbers denote the physical relationship in terms of tonnage. Source: Graphic kindly provided in interview [D1].

Companies are part of trading associations, which offer standardised forward contracts and arbitration services. Cocoa trade, involving Ghanaian beans, is usually based on contracts drafted by the Federation of Cocoa Commerce (FCC)[97]. Two basic contract forms can be distinguished: (1) fixed price contracts, in which the price is fixed to the price of the futures contract close to maturity plus a premium, and (2) differential contracts, in which the price floats with the price of the futures contract plus a premium. Under the former contract type, the price risk is with the seller. Since the exchange only trades the 'generic cocoa bean' the difference of the traded bean to the generic bean has to be negotiated, which is the premium[98] [D1]. Further, details about bean quality are included in the contracts, and delivery point, transportation, and insurance are negotiated [A1, D2]. Regardless of the precise contract specification, the price is linked to the futures market [A1]. On the example of a large chocolate manufacturer buying cocoa via a differential contract the close relationship becomes apparent:

> *"The futures and the physical market are the same. Let's say we are a chocolate company. When we are starting to buy beans, we purchase a 3-month forward future and at the same time go to a dealer and order 100 tonnes of cocoa beans for 60 over terminal. We have to close the futures at some point. So we exchange the futures contract with the dealer for the physical cocoa. The dealer*

[97] FCC emerged out of the merger of CAL and AFCC in 2002

[98] Premium, differential and market basis are interchangeable.

can then decide if he actually wants to take delivery through the futures or close out the position before expiration". [D1]

Some buyers might opt for a variation of the differential contract, where the timing of the price fix is determined by the buyer (or the seller, depending on the contractual arrangement) after the contract has been signed:

"It is all tied to the futures price. So 99 per cent of the sales we make are done on the basis of a price that is fixed at a later day. […] If I am selling a year forward […], I will always talk in terms of what premium to London the cocoa is. So we might say, I offer you 1,000 tonnes of Ivory cocoa for October-November shipment at £30 over December London. This means the premium is £30 [over the Liffe contract price maturing in December]". [D3]

The price formation process embedded in each transaction is hence determined by the existing working rules formalised by FCC. Working rules link the price of the physical bean to the price at the futures exchange—the London LIFFE[99] exchange for West African beans. However, some agents with sufficient economic power can bend existing working rules. For example, Nestle occasionally issues a tender and invites offers for a certain quantity of cocoa for a certain delivery time at a certain destination, which means they operate a Dutch auction [B1]. Nevertheless, such an auction is the exception and most transactions are negotiated based on standardised forward contracts.

Since the price level is set by the exchange, only the premium is left for negotiations. Those negotiations are strictly private and terms are undisclosed.

"The differential is separate and non-public. It is very subjective, based on negotiation. Butter and powder markets are even less transparent". [D1]

The outcome of negotiations is determined by information asymmetries, as well as other sources of economic power. In order to gauge the appropriate premium both parties take factors like historical market basis, freight costs, interest, crop forecasts, competition for the upcoming crop, and alternative suppliers into consideration. After assessing these factors, both parties enter into negotiations [D3].

In contrast to raw cocoa beans, the prices for butter and powder are fully negotiated if not acquired through intra-firm trade. The negotiation process is as opaque as for the premium of the raw beans [D2]. Butter and powder prices are noted as ratios to the bean price.

[99] In the previous analysis US based ICE cocoa futures were analysed. Although LIFFE would have been the better choice, only US based futures exchanges provide trader-position data.

These do not necessarily reflect the cocoa bean content and powder and butter prices even move in opposite directions as grinders try to offset their prices when either butter or powder prices are low. The fact that prices are off-setting is clear evidence for the bargaining power of grinders (Figure 7.11).

Figure 7.11: Cocoa Powder and Butter Ratios at US Markets
(Oct. 2000–Oct. 2014)

Source: INTL FC Stone, Cocoa Monthly Report, November 2014.

Butter is an essential ingredient in chocolate, while powder is used for drinking chocolate, cookies and other confectionary products. Hence, butter is usually the dominant value factor. However, in the aftermath of the financial crisis in 2008 the situation changed. Confectionary producers expanded into emerging markets as a coping strategy during the recession [D1]. The choice of cookies over chocolate products was mainly driven by climate considerations, since regular chocolate melts in hot climates. In addition, the buying habits in conventional markets changed in favour of cookies and other bakery products since those are cheaper than chocolate [D1]. As a result, the powder ratio increased with a decrease in the butter ratio. A similar development is observable during the previous recession following the dot-com bubble crash in 2000.

Prices for intermediate cocoa products are not always negotiated. Especially in the case of origin grinding, intra-firm trade is common, where parent companies calculate the price for intermediate products regarding the bean content and the processing costs. Companies receive the order of how much cocoa they have to process into which intermediate product for export. Transactions are hence managerial. The beans used for origin processing are brought by the parent company in negotiations with CMC [C3]. In the 2012/13 crop year 68 per cent of Ghana's processed cocoa was transferred via intra-firm trade (Table 7.2).

Table 7.2: Local Processing Companies in Ghana

Companies	Location	Date of Establishment	Installed Capacity[2] as of March 2011	Realised[2] Processing (2012/13)	Products	Ownership
CPC LTD	Tema	1965	64,500	21,000	butter, liquor, cake, powder, chocolate	Former state owned, Ghanaian
WAMCO LTD	Takoradi	1947	47,000	-	butter, liquor, cake	Joint venture Ghanaian & German company
BARRY LTD	Tema	2000	67,000	63,000	liquor only	Foreign
AFROTROPIC	Accra	2007	15,000	-	liquor only	Ghanaian
NICHE COCOA*	Tema	2007	18,000	26,000	liquor only	Ghanaian
CARGILL	Tema	2008	65,000	57,000	butter, cake, powder	Foreign
ADM LTD	Kumasi	2008	42,000	31,000	liquor only	Foreign
PLOT	Takoradi	2009	32,000	25,000	butter, liquor, cake	Ghanaian
B.D ASSOC.[1]	Tema		?		liquor only	Ghanaian
REAL PRODUCTS[1]	Takoradi		11,200		liquor only	Joint venture Ghanaian & Ecuadorian company
Ghanaian			129,500	72,000	34% - capacity	32% - realisation
Joint ventures			58.200	-	16% - capacity	0% - realisation
Foreign			174,000	151,000	48% - capacity	68% - realisation

Note: * Before called COMMODITIES LTD, [1] installation of machines in progress, [2] in tonnes. Source: Data kindly provided during interview [G8].

As outlined in Chapter 6, transactions embed risks. Chocolate manufacturers commonly outsource in parts or fully their price risk to their first-tier suppliers. For instance, basis risk is transferred to first-tier suppliers while the remaining price variability can either be hedged via the exchange by the manufacturer himself (differential contracts) or the first-tier supplier offers to take over the hedging (fixed price contracts) as well as exchange rate risk. Hence, the allocation of risk exposure is written into the contracts by determining the mode of transfer. First-tier suppliers demand a negotiated premium for their risk management services to the manufacturers.

> *"The only way to insure against the basis risk is forward contracts. The risk is then by the trader. However, the trader demands a premium for managing such risk, which makes the purchase of the beans more expensive. In return the supply is guaranteed and price risk is managed". [A1]*

Chocolate manufacturers usually purchase beans from first-tier suppliers 12 to 18 months forward. Through the forward buy, the firm can decide early on whether and when to hedge. Especially larger manufacturers hedge strategically and lock in prices "at the most preferable point in time" and not mechanically at the point when the forward agreement is made. Contracts used for such arrangements are differential contracts. The price is floating with the price of a particular futures contract until the hedge is placed [A1].

Especially smaller chocolate manufacturers often lack the capacity to hedge via the exchange, and first-tier suppliers offer tailor made long-term risk management arrangements—contracts can span over 4 to 5 years [D1]. For instance, a small manufacturer buying curvature, which is chocolate with high cocoa butter content, enters into an arrangement with the supplier to fix the price for curvature. The price fixing is done in accordance to the particular formula of the required curvature.

> *"I can decide how to fix every price that is in that [curvature] formula. So I can say, let's fix the butter price today for the next six months of curvature. And for all the butter that goes into my curvature the price is fixed; or let's fix the sugar price, or the liquor price, or the cocoa bean price. And I can choose at any day which prices in my curvature I want to fix from then onwards and for how many weeks." "Behind the scenes [the large processor] is taking care of all the futures and handling all that in a way so that they can make money. They ask for a margin for their services and make some additional money". [D2]*

Traders, on the other end of the contract, net their price risk exposure internally and use derivative instruments, foremost futures and options, to hedge the residual risk [B1]. The task is complicated by the seasonality of the crop. While cocoa is seasonal on the supply side, it is less so from the consumption side. Although, there are certain peak times during Christmas and Easter, chocolate is consumed throughout the year. Due to seasonality factors, suppliers also manage quantity risk for their clients by agreeing to just-in-time delivery or similar arrangements.

> *"Our customers may ask us […] to deliver the cocoa to a port, it may be FOB it may be CIF, they may want us to deliver it just in time and they require us to hold the beans in their warehouse and we negotiate a minimum quantity and, perhaps, a maximum quantity that we hold". [B1]*

Similar to price risk, quantity risk is relatively easily manageable via the financial exchange and hence of only minor concern[100] for the first-tier suppliers. Of greater concern is basis risk, which ultimately remains with the first-tier supplier.

> *"The price risk is easy. That is just a matter of buying and selling futures against your cash positions. What isn't so easy is the basis risk; that you cannot hedge." "We have to buy and store cocoa because the crop comes out the three months before March but we are selling the entire year. So we don't have the luxury of buying just in time to get it to our customers. We have to buy when the crop is flowing and not when the customer wants to buy." "We are the ones who manage the most of the risk. This is actually why we exist. This is our business". [D3]*

[100] Short term quantity risk can be hedged via option trading.

Since the cocoa at the exchange is the residual cocoa, the exchange is usually not used by chocolate producers or processors for sourcing their cocoa. However, for large trading houses the cocoa at the exchange has value when arbitrage can be made [B1].

> *"Occasionally we use the futures market actively." "So the futures market becomes a supplier to us or a customer to us". [B1]*

For strategic hedging, basis risk management and arbitrage trading, information about cocoa supply and demand is essential. Through forward sales, high concentration of the first-tier supplier segment, and availability of grinding statistics[101] first-tier suppliers can make an informed prediction about future demand. Future supply, in contrast, is not as easily predictable. Especially for the management of basis risk, knowledge about country-specific supply conditions is, however, essential [D3]. In this context, vertical integration into bean sourcing is a strategy used by first-tier suppliers to gain access to information.

> *"If you only do external trading you do not know what is happening in the country. But if you have your sourcing operation also, you are closer to the farmer, to the producer and you are able to have some influence on the trade you are doing eventually. You have a better idea on how the crop will look like and how is the weather impact. This is important in order to make better informed decisions. One thing is as a trader you would read through say what Reuters would report, here you will have your own information sources to tell you this is what the competition is doing this is what is happening; so you have a better feel". [L4]*

Additional information is obtained via external services which might include brokers at financial markets, who are not only used for hedging but also information provision [D3]. Big trading companies even build their own weather stations [I1] and engage in pod counting[102] activities [B2] in order to forecast more accurately.

The only risk that is not yet frequently outsourced by manufacturers to first-tier suppliers is quality risk. Technology advances have, to some extent, mitigated such risk. However, luxury chocolate still requires high quality beans in order to achieve unique flavouring. Chocolate producers, who engage in luxury chocolate production, integrate vertically into sourcing in particular regions [A1]. Those engagements are usually confined to South America, where the cocoa is of particularly high quality. Another recently developed mechanism to mitigate quality risk used by chocolate manufacturers is the purchase of beans on 'in-store-basis', which means that if the quality of the beans delivered to the

[101] Grinding is used as a proxy for consumption, since cocoa is ground for all intermediate products.
[102] Pod counting entails counting the number of pods on a cocoa tree at a randomly selected farm and attaching a probability to it for reaching maturity [G2].

buyer's warehouses is insufficient, the manufacturer can decide against the purchase at the expense of the supplier. First-tier suppliers demand a premium for this service [A1].

Risk management services offered by first-tier suppliers have become more sophisticated and tailored towards clients. Simultaneously, the financial side of the trading, crucial for quantity and price risk management, has grown over recent years. New actors, unfamiliar with the physical business, like banks, increasingly seek to enter into the commodity segment. Two traders reported that they frequently receive calls from banks offering them tailored risk management derivative packages [B1, D2]. It is, however, ironic and maybe proof of the little understanding of banks about the commodity sector that they approach traders, whose very existence is built on the risk management services they provide to their clients. While first-tier suppliers would not be potential customers, manufacturers appear to take into account these services lured by the complexity of the instruments offered to them [D2].

Further, hedge funds increasingly build up commodity-specific expertise [D3]. Some of these hedge funds are associated with a physical trader, as for instance Amajaro until recently. These funds employ traders who are experienced in the commodity business and bring along their own industry contacts.

> *"Whether it is algorithmic system strategies or macro type guys or much more soft commodity-specific funds, who come in and out of the market; it is a combination of all of them I must say." "Some of the people that I used to work with in trade houses, ended up in hedge funds, operating with similar strategies that the ones we operating here in terms of the speculative activities we do". [B1]*

The fact that hedge funds have substantial knowledge over the market, makes traders in the physical business suspicious of changes in positions they do not foresee. As suggested in Chapter 3, traders constantly watch position-taking by other traders and try to extract information content.

> *"It is mainly couple of funds that have most of it. So do you know why they are in there, what are they doing, what is their reason for being in cocoa? Is it because they see profit in cocoa, is it because they don't see profit in other market, do they have information we don't have? This is another thing we look at and analyse all the time". [D3]*

While most interviewees have stressed that the surge in speculative investment has provided liquidity and made it easier to find a counterparty for their hedge, they have also uttered concern over the impact of speculative traders and over those "absurding the market" [D2]. Traders unanimously agree that speculators have a price impact, both positive and negative, given their size relative to the physical market [B1, D1-3]. However, opinions are divided regarding implications for smallholder producers. On the one hand, a price rise, driven by speculative investments, is perceived as positive for farmers. On the other hand, it is stressed that wrong incentives are set for farmers, which leaves them disadvantaged in the long-run.

> *"If the price goes up quickly it does two things: firstly it takes cocoa away from the factories and secondly at the same time tells farmers to plant more cocoa. So it has positive and negative effects. It does affect the price of cocoa, depending on what they [speculators] do. If it goes up it is not necessarily a bad thing". [D2]*

The high price level, attributed to the presence of speculators, certainly caused problems for the chocolate manufacturing sector at the time the fieldwork was conducted. Chocolate manufacturers delayed hedging their exposure. Manufacturers and processors time their hedges meticulously in order to lock in the most favourable price. However, this time the price did not decrease as expected, which left the industry with an unfavourable price cover.

> *"Traditionally they [the industry] have long-term risk coverage, but right now they are not well covered. This is probably because the market went sideway since March/April. Now the price has broken out of this range as funds have taken it up. End-users who were waiting for the price to come back to lower level are now without coverage as the price is unlikely to return. So they are in trouble". [D1]*

> "*In this way the industry might actually end up buying the counter position at such a high price and hence suffer. […] They are likely to then pass on the higher price to the consumer and blame the speculator for it". [B1]*

While speculators are not responsible for the low price cover of the industry, they are likely to be responsible for the market not behaving in the way expected by the industry. The higher price paid by manufacturers is then passed on to consumer in the form of a decrease in cocoa content of confectionary products or a decrease in the size of the product [G3, B1].

With reference to the framework outlined in Chapter 6, the most common form of transactions between chocolate manufacturers and first-tier suppliers is a bargaining transaction between legal equals[103]. Given the strong economic power of both segments, the negotiation psychology is one of persuasion. Further, the custom that manufacturers compensate first-tier suppliers for their risk management services by a premium, is evidence for the bargaining power of the first-tier supplier segment.

Working rules do not permit negotiation over the cocoa bean price beyond the differential, which is driven by origin parameters. The FCC has legislative and judicial power (if its arbitration services are used) regarding the working rules for both price formation and quality standards. All industry players buying from Ghana are members of the FCC and working rules are constantly negotiated within the organisation. Interestingly, not only multinational companies acting as first-tier suppliers and chocolate manufacturers are FCC members, but also futures exchanges, hedge funds (e.g., Black River Asset Management[104]), futures brokers (e.g., BNP Commodity Futures) and other financial entities; some of which are even voting members (FCC 2014). This highlights the increasing legal power of the financial segment in commodity sectors.

Manufacturers are dependent on the risk management services of the first-tier suppliers. Those have gained economic power through rents over asymmetric information and special skills acquired through their penetration of the souring segment. Another source of first-tier supplies' economic power is scale economies, which have resulted in a concentration of the sector. Despite their economic power, suppliers are left with the basis risk, which cannot be hedged at the exchange. Superior information about origin parameters is essential for mitigating this risk factor. This information is not only used to manage risk but also to obtain additional revenue through arbitrage and speculation in the futures exchange.

Since cocoa powder and butter lack futures markets, working rules regarding the price formation mechanisms are less formalised and mode and matter of the transaction are more open to negotiations. This causes certain problems to price risk management. Such risk is dealt with in different ways: (1) intra-firm trade, (2) intermediaries offer to hedge the bean content of the product in order to secure a stable price, and (3) grinders offset their price risk from processed cocoa by compensating lower powder prices with higher butter prices and vice versa.

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103 In the case of intra-firm trade these can take on the form of managerial transactions, but those are rare and confined to the luxury chocolate segment.

104 Which is a subsidiary of Cargill (Black River 2014).

Chocolate manufacturers' economic power is linked to their market share, which can be considerable in the chocolate and confectionary industry. Economic power enables manufacturers to change the mode of transfer so that their price, quantity, and even quality risk is managed against a negotiated service charge. Large chocolate manufacturers are further able to bend existing working rules and thereby enable smaller suppliers to enter in strategic transactions. Smaller suppliers are purposefully used in order to mitigate the economic power of large grinders and trading houses (Fold 2001).

7.4.2 External Marketing: The Cocoa Marketing Company

Two organisations are crucial for the price formation process in the external and internal marketing of Ghanaian cocoa: CMC and PPRC. Any cocoa that is collected[105] in Ghana has to be sold to CMC for resale to multinational buyers or domestic grinders. In advance of the main harvest period, which starts in September and lasts till March, CMC sells forward 60 per cent of the forecasted cocoa harvest. The residual is sold to the spot market during the harvest period. If the world market price during harvest is higher than the price obtained during the forward selling period, the additional revenues earned are allocated ex-post to the farmers. As in the global cocoa market, contracts are based on FCC standards and prices are determined by the futures market for the delivery months and a premium.

On the basis of the forward sales, a projected gross FOB value is estimated as in Equation 7.1. The projection serves as foundation for calculating the predicted annual cocoa income:

$$FOB\left(\frac{US\$}{t}\right) * ExRate\left(\frac{GH¢}{US\$}\right) * CropSize\,(t) = GrossFOB(GH¢) \qquad (7.1)$$

FOB is the projected average FOB price in USD per tonne, *ExRate* is the projected average exchange rate, and *CropSize* is the projected crop size (main and light crop). The product of the three is the gross FOB value. Average FOB and crop size are projected by the statistical division of Cocobod based on forward sales and pod counting. The Bank of Ghana is responsible for forecasting the exchange rate. Both Cocobod and the Bank of Ghana forecasts are usually conservative. Cocobod avoids making false promises, while the Bank of Ghana benefits from conservative forecasts since US dollars, which are borrowed by CMC against the collateral of their cocoa forward contracts, are transferred to them [G2]. In return, the Bank of Ghana provides Ghanaian Cedi to Cocobod which are used to extent credit to LBCs for cocoa recovery. The Ghana International Bank in London

[105] Not necessary harvested, since smuggled beans from neighbouring Ivory Coast often make their way into Ghana.

handles most of the Cocobod funds. It receives US dollar as payment for the cocoa from buyers at the time the cocoa is shipped. From the US dollar account they pay back loans and interest to the international creditors and the residual is transferred back to Cocobod in Cedi.

The forward sale provides Cocobod with several advantages over a spot sale system. Firstly, the season's cocoa income is estimated in advance, which allows for the stabilisation of the farm-gate price (see Section 7.4.3). Secondly, forward contracts are used as collateral to gain access to more favourable loans at international credit markets. Previously, loans were received from the IMF or WB at a 20 to 30 per cent interest rate. Loans also came from the private sector conditional on repayment in raw materials, so that a considerable amount of the upcoming harvest was tied to private companies for loan repayment regardless of the world price [G3]. Since trading partners are well known multinational companies, international banks are willing to lend at competitive rates. Thirdly, the risk of counterparty default is low, since buyers have time to plan their finances [G3]. However, international buyers use the system to their advantage as well. Since forward contracts are offered over twelve delivery months they can save storage costs [G3].

CMC and international buyers are in a bargaining transaction since trading partners are legal equals. CMC is registered as a limited company and as such, like its trading partners, a member of FCC. The contractual form of any transaction depends on the relative economic power of the trading partners as well as existing working rules and the ability to influence those. Under FCC working rules, the outcome of the bargaining relationship in terms of price depends on three factors: (1) the *time* at which the contract is agreed upon; (2) the *futures market price*; and (3) the *premium* which is fetched by Ghanaian beans. Of these three factors only two can be negotiated by CMC, since it is not actively trading in the exchange. However, CMC can still indirectly influence the price formation process at futures markets by entering traders' expectations regarding cocoa supply. The timing of the trade and the premium are negotiable and hence depend on the bargaining power of the parties involved. Bargaining power in this context arises from the availability of alternative trading partners, asymmetric information about the future crop, and existing working rules regarding the mode of transfer.

Regarding existing work rules, the CMC representative in London is also member of FCC's Contracts and Regulations Committee as well as the arbitration services, which negotiates the exact wording of the trading contracts [G1]. CMC has hence judicial power regarding existing working rules. While CMC is a member of FCC, QCD is not—although efforts are made to become a member in order to influence quality standards embedded in existing contracts [G4]. Arbitration is done by a member of the arbitration panel. The panel consists of voting member representatives. Voting members are those who meet the requirements of over £500,000 capital assets. If FCC rules against CMC, CMC has the right to appeal. The ruling is done according to the FCC rulebook, which is amended if unprecedented cases arise [G5].

Since CMC is the monopoly seller of Ghanaian cocoa, it has the economic power to both influence existing working rules and set new ones. For instance, CMC offers only one particular standardised forward contract on the basis of which sales are negotiated. The contract, informed by FCC standards, is a fixed price contract based on CIF delivery for either Tilbury or Felixstowe UK ports with a French insurance company. Deviations regarding insurance type[106], destination, and choice of vessel are facilitated against administered premiums or discounts as published in a CMC statement, valid from the first of October each year until September the coming year (Appendix 7.7, [G5]).

Prior to negotiation, CMC and buyers conduct extensive research regarding the crop outlook. For CMC, the Statistical Division of Cocobod forecasts the size of the upcoming crop based on pod counting. In addition, farmers are asked about weather conditions and their prediction for the coming harvest. Whilst Pod counting is also entertained by large buyers, the exact methods applied differ [G6, B2]. Buyers have their own information sources and some even have their own weather stations upcountry. These are, however, of limited use in tropical weather [I1]. Extension services using satellite data have recently emerged to fill the gap, and farmers, LBCs and multinationals alike take advantage of these services [I1]. In addition to the information CMC traders are supplied with, traders look at exchange rates, past price trend, and technical indicators [G3, G6]. After information is gathered, traders enter into an active bargain over the premium [G6]. The negotiation psychology is one of persuasion, as evident from the below statement:

> *"At the end of the day I am trying to sell cocoa at the highest possible price and they [multinational buyers] are also trying to buy at the lowest possible price. I get on the phone and say 'listen it is not raining here, the crop is looking horrible. I don't think we have enough cocoa for*

[106] Arrangements offered include "cost, insurance and freight" (CIF), where comprehensive insurance and shipping line is organised by the seller, "cost and insurance" (C&I), with comprehensive insurance and shipping line organised by the buyer, and "free on board" (FOB), where the buyer organised shipping line and insurance.

you'. - I am trying to drive up the market. And they are doing the opposite. The truth is somewhere in the middle". [G3]

Asymmetric information does not only provide advantages in bargaining, but is also used to influence traders' expectation regarding the futures price. Since Ghana is the world's second largest cocoa producer, a credible announcement of a shortage in harvest has a twofold effect. It enters expectations about the origin premium, as well as the price level at world markets.

The transaction between CMC and its buyer is initiated by the latter, who sends an offer to CMC for review. CMC traders refuse a transaction if there is indication of an upward trend. Similarly, they signal to potential buyers that they are considering bids if the price is favourable. Hence, the decision over the timing of the trade lies not solely with the buyer.

"There is always a market base from which you start for the year and your yearly expectations. So you would have to be happy with three things to sell: exchange rate […], market health […] – some rallies are very weak rallies –, and […] premium. If the premium is 90 you can't quote it for 150. If you have good information that you can push the premium to the limit, you can. But not out of the way. So your expectations have to be realistic regarding the market and then you can rely on competition to drive it even further up". [G6]

Negotiation takes place over the phone between CMC traders and buyers [G3]. Since the trader network is closely knit, other traders know when the first bid goes through and more bids are rolling in.

"You know the market also has its own ears; once it goes to the broker to do a hedge, then words easily go around, because people normally apply common brokers" […]. "People still use brokers […] because […] you get additional information." "It is the same broker that works for me and my competitors and others. And I expect that he tells me this private information." "Even if they employ their own broker, brokers still talk with the other brokers". [G6]

CMC traders use technical indicators on futures prices in order to time their cocoa sales. As every seller, they attempt to place their sale in an upward trending market. However, with short hedgers entering the market after the first contracts are signed, the trend often breaks. If prices fall below a certain threshold, CMC might decide for a sales stop [G6]. While CMC does not have access to the information usually provided by brokers, CMC traders maintain their own network of personal friends for information provision. This network is built during their trainee years, during which they work at various trading desks across Europe and the US [G6].

The Ghanaian industry critically relies on the provision of foreign reserves through cocoa trade. Because Cocobod needs the forward contracts as collateral for credit provision from international banks, it is forced to forward sell even if prices are not favourable. A fact, multinational companies are aware of and exploit by attempting to keep prices low during the forward selling season [L1, G2]. Although buyers would not approach CMC at the beginning of the season when the market is unfavourable, they are in the position to pressure CMC later in the year. However, traders also have to meet cocoa quantity targets and have to compete with other buyers. This means, they are not unconstrained either.

Since the differential is the only negotiable aspect of the bean price, maintaining control over this variable is crucial. However, the long-term existence of the premium is not secured for reasons over which Cocobod has limited control. Since the differential is a relative measure, it depends on the quality of non-Ghanaian beans as well. Ivory Coast, for instance, already improved its bean quality over recent years [G4]. Further, global demand for quality has decreased. Nevertheless, Ghana invests considerable resources in bean quality, which is closely monitored by QCD. Enforced standards exceed those specified by FCC [G4]. Further, CMC seeks to establish a brand name for Ghanaian cocoa by visiting trade shows in East and South East Asia [G3]. In Japan Ghanaian beans already have the status of a brand as evident by a chocolate bar named 'Ghana' (Figure 7.12).

Figure 7.12: Japanese Lotte Ghana Chocolate Bar

Source: Www.coolstuffjapan.com.

Ghana has successfully established collaboration with Japan, a country that maintains particular stringent food regulations [G3, G4]. The Japanese government built a research centre in Ghana in order to help reaching the required quality standards, which is a prime example for executive governance in the Kaplinsky and Morris (2000, 31) framework.

Although Ghana itself holds a considerable market power as the seller of 17.4 per cent of the world's cocoa production in 2013 (Table 7.1), the buyer side is getting more concentrated which limits the amount of next best buyers and hence the bargaining power of CMC over the premium. The number of CMC's trading partners has decrease substantially from about 100 companies twenty years ago to 11 in 2013 [G3].

Recalling Equation (7.1), Ghana's total cocoa income depends on three parameters, which are FOB price, exchange rate and the crop size. By forward selling, Cocobod is able to lock in cocoa revenues for the upcoming harvest early on and this way manage price risk. The cocoa not sold forward prior to the crop year serves as risk mitigation and speculation tool. On the one hand, it insures against miscalculations in the crop outlook and smuggling. If the crop forecast exceeds the harvest, too much of the crop might be sold and CMC has to go into arbitration with its buyers. Despite this precautionary measure, such incidence caused severe difficulties for Cocobod in 2015 (Terazono 2015). On the other hand, it enables CMC to take advantage of price rallies during harvest. However, speculation might go wrong and leave CMC with beans from last year.

Most buyers are open to renegotiating contracts in the case more cocoa was sold than produced. Buyers, who are mostly intermediaries, do not always have customers for immediate delivery or they might have miscalculated as well. Renegotiating the contracts is hence in their interest [G6]. However, as buyers allow renegotiation of contracts without penalties, they in return bend existing working rules for which Cocobod does not take them to arbitration either. For instance, international buyers save storage cost by leaving cocoa in CMC warehouses beyond the actual delivery date. Due to contract specification, CMC is paying for the warehousing until shipment. This behaviour has severe repercussions for the local cocoa sector during the harvest periods as shall be discussed in Section 7.4.3.

A severe form of quantity risk, which affects Cocobod, is caused by smuggling. If prices decrease during the harvest period, Ghanaian farmers receive a higher price than neighbouring farmers and hence beans are smuggled into Ghana. Beans are smuggled out of Ghana if the price increases during harvest period [B1]. Since Cocobod takes loans on the basis of the predicted crop, it might not be able to repay if the harvest falls short of the predicted and it is forced to borrow additional money from local sources at higher interest rates if the harvest turns out larger than expected [J3, G2]. Although Cocobod tries to account for smuggling in their forecast, this is a difficult task especially in a high inflation environment where the real cocoa price deteriorates quickly [G2]; a factor that contributed to the problems in 2015. Another problem that arises from smuggling is the loss of the quality premium. Ivorian beans are still of lower quality than Ghanaian beans and, when smuggled, those former are mixed with the latter. Hence, the premium of Ghanaian beans declines, which undermines CMC's bargaining power over the premium [J2].

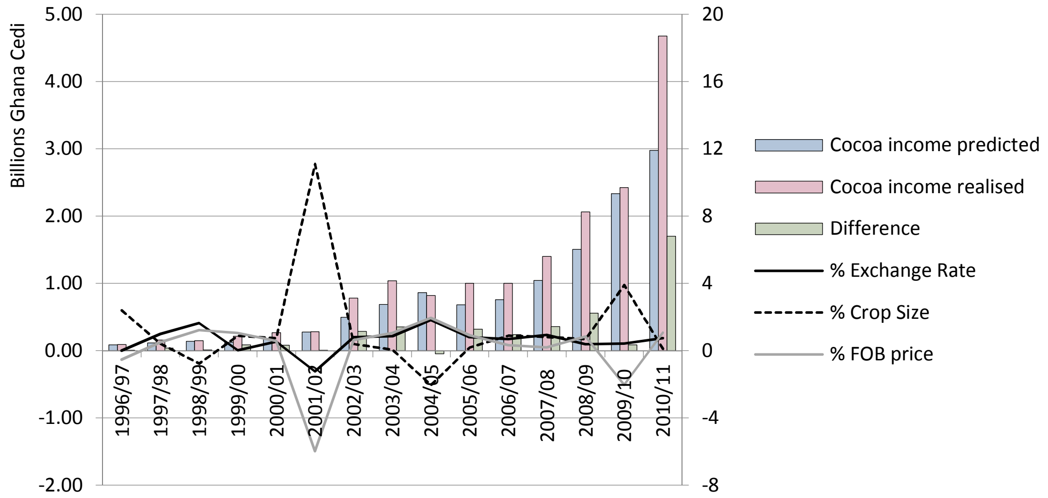
While through forward selling at least parts of the cocoa revenue is secured, it is secured in USD terms. Hence the exchange rate is another risk factor. Exchange rate fluctuations can cause difficulties regarding loan repayment as well as cocoa farmers' real income. During the time of the fieldwork, movements in the exchange rate contributed to lower farm-gate prices.

> *"In Ghana, inflation and bad exchange rate is such a big problem. Farmers earn less and less in USD terms and the cost of living increases. This is good for us as buyers but bad for the farmers". [E2]*

However, as shown in Figure 7.13, the major risk to Ghana's cocoa income originates from variations in the FOB price, that is, futures price plus premium. The predicted FOB price has been lower during the 2001/02 and 2009/11 seasons than the realised FOB price. An interesting observation is that crop size works as an insurance for the export price and vice versa in line with Dana and Gilbert's (2008, 209-10) prediction. Since Ghana is the second largest producer globally, a lower than predicted crop size results in a higher export price, which then counter balances the negative effect of the lower harvest on total cocoa income.

Large swings in the FOB price might be due to droughts or a decline in the premium due to smuggled beans. The 2001/02 crop year witnessed several disruptions. The civil war in Ivory Coast left the market in an expectation of supply shortages. However, as shortages did not materialise, expectations were revised and prices dropped during the harvest period. Hence, CMC lost on the spot market sales relative to the predictions made. Much of the crop was smuggled to Ghana which also contributed to the larger than expected harvest. Further, speculation in the terminal markets and technical buying were cited as one of the main reasons for the high price during the forward sale period (ICCO 2002).

Figure 7.13: Predicted and Realised Cocoa Income and Sources of Loss (in GHC/tonne)



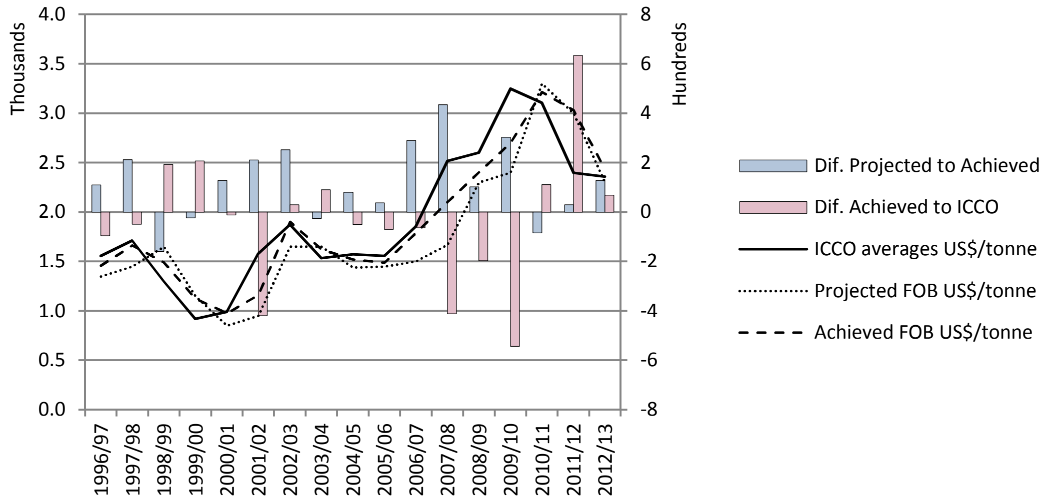
Notes: The percentages for exchange rate, crop size and FOB price are estimated by calculating the realised cocoa income as if the predicted exchange rate, crop size, and FOB price were the realised. The difference from the realised for each scenario is then normalised by the difference between predicted and realised cocoa income. Source: Cocobod Statistical Division, author's estimation.

CMC traders and multinational buyers alike have shown concern over the presence of speculators. However, since multinational buyers are mostly intermediaries in the global industry, they are less concerned with price levels than chocolate manufacturers on the consumer side and CMC on the producer side. For CMC the long positions by speculators are favourable, but they are afraid that the 'big elephant' in the room might liquidate positions [G6]. Further, speculators have made it more difficult to gauge the market and to time sales accordingly.

> *"Now we have specs. They have different models, they have different time frames, they have different expectations and they have different indexes; a different approach. So it makes it a lot harder to follow fundamentals that are normally theoretical drivers of the market than it used to be". [G6]*

Due to the uncertainty over future production as well as the exchange rate, Cocobod is unable to manage its income risk fully, although, forward sales contribute to predictability. Figure 7.14 shows how forward sales affect Ghana's cocoa income in USD terms. In an upward trending market, Cocobod outperforms its own prediction—which is not surprising since it is incentivised to predict conservatively—but underperforms the market. The reverse is true for falling prices. Another implication of the forward sale is that the Ghanaian cocoa farmer receives the world prices with a lag.

Figure 7.14: CMC Performance of Forward Sales Compared to ICCO World Prices (in USD/tonne)



Source: Cocobod Statistical Division; ICCO.

In summary, CMC and international buyers are in a bargaining transaction. Although working rules permit negotiation of the price level, which is fixed to the futures exchange, the timing of the trade and the premium is negotiated. The outcome of this negotiation is determined by the relative bargaining power of the parties involved, as well as the power to influence existing working rules. Ghana as the second biggest producer globally holds considerable economic power and can chose, to a certain extent, its trading partners[107]. An additional source of market power is the particular flavour of Ghanaian cocoa beans, which is achieved through a more demanding fermentation process compared to Ivorian beans. Hence, chocolate producers still rely on Ghanaian beans for blending and flavouring. However, buyer power is highly concentrated. Only one cocoa trading company and a couple of grinding companies make up the bulk of Ghana's cocoa bean trade. Further, as discussed earlier, Ghana has to sell during a particular time period in order to finance its cocoa trade as well as acquire necessary foreign reserves. This makes CMC particularly vulnerable to low world market prices during this period.

7.4.3 Internal Marketing: The Producer Price Research Committee

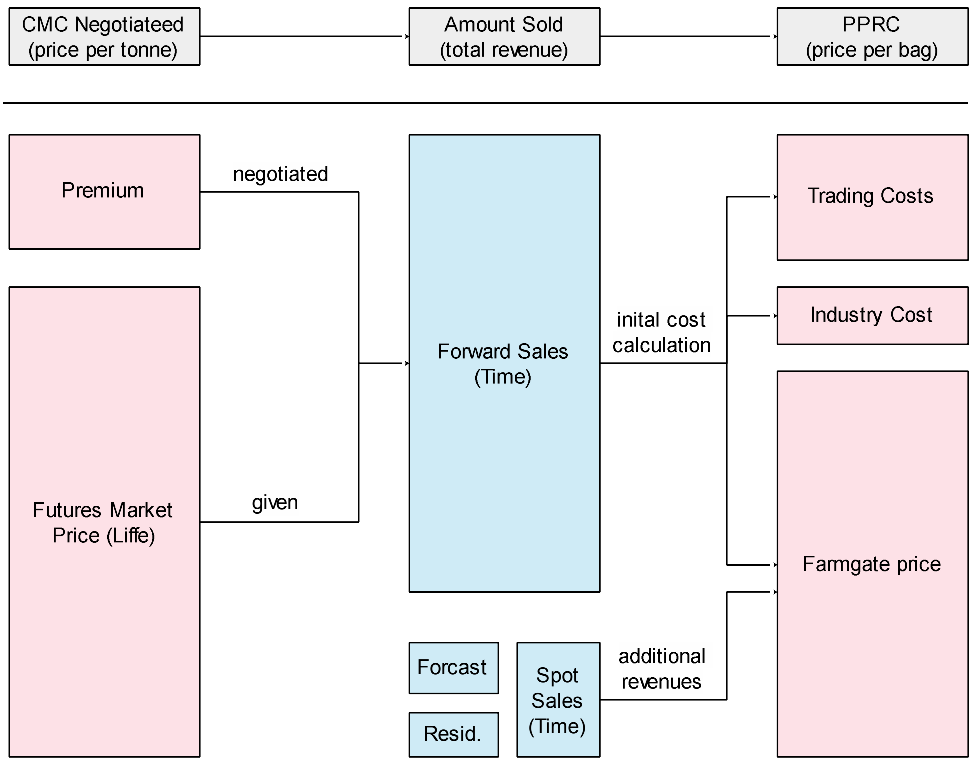
At the internal marketing level the PPRC plays a key role in price formation and risk allocation along the cocoa chain and all prices and margins earned by different stakeholders are administered by the PPRC. The PPRC itself consists of a number of cocoa stakeholders including farmers, hauliers, LBCs, representatives from academia and Cocobod. The committee is chaired by the Minister of Finance. All present at the negotiations are

[107] There was a case when one multinational buyer was refused a contract over a row until it openly apologised to the Chairman of Cocobod [G1].

representatives for their respective branch. The committee negotiates the price received by the farmers, rates for transportation, commission for LBCs, and other industry costs including social support services [G2]. Prior to negotiations, all stakeholders are asked to submit an approximation of their costs and a suggested margin. Given the reports from the different stakeholders, the final allocation of predicted cocoa income is decided. The last word lies with the chair.

Negotiations take place over the allocation of the (projected) cocoa income or total revenue. Figure 7.15 links the outcome of the PPRC negotiations to the price formation processes at the global and external marketing level as described in the previous sections. The net-FOB is the gross FOB value minus services, which are accounted for as industry costs (Kolavalli, et al. 2013). Agreed prices and margins are made public a few days prior to the start of the main buying season in October. Those are fixed for the entire crop year, however, can be altered during the light crop season if large price swings at the financial market occurs. This happened only once during the 2007/08 crop year.

Figure 7.15: Price Formation in the Ghanaian Cocoa Industry



Source: Author.

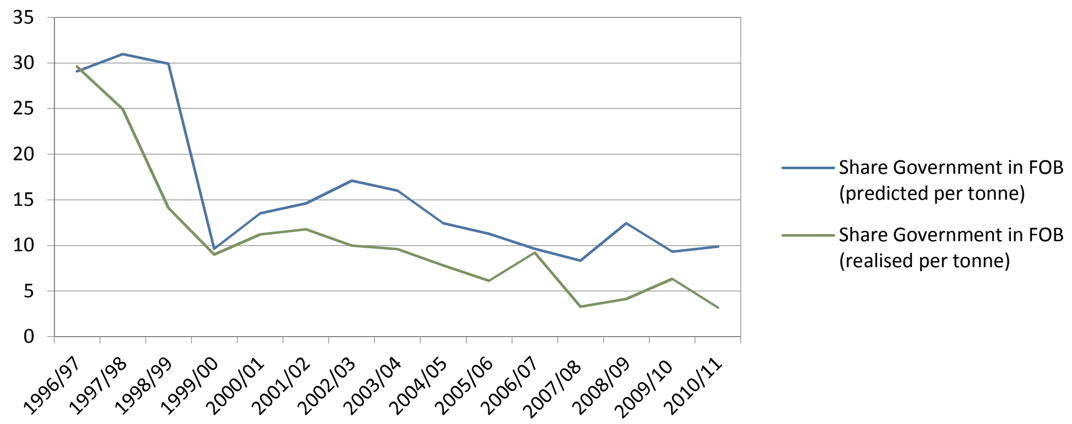
Table 7.3 presents the breakdown of forecasted cocoa income including industry costs. From the average FOB, industry costs are subtracted and, since the 1999/00 season, a minimum of 70 per cent of the net-FOB is allocated to farmers. The remaining net-FOB is distributed among other stakeholders.

<table>
<tr><th colspan="4">Table 7.3: Statistics of Projected Net-FOB Sharing</th></tr>
<tr><td rowspan="22">Projected Gross FOB Value (GHC)</td><td>Π</td><td>Σ</td><td></td></tr>
<tr><td rowspan="7">Projected Average FOB Price (USD/tonne)</td><td rowspan="7">Industry Cost (GHC)</td><td>Σ</td></tr>
<tr><td>Disease and Pest Control</td></tr>
<tr><td>Jute Sacks</td></tr>
<tr><td>Farmers' Scholarship</td></tr>
<tr><td>CSSVD Essam Project[1]</td></tr>
<tr><td>Fertilizer Subsidy Program</td></tr>
<tr><td>Child Labour Program</td></tr>
<tr><td rowspan="7">Projected Average Exchange Rate (GHC/USD)</td><td rowspan="14">Net-FOB Value (GHC)</td><td>Σ</td></tr>
<tr><td>Producer Price (min 70%)</td></tr>
<tr><td>Stabilisation Fund</td></tr>
<tr><td>Buyers' Margin</td></tr>
<tr><td>Hauliers' Cost</td></tr>
<tr><td>Storage and Shipping Cost</td></tr>
<tr><td>QCD (Disinfestation, Grading, Sealing, Check Sampling Cost)</td></tr>
<tr><td rowspan="7">Projected Crop Size (tonne)</td><td>Crop Finance</td></tr>
<tr><td>Scale Inspection & Phytosanitory</td></tr>
<tr><td>Cocobod</td></tr>
<tr><td>Farmers' Housing Scheme</td></tr>
<tr><td>Replanting</td></tr>
<tr><td>Farmers' Pension Scheme</td></tr>
<tr><td>Cocoa Roads and Export Duty</td></tr>
<tr><td colspan="4">Note: [1] Project run by CSSVD in order to contain swollen shoot virus in the Essam region. Source: Cocobod Statistical Division.</td></tr>
</table>

Industry costs, since excluded from the negotiation process at PPRC, are prone to allocation inefficiencies arising from corruption. For instance, it was claimed that 20 to 30 per cent losses in industry costs are incurred due to inefficiencies in the implementation of mass spraying. Often the implementation of the scheme is given to those with close ties with the political body and not those with the means to transport the chemicals or fertiliser upcountry. As a result, the process is delayed and the fertiliser arrives too late; maybe in the raining season, which means that the fertiliser is washed away without effect [F1].

With the introduction of the net-FOB share approach, the share received by the government decreased considerably (Figure 7.16). At the end of each season, Cocobod deduces its operational costs (trading costs), which are also negotiated by PPRC, and then transfers the residual to the Ministry of Finance as an implicit tax. However, given the nature of the system, the tax varies with the buffer function Cocobod plays in order to secure stable prices for stakeholders in the chain.

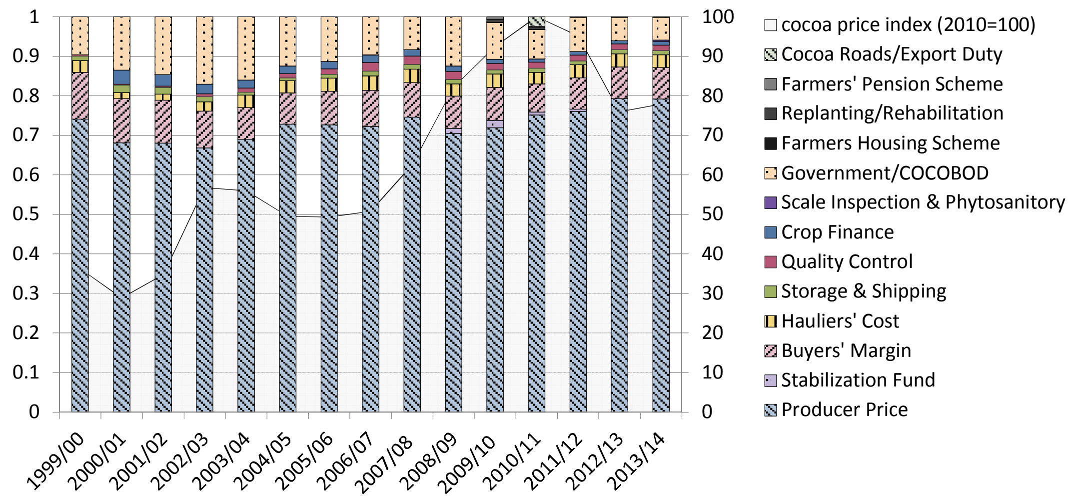
Figure 7.16: Percentage Share of Government in Total Cocoa Income



Source: Cocobod Statistical Division.

Figure 7.17 depicts the allocation of the net-FOB value among stakeholder since 1999. After farmers, another major share goes to LBCs and Cocobod. Again, the buffer function of Cocobod is clearly visible, as the Cocobod share varies with the price level, while the producer share varies inversely with the price level.

Figure 7.17: Different Stakeholders' Share in Net-FOB



Source: Cocobod Statistical Division

The 70 per cent rule, that is a minimum 70 per cent share for farmers in net-FOB, is a formalised working rule, written into the Ghanaian constitution. Another informal custom which benefits the farmers emerged, which is that PPRC cannot reduce the farm-gate price.

> *"The price for the farmer changes annually but it has never been down. So we follow this convention. In extreme conditions we might have to consider the farm-gate price though. It is possible". [G2]*

Customs hence permit PPRC to exercise its potential power to decrease the producer prices, which is an act of forbearance. This is clearly motivated by the political power of cocoa farmers, especially during election years.

At the level of the PPRC, the transaction process is a rationing one. The price or margin earned by different stakeholders in the Ghanaian cocoa chain depends on the bargaining of the representatives with authority. However, there are both economic and legal power imbalances within the PPRC. Farmers' bargaining power arises from their large population share. This position is strengthened with a democratically elected government. However, other stakeholders might entertain close ties with the political elite and exercise power through these relationships. Further, the indeterminacy of industry costs leaves freedom to the government regarding the allocation of cocoa income. In the following, economic and legal power of each stakeholder in the chain will be assessed in regards to income and risk in each segment.

7.4.3.1 Farmers

The price received by farmers depends on the price negotiated by CMC with external buyers, the negotiation process within the PPRC and working rules guiding the negotiation process. Existing working rules limit the scope of negotiations by linking the producer price to the net-FOB price. Further, customs prevent a decrease in farm-gate prices, which means the last season's nominal price sets the minimum.

Farmers' representatives in the PPRC are not democratically elected. Hence, an individual farmer has little influence on the choice of her representative and, therefore, the negotiation process. Further, despite their political significance, farmers have limited economic bargaining power, since, in Commons' terminology, they cannot easily withhold from others what is demanded by them for their own use. Hold ups organised by cocoa farmers are constrained, since the crop spoils quickly if not stored properly, and income for a year might be lost. Further, the switch to other crops is difficult for farmers since this requires investments [F2].

Usually, farmer representatives are chief famers who are selected by the government [F1]. Representatives are not necessarily homogenous in their interests. For instance, a chief farmer of Ghana's Kuapa Kokoo and PPRC representative wishes for cocoa prices to vary more strongly with world prices while another farmers' representative stresses that farm-gate prices are too low [F1, F2]. The reason for the first farmer's wish is that Fair Trade certified farmers only receive a premium if the Cocobod price is below the Fair Trade minimum price. If this is not the case, farmers do not receive a premium, although they incur costs from the certification process, which makes the scheme unattractive [F1].

Farmers are exposed to a variety of risks, many arising from their low economic and legal power. LBCs are prohibited from buying cocoa outside the buying season (twice a year for the mid and the main crop), but the cocoa tree produces, with varying degree, throughout the year. This is problematic for farmers since those do not have the means to store the beans. However, with increasing competition among LBCs over volume, farmers find buyers more easily between the buying seasons. They are typically foreign owned LBCs, which receive funding independent from Cocobod loans.

> *"If season is closed, the farmer does not have an appropriate space to keep it. You cannot allow it to go waste. So you holding his property at your warehouse for some time till the season opens. But you cannot do anything about it if the season is not open. Because Cocobod will not accept it, you will not accept it. But the cocoa will not go to waste". [L4]*

However, between seasons buying opens opportunities for intermediaries to renegotiate prices. Since formalised working rules regarding the price setting mechanism do not extent to the months outside the buying season, farmers are offered unfavourable deals for their cocoa (see Section 7.4.3.2).

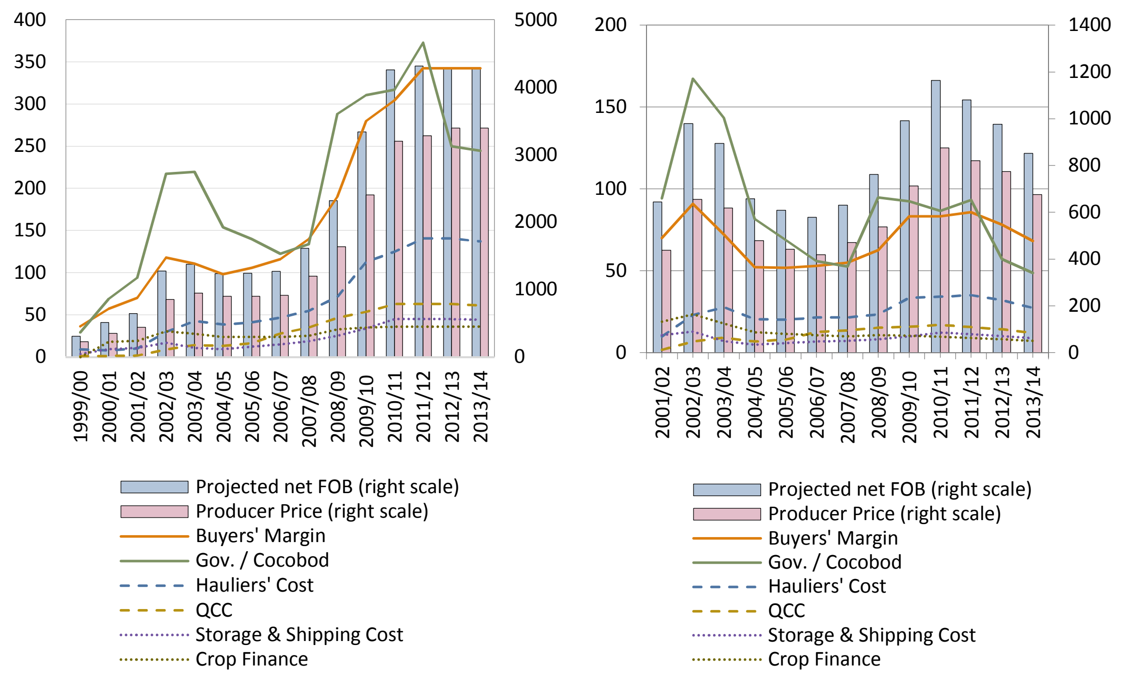
Quality is another risk factor. If the cocoa is not properly fermented or contains foreign material, QCD might reject the cocoa. However, this is less problematic for farmers since at the society level, only purchasing clerks check the bean quality. Those can ask farmers to redry the cocoa, but they rarely decline the cocoa over quality, since they have the opportunity to mix low quality with high quality beans and that way pass QCD tests.

The most severe risks affecting farmers' income in the Ghanaian system is quantity risk, long term price risk and inflation. While nominal prices don't decrease they are not following up with inflation either. As can be seen from Figure 7.18, inflation has continuously reduced real cocoa income since the 2010/11 season.

Additionally to inflation, volume, and quality risk, farmers struggle with a row of other risk factors. One factor mentioned repeatedly during the Ghana Cocoa Platform Stakeholder meeting on the 27th and 28th of November 2013, was land grabbing by mining companies, facilitated by unclear tenures systems and corruption in ministries as well as among chiefs. Regardless of the great numbers of farmers and their large share in the total population, farmers have low executive power and existing working rules are frequently breached by other stakeholders to the farmers' disadvantage.

Figure 7.18: Nominal and Real Net-FOB Rate per Cocoa Tonne (1999/00-2013/14 season, in GHC)

Rate per Tonne of Cocoa Nominal Price | Rate per Tonne of Cocoa Real Price



Source: Cocobod Statistical Division; IMF, IFS (author's calculation).

7.4.3.2 Purchasing Clerk

Purchasing clerks are one of the few stakeholders in the Ghanaian cocoa chain whose margin is not set by the PPRC. They work on a commission basis for LBCs and receive cash advances for buying cocoa at the farm level and delivering it to the district level. They are in a managerial relationship with LBCs, however with substantial room for bargaining before entering into the transaction and with limited judicial and executive governance by LBCs. LBCs have only limited power to monitor and deter purchasing clerks from breaching contracts.

Given the limited governance power of LBCs, adverse selection and moral hazard are risk factors for LBCs in the selection of purchasing clerks. Different selection strategies are maintained by LBCs. District officers, who are in charge of selecting purchasing clerks, are usually from the districts they are working in. Hence they entertain personal relationships with the communities in the district [L4]. District officers consult with village chiefs or a committee of experienced purchasing clerks from the same area over appropriate candidates. Candidates from the same community are considered to be less likely to abscond with cash advances or move elsewhere. Besides a good reputation, basic education is crucial for being selected [L2]. Further, district officers ask friends and relatives, especially those with a cocoa farm, to guarantee with farm land or other property for the candidate [L3].

The district manager maintains a close relationship with each purchasing clerk and visits up-county buying stations regularly to ensure cocoa is only delivered to him and that cash advances are given proportionally to the buying capacity [L4]. Especially in times when the district officer is short in cash, purchasing clerks might chose to sell to other LBCs operating in the area [G2]. For LBCs, the only way of ensuring that purchasing clerks exclusively deliver to them, is to ensure constant cash availability [L2, L4].

Purchasing clerks hold considerable economic and hence bargaining power vis-à-vis LBCs and farmers and are hence in a lucrative position [B2]. They are not only given cash advances but also sheds, scales, tarpaulin, and jute sacks by the LBC [L3]. Hence LBCs face sunk costs, while they dependent on the purchasing clerk for his relationship with the societies. If costs like transportation increase, the purchasing clerk receives compensation.

> *"We [LBC] pay them [purchasing clerks] per bag. So when they hear that fuel has gone up they also increase their charge. And when they see that inflation has gone up, they also increase their change". [L2]*

Further, purchasing clerks have some leverage over the price at which they buy cocoa beans even during the buying season. Through smuggling, they are able to buy cheaper and keep the difference for themselves [B2]. Further, farmer representatives uttered complaints over rigged scales—a common practice by purchasing clerks to pay farmers less[108].

As mentioned previously, purchasing clerks buy beans throughout the year. Farmers, who do not own sheds, are forced to deliver to the purchasing clerk's sheds for safekeeping—theft of cocoa beans is common—and appropriate storage to prevent beans from moulding. Purchasing clerks exploit this situation and pay less for the cocoa than during the season or lend the farmer money for high interest rates—100 per cent is common—keeping the beans as collateral until the season opens. The purchasing clerk is middle man and bank at the same time and is often the wealthiest society member [B2].

Although farm-gate prices are administered and the purchasing clerk is in a managerial relationship with the LBC, the LBC has limited legal power over the purchasing clerks. Further, due to their strong economic power given by their cash availability and their

[108] Complaint made by farmer representatives at the Ghana Cocoa Platform stakeholder meeting at Alisa Hotel in Accra on November, 27th 2013.

linkages with LBCs, they can enter into managerial relationships with farmers through money lending activities, which earns them additional income.

7.4.3.3 Licenced Buying Companies

LBCs are in a rationing relationship with PPRC, while they are in a managerial relationship with CMC as they are licenced to buy the cocoa on CMC's behalf. At the beginning of the season CMC publishes a schedule regarding how much cocoa each LBC has to deliver to which port [H1]. Especially domestic LBCs, which have limited access to capital, rely on Cocobod for loans to fund their buying operations. LBCs receive a PPRC negotiated margin per tonne of cocoa from CMC [L2-4].

All interviewed LBCs believed to have an influence on the negotiation of the margin, although they were not fully satisfied with the outcomes [L1-4]. The manager of PBC is the first and the manager of Adwumapa Buyers Limited the second representative to PPRC [L3]. Representatives collect estimates over operational costs as well as suggested profit margin and forwards those to the PPRC as a basis for negotiations [L2]. While the asked profit margin was never approved, profit margins did not decline when world prices declined. Hence, LBCs were protected from price volatility [L4]. Although costs have increased due to inflation [L2], LBCs refrain from executing bargaining power during falling world cocoa prices. This act of forbearance is partly driven by fairness considerations [L4].

LBCs require cash during the buying seasons to issue advances to the districts and purchasing clerks. Cash is provided by Cocobod, which offers loans below market rate. Cocobod acquires the necessary funds through forward sales to international buyers. The loans are allocated based on the LBC's previous sales. The main season last for 33 weeks, starting in late September, in which LBCs are expected to turn around their funds 2.2 times on average. About 60 per cent of the harvest is bought in the first cycle and LBCs are supposed to redeem their loans fully in January/February when buying the beans in October. The light season only lasts for 10 weeks and loans are usually not turned around [G2].

Revenues received by LBCs hinge on three main factors: 1) the volume of cocoa recovered, 2) the rate at which loans are turned over in tandem with the interest rate paid, and 3) operational costs which are driven by fuel costs and commission paid to purchasing clerks [L2].

Operational cost increase with volume bought. Hence, LBCs might increase their revenue by focusing on districts that produce sufficient cocoa to reach high volume [L4]. Further, LBCs try to gain farmers' loyalty though services. Based on a survey of 441 Ghanaian cocoa farmers conducted in 2002 and 2004, Vigneri and Santos (2008) find that the selection of a particular LBC—if more than one LBC is active in the district—by a farmer is mainly driven by the immediate availability of cash and the provision of credit. In this regard, companies associated with a multinational buyer have a competitive advantage. Those have access to sufficient credit from abroad, while local companies are forced to borrow from local banks at much higher rates if Cocobod funds are insufficient [L2]. LBCs which have external linkages are hence able to reach higher volumes. Another obstacle for local companies is that, in order to borrow, collateral is needed. While for the former state owned PBC the Ministry of Finance serves as a guarantor, other local companies struggle to provide such [L2].

Availability of cash and credit can bind farmers to certain LBCs. Building of trust through reliability is another factor. Especially large LBCs, associated with multinational trading houses, can build deeper relationships and dependencies with farmers through provision of input factors and credit as well as sale of other products such as staples like rice, and biscuits [L4]. Thereby LBCs signal presence in the region and build trust.

In the current system, LBCs are exposed to several risks. One is inefficiencies in the delivery system. At ports, CMC has a certain warehouse capacity. Disruptions at the port level prolong offloading, which delays the turn-over of loans. Lower turn-over rates result in losses incurred on interest rates [L3] as well as additional costs due to borrowing at higher rates from local banks to buy cocoa in order to maintain volume [G2]. During the time of the fieldwork in late 2013, several factors caused delays at the ports. Shortly before the season started, labourers, hired to offload the cocoa into warehouses at the ports, went on strike. Additionally, some of the warehouses were filled with last season's crop, which squeezed warehouse space [L2]. Congested warehouses were blamed on both Cocobod and multinational buyer. Cocobod was accused of having speculated on higher prices for the spot sale, which did not materialise and resulted in some cocoa remaining unsold. Multinational buyers were accused of not taking delivery in breach of their contracts in order to avoid storage costs [L2, H1].

Besides the risk of increasing operational costs and inflation, the issuing of cash advances poses another risk. Thefts and attacks on those who carry the cash to the districts—usually in heavily guarded trucks—are common [B2]. Further, moral hazard in the selection of purchasing clerks is a threat. Despite guarantees and collateral, purchasing clerks have absconded with cash advances [L3]. Such incidences occur particularly frequently when purchasing clerks cross borders with the intention to smuggle beans and run into difficulties [L3].

Another risk factor is quality risk. Smuggling is common, especially if prices are more favourable in neighbouring countries. This can undermine the quality of the crop received by district managers from their purchasing clerks. Since the purchasing clerk buys on behalf of the LBC, quality risk and resulting losses remain with the LBC [L4].

> *"You fire him, you arrest him, whatever. But you have lost. When quality control confiscates the cocoa then it is confiscated and you lost it". [L3]*

QCD has judicial and executive power at the district level, where quality is monitored and cocoa of insufficient quality is confiscated without compensation [G2]. The moment the farmer receives cash from the purchasing clerk, the ownership of the cocoa is with the LBC until the cocoa is offloaded into a CMC warehouses at the ports [L4]. Any losses that are incurred are hence losses to the LBC. Not only low quality can result in losses, but also theft and fire [L4].

7.4.3.4 Hauliers

Hauliers are in similar transaction relationships as LBCs. They are in a rationing relationship with the PPRC and in a managerial relationship with the LBC they are working for. They are compensated by volume of cocoa transported, as well as by distance over which they transport the beans and the quality of the roads. Prior to negotiations over the margin, hauliers are asked to submit a calculation of their costs and a suggested margin. The chairman of Global Haulage is the first PPRC representative [H1].

> *"The fixed costs include the vehicles, financing charges which we calculate with a 5 year amortization period to get the fixed cost. Then we do variable costs which is operational costs, like fuel, tarpaulin, maintenance, tyres, salaries and alike. We do this and determine the variable cost and we add the two and then determine the price per tonne per mile." [H1]*

Although costs have increased and inflation has squeezed margins over recent years, margins in nominal terms have been stable for the past crop years. However, as cocoa prices were declining, hauliers refrain from executing bargaining power. As a result, hauliers together with LBCs absorbed the increase in operational costs while Cocobod absorbed declining cocoa prices [H1].

Usually hauliers are contracted by LBCs for the crop year. The moment the cocoa is loaded onto the truck, it is the hauliers' responsibility if damage is incurred through rain or road accidents. Hauliers are reimbursed for each delivery from the district to the port. Their revenue hence depends on the turn-around time, that is, how many loadings a particular truck can deliver. Complications at ports hence affect them in a similar manner than LBCs [H1].

Global Haulage in this regard is an interesting case study. In order to minimize costs arising from these inefficiencies, they established their own warehouses at the ports as transit points. Newer trucks, better suited for the longer distance from the district to the ports, can hence quickly return back to the districts while the older trucks are used to bring the cocoa from the warehouse to the CMC takeover point. Even if older trucks wait for several days at the port before offloading, a high turn-around time can be achieved with the newer trucks. At the time of the fieldwork, Global Haulage was in negotiations with CMC over CMC accepting delivery to Global Haulage's warehouses as special offloading. If negotiations are successful, CMC would compensate Global Haulage for the cocoa delivery after delivery to the Global Haulage warehouse. This is a prime example for limiting factors resulting in strategic transactions within Commons' framework.

Further Global Haulage owns four LBCs for which it exclusively handles the bean transportation. Hence, turn-over of loans by LBCs is another reason for the negotiation with CMC. Given the small margins earned by LBCs and hauliers alike, mergers across those two sectors are not uncommon [L4]. Given that it was foremost haulage companies to move into the buying segment after partial liberalisation, there have long been strong linkages between the two segments. Further, Global Haulage works within a conglomerate of companies that includes banks and a fuel company. With decreasing margins and high interest rates most LBCs and hauliers work foremost for the benefit of the banks. However, with the banks being associated with the LBC and haulage business, the conglomerate engages in cross-subsidisation [H1]. Operational rents accruing from this conglomerate of companies has strengthened Global Haulage's economic power.

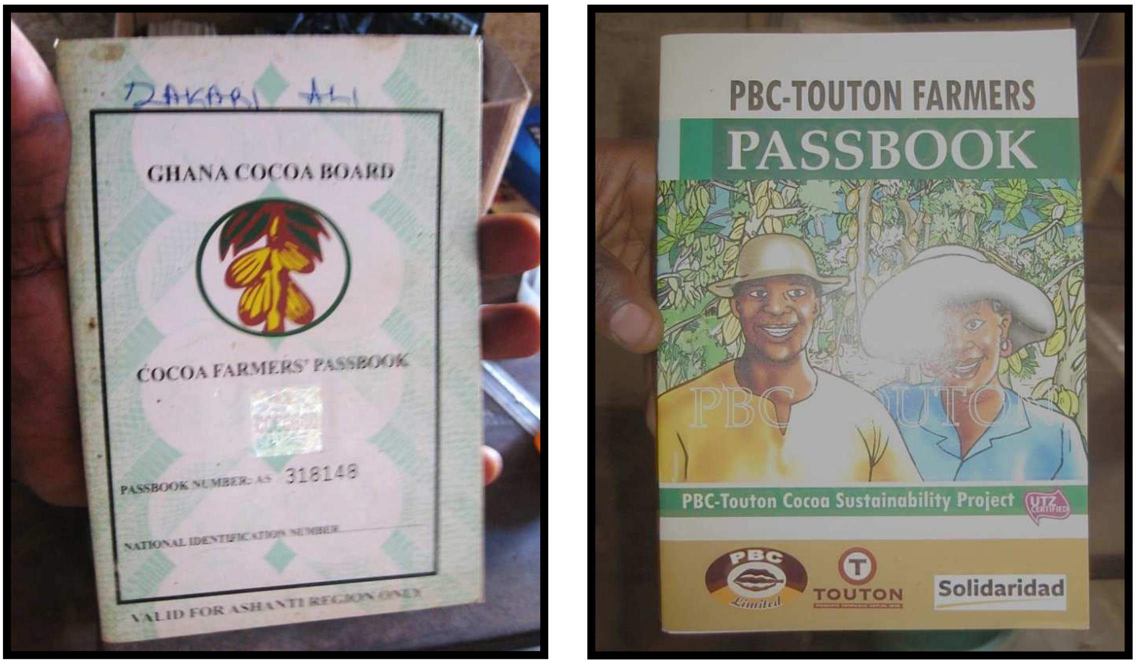
7.4.3.5 Certification

Certification is a relatively recent development that in parts circumvents the rationing transaction of the PPRC. Stakeholders entering into certification are motivated by the possibility to increase economic and legal power. They hence engage in strategic transactions. Certificates have become numerous. However, despite the heterogeneity of labels, the transaction processes are similar across certificates in the Ghanaian cocoa sector.

Usually the LBC is the holder of the certificate [E3][109]. The LBC is either directly associated with a multinational buyer, who demands certified cocoa, or collaborates with one. The collaboration amounts to the buyer financing parts of the operations, like providing inputs and hiring extension officers [L2]. Extension officers train the farmers according to the requirements of the certificate. Further, the holder of the certificate receives a premium for each bag of cocoa produced under the scheme.

It is the LBC's responsibility to gather famers under the scheme and compensate them for their additional costs. Most LBCs collaborate with NGOs who are associated and/or funded with/by them or the multinational buyer [E4]. After the certification guidelines are implemented, an external auditor from the certification body checks compliance to the standards [L2]. If the standards are met, the LBC receives the certificate and the farmers' cocoa passbooks are replaced in order to distinguish them from the non-certified farmers (Figure 7.19).

Figure 7.19: Cocoa Passbooks of Certified and Non-Certified Farmers



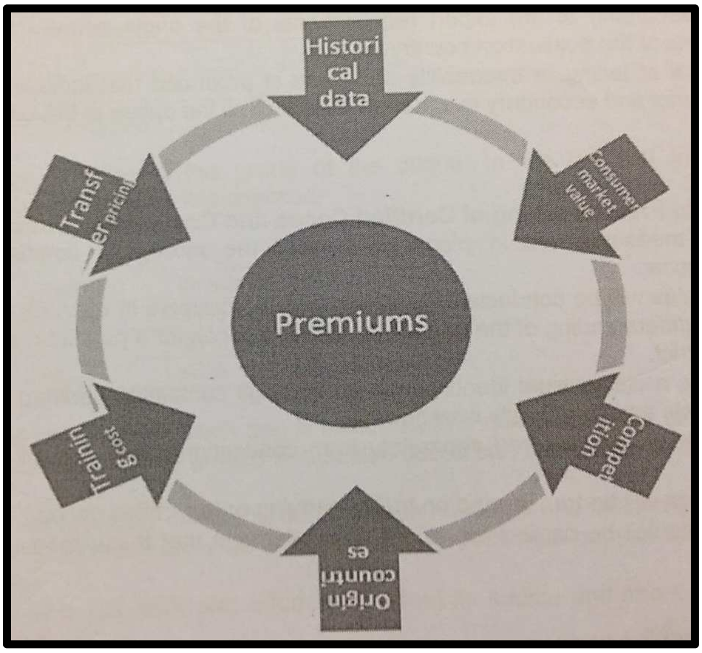
Note: Farmers got recently certified by PBC. The UTZ certification is funded by the multinational buyer Touton and implemented by the NGO Solidaridad. The left picture shows the former passbook and the right picture the new one. Source: Pictures were taken during a cocoa village visit near Kumasi at November, 13th 2013.

The Certifier and the certified are in a bargaining transaction before entering into a managerial transaction with the certifier setting the rules, which the certified has to obey. Interestingly, the intermediary, i.e., the LBC, negotiates the certification premium with the

[109] Fair Trade is the exception where the certificate is given to the farmers' co-operative.

international buyer, while the farmer is the subordinate who has to obey the rules set by the certificate with the LBC holding judicial and executive power over the farmer. The certifying body, which is an independent entity such as Fair Trade or Rainforest Alliance, holds legislative power. In an attempt to gain legislative power, the industry recently developed the UTZ certificate for cocoa, coffee, and tea. The premium received by the farmer is subject to negotiations between the LBC and the farmer [L3]. Figure 7.20 shows factors that are considered in negotiating the premium [C3].

Figure 7.20: Establishing and Negotiating Premium, Factors to consider



Note: The picture is taken from an UTZ certificate guide book to explain the calculation of the premium. Source: Picture taken during interview [C3].

Due to the lack of a co-operative system in Ghana, with the exception of Kuapa Koko and Cocoa Abrabopa, certification in Ghana differs from neighbouring countries like Ivory Coast where it is the co-operatives holding the certificate[110]. Although LBCs are eager to stress that they only act as 'transient partners' who bring the buyer and the farmer together [L4], an UTZ certification officer, working in both Ivory Coast and Ghana, points out that the premium for farmers is lower in Ghana than in Ivory Coast since LBCs demand their share [E3]. Evidence suggests that also Cocobod demands its share in the certification business, since the collaboration between LBCs and multinational buyers has to be approved by the board [L3].

[110] It has also been pointed out that even under the co-operative system it might not necessarily be the farmer who gets the major share of the premium, since chief farmers act in a similar way as the LBC and would acquire most of the margin [L3].

Stakeholders enter into certification for different reasons. For chocolate manufacturers the main motives are branding and marketing [I2]. Certification serves as a marketing strategy to consumers, which builds the narrative of traceability and adds the illusion of a personal relationship between the consumer and the cocoa farmer. Interestingly Ghanaian beans have always been traceable, since Ghana is the only country where cocoa filled jute sacks are sealed upcountry for export [B2]. Each jute sack has a chip with the unique number of the buying station where it has been sealed and hence it is traceable up to the society level (Figure 7.21). However, Cocobod has no interest in stressing this fact over fears of product differentiation where beans from one area are preferred over beans from another [J2].

Figure 7.21: Cocoa Jute Sack with Chip Number and Shed with Number

Source: Photos taken in warehouses in Tema and in a cocoa shed in a society near Kumasi.

Grinders and traders enter into certification to gain greater control over the chain and achieve a better information flow. Aging farmers, growing practices on virgin forest land, and infestation of trees are only a few of the factors which contributed to sustainability concerns of the industry which predicts a massive shortage of cocoa beans in the near future. Especially the UTZ certificate, under which farmers receive training and extension services, grew out of these concerns. However, whether greater control over the growing processes is a solution to those problems is questionable [I2]. Another reason for first-tier suppliers to enter into certification is quality control. Depending on the certificate's working rules, grinders are able to set quality standards. Further, certification is another way to secure supply and in that way sidestep CMC [L3]. Since the certificate is funded by the multinational buyer, the cocoa has to be delivered to that buyer and CMC cannot sell it to another buyer.

LBCs join certification schemes to circumvent PPRC by negotiating additional margins with external buyers [L4]. Further, certification is another factor with which traders can compete over volume and bind farmers to them. However, securing volume through certification also comes with disadvantages. LBCs cannot decline farmers, who seek certification, due to concerns over securing the necessary volume. Farmers are hence able to use the certification to their own advantage.

> *"You cannot decline farmers who want to join the certificate as you want to scale up in future. […] The competition is really high. You really need to make sure that they sell to you. Certification is one way of doing it as they waiting for premium". [E2]*

Therefore, a LBC might be forced to buy more certified cocoa than its buyer demands. In some cases the buyer would still step in and buy the additional cocoa at a premium, but this depends on demand at the world market. Two certification managers working for multinational buyers mentioned that, while the certification project is being implemented for at least four years, they only have secured a buyer for the next two or three years [E1, E2]. If no buyer for the certified cocoa can be found, the cocoa has to be sold at a regular price while produced at a higher cost [E2].

Another problem is that certification premiums, like quality premiums, are relative. The more farmers sign up under the scheme, the smaller the premium, while implementation costs are unlikely to decrease. This might leave LBCs with higher costs while manufacturers gain higher quality cocoa and more stable supply.

The farmer holds the greatest risk, with the degree of risk exposure depending on the particular certificate. For instance, the enforcement of certain growing practices might come at the costs of lower yields or higher risk of tree infestation. In the case of organic cocoa production, costs have been too high so that the scheme was dropped soon after its implementation [G3]. However, yields took years to recover. Also incidences were reported where LBCs renegotiated the certification premium with farmers post-harvest. Since farmers already produced under the more costly scheme and cannot turn to another LBC for selling their certified beans due to the licence agreement under Cocobod, they are left with no choice but selling it for a smaller premium [I1].

7.5 Conclusion

The previous analysis has shown that price formation, as well as stakeholders' exposure to risk factors in commodity sectors depends on the institutional structure, here understood as the chain of transactions kept together by working rules.

In the case of Ghana's cocoa sector, the institutional structure alters the income received and the risk carried by the sector's stakeholders in a unique way. In most cocoa producing countries—e.g., Nigeria and Cameroon—multinational exporters directly negotiate with farmers or farmers' cooperatives. The transaction is a bargaining transaction between agents with unequal economic power. In Ghana, however, negotiations takes place between multinational exporters and CMC and the bargaining relationship between these actors is one between legal and economical equals.

The bargaining relationship is limited by existing working rules, which determine the price level to be set by the London futures exchange. Consequently, only the price differential can be negotiated in the bargaining transaction between CMC and buyers. The differential is determined by the bargaining power of the parties involved. The bargaining power of CMC is immediately linked to tangible and intangible properties of the Ghanaina cocoa beans, as well as CMC's monopoly on Ghanaian beans.

Although CMC holds equal economic power vis-à-vis multinational buyers, negotiations are asymmetric since CMC, in contrast to multinational buyers, does not directly participate in the futures exchange. It is hence excluded from a major part of the price formation mechanism. However, CMC can indirectly influence the futures market through entering traders' expectations. Since Ghana is the second largest cocoa producer globally, it benefits from a quantity-price insurance mechanism through the inverse relationship between quantities produced and price received at world markets.

The role of Cocobod prohibits multinational buyers from downward penetration of the local sourcing segment and execution of legal and economic power over cocoa producers. This poses limiting factors to multinational buyers. Buyers attempt to circumvent these limitations by entering into strategic transaction in the form of extension service provision to farmers (usually through NGOs) and, more recently, through certification. In this way, buyers undermine Cocobod's working rules and impose their own product and production standards on cocoa farmers—a process that is viewed with suspicion by Cocobod.

The working rules, which keep Cocobod with its divisions and subsidiaries and the Ghanaian cocoa sector together are rooted in Ghana's colonial past. With a democratically elected government, the collective power of farmers has increased and revenues extracted by Cocobod have declined substantially. However, the institutional structure does still provide for extraction. This comes foremost in the form of industry costs, which are arbitrary and prone to corruption.

Similar to Ghanaian cocoa farmers, domestic intermediaries like LBCs and hauliers are freed from the risk of declining cocoa prices through administered margins. However, they carry the risk of increasing operational costs and, since they have only limited control over the margins they receive, they are unable to (openly) pass on increasing costs to farmers or buyers. Farmers, although enjoying protection from declining world market prices in nominal terms, are still exposed to quantity risk and income risk, in particular through inflation. Further, farmers have weak bargaining power vis-à-vis intermediaries. Since farmers commonly lack storage space and credit, they depend on purchasing clerks. Purchasing clerks, through credit provision, often enter into managerial transactions with farmer to the purchasing clerks' benefit. Further, purchasing clerks rig scales to their own advantage and LBCs renegotiate the certification premium post-harvest.

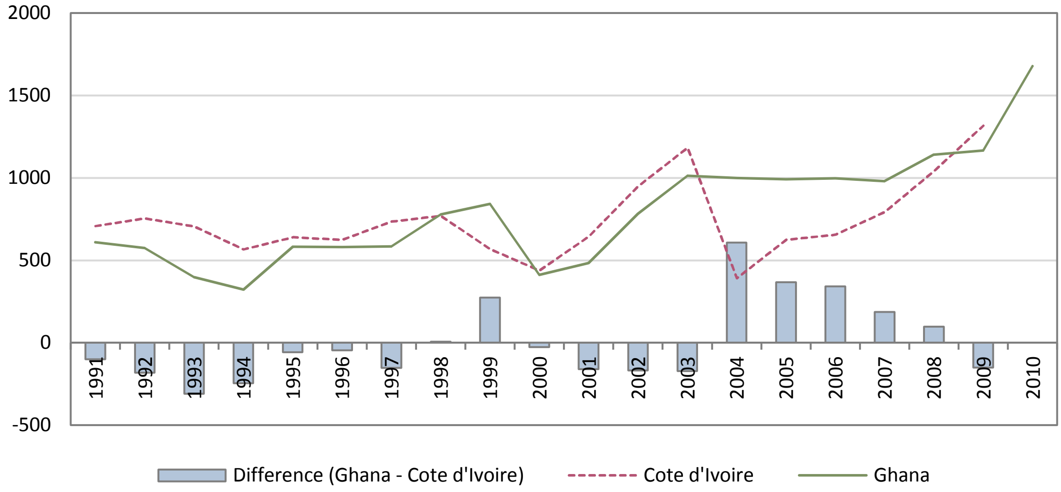
Overall, Ghana reached the goals promoted under the liberalisation doctrine like increasing competition, reduced administrative costs, and a high world price share for producers (Gilbert 2009), without facing the unintended consequences of other cocoa producing countries, like exposure of farmers to price volatility (Dana and Gilbert 2008, Gilbert and Varangis 2003) and erosion of the quality premium (Gilbert 1997). However, in order to fully assess the costs and benefits of the Ghanaian system, a comparative case study is necessary. This has to be left to future research. For preliminary insights, Figure 7.22 shows the difference in producer prices received by Ghanaian and Ivorian farmers since 1991. During the period of declining price in 2004, Ghana could maintain the farm-gate price while Ivorian farmers received less[111].

While Cocobod manages short term price risk through forward sales, the long term price risk depends on Ghana's weight as a producer in the world market as well as Cocobods control over the premium received for Ghanaian beans. This depends on quality control as well as branding. Although forward selling contributed to greater price stability in the Ghanaian cocoa sector, Cocobod is left with considerable exchange rate, inflation,

[111] Ul Haque (2004) argues that the income accruing to Ghanaian farmers is commonly underestimated, since industry costs, which at least partly benefit farmers, are not accounted for.

premium, quantity and long-term price risk. The future will show how resilient the board is against shocks at global cocoa markets and increasing price volatility through financialisation.

Figure 7.22: Producer Prices in Ghana and Ivory Coast (USD/tonne)



Source: FAO and ICCO.

Chapter 8 Summary, Conclusion and Implications

8.1 Introduction

This dissertation presented a detailed analysis of the financialisation of commodity derivatives markets and its impact on price formation and risk management mechanisms in commodity markets, as well as implications for stakeholders in commodity sectors. Financialisation was understood as the increasing inflow of financial liquidity, provided by traders without a commercial interest in the physical commodity, into commodity derivatives markets. This dissertation focused in particularly on the linkages between commodity derivatives and physical markets. It is through these linkages that the financialisation of commodity derivatives markets materialises empirically and affects the commodity sector as a whole. These linkages were established through arbitrage possibilities, traders' expectations formation and the institutional structure of the commodity chain.

It was argued theoretically and shown empirically that price dynamics in commodity futures markets are increasingly driven by speculative liquidity, which causes these markets to move away from what is considered market fundamentals. Conflicting price signals between physical and derivatives markets then cause anomalies in market basis, convergence mechanisms, and also market term structure. These developments do not only undermine the price discovery and risk management function of commodity futures markets, but also spill over to physical markets through arbitrage mechanisms and traders' expectations formation. Based on the case of the Ghanaian cocoa sector, it has been shown that, depending on the institutional setting and existing working rules that guide transactions within the sector, price dynamics in cocoa futures markets have direct implications for the distribution of cost and benefits among stakeholders in the Ghanaian and global cocoa sector.

This final Chapter 8 is divided into four sections. Following this introduction, Section 2 summarises key findings and conclusions drawn against the evidence gained to answer the research questions posed in Chapter 1. Section 3 discusses implications of the presented findings for both economic theory and policy. Section 4 identifies limitations in the study and presents an outlook for future research.

8.2 Key Findings

This thesis was structured into 8 chapters. Following a brief summary of the motivation, research questions, main contribution, and outline of the thesis in Chapter 1, the next Chapter 2 laid out the theoretical framework towards an answer to the overarching research question: *how, and in what way, are commodity prices affected by the latest episode of financialisation?* In particular, the framework focused on the effect of financialisation on futures markets (Q1) and elaborated on potential spill-over mechanisms to the physical market. Towards this goal, the chapter presented a synthesis of two strands of literature: theories of price formation in commodity markets and theories of price formation in asset markets. The former strand accounts for the interplay between physical and derivatives markets, but not for price formation mechanisms in derivatives markets beyond mechanical no-arbitrage relationships. The latter strand provides a theory of price formation in derivatives markets, but does not account for the commodity-specific interplay between physical and derivatives markets. These two strands of literature are synthesised towards a hypothesis on price formation in commodity markets, referred to as the 'financialisation hypothesis'.

Regarding the financialisation hypothesis, this thesis argued that, under uncertainty, financial traders engage in extrapolation, herding and portfolio insurance strategies (H1.1). If the market weight of traders employing such trading strategies is large enough, prices move away from what is considered to be market fundamentals, and commodity futures markets behave more like asset markets. This change in price behaviour materialises empirically in excessive volatility, and anomalies in market basis and market term structure (H1.2). Price dynamics introduced by financial traders, and in particular index traders, spill over to physical commodity markets through spatial arbitrage and traders' expectations (H2.1).

Chapter 3 presented an econometric analysis of assumptions made about traders' behaviour under uncertainty in support of H1.1. The analysis extended to the cocoa, coffee and wheat futures markets. Econometric evidence was presented for traders using extrapolative, herding and portfolio insurance strategies. By applying rolling window and recursive estimation techniques, it was shown that traders change their strategies dynamically with market developments, regulations and innovations. These findings confirmed the assumptions underlying the financialisation hypothesis, and the econometric tests presented set the stage for the preceding empirical analyses in Chapters 4 and 5.

Chapter 4 presented an econometric investigation into the cash–futures relationship in light of H1.2 and in anticipation of H2.1—taking the cocoa and wheat markets as case studies. Both markets exhibited a large market basis and convergence failure in recent years. Empirical results suggested that fundamental market factors have lost explanatory power regarding the market basis since 2006, while index pressure has altered the short- and long-run relationships between cash and futures markets significantly. Further, in reference to the financialisation hypothesis, it was argued that incidents of limits to spatial arbitrage are particularly interesting since, if spatial arbitrage is limited, the extent of the difference in price formation mechanisms in the physical and derivatives markets is revealed in the basis size at the maturity date of each futures contract. The thesis was able to theoretically and empirically link the extent of non-convergence in the wheat and cocoa markets to the composition of hedgers and speculators in the respective futures exchanges.

Chapter 5 presented further evidence in support of H1.2, by analysing futures markets' term structure dynamics—taking the cocoa and coffee markets as case studies. As in the previous Chapter 4, evidence suggested that the influence of fundamental market factors has weakened in recent years. Further, futures contracts, which are dominated by hedgers, tend to be driven by market fundamentals, and those dominated by index traders tend to be driven by financial risk variables. The significance of index pressure, especially at the tails of the futures curve, strongly supported the conjecture that index traders' rollovers of contracts significantly impact price. Short-dated contracts are known to serve a price discover function for the physical market, whereas long-dated contracts provide information regarding storage level to market practitioners. Through the information role of futures exchanges, the price pressure executed by index traders and speculators enters price formation, as well as storage decisions in the physical market through traders' expectations formation.

The empirical analyses presented in Chapters 4 and 5, although insightful, have been constrained by shortcomings in trader-position data as identified in Chapter 3. Only index trader position-data was found to be an appropriate approximation of trading strategies. For other speculative trader categories the level of aggregation impeded inference about these traders' impact on price dynamics. Although statistical inference was confined to the effect of index traders, it should be stressed that the effect of other speculative traders is potentially of equal importance.

Chapter 6 developed a theoretical framework for an institutional theory of price for commodity markets. The framework is informed by two strands of literature: 1) chain theories, and 2) institutional theory for price, and in particular, Commons' (1934) transaction theory. In reference to Q2—*How, and in what way, do price dynamics in commodity futures markets affect commodity sectors and, in particular, commodity producers and producing countries?*—it was argued that the interrelationship between futures and physical markets and its implications can only be fully understood by examining the underlying institutional structure, which governs price formation mechanisms across a commodity sector. Chain approaches provide a useful framework for understanding linkages and embedded power relationships within a commodity sector. However, these approaches do not provide any insights on implications of different power relationships for price formation and risk allocation processes. An institutional theory for price was used instead from which an analytical framework was drafted, which provided an institutional theory for price within the chain analogy.

It was hypothesised that price dynamics in the derivatives markets spill over to the physical markets not only through arbitrage and traders' expectations, but also through the underlying institutional framework (H2.1). Further, it was argued that if there are asymmetric power relationships within a commodity sector, market risk and price pressure are passed on to the weaker end of the commodity chain (H2.2). This weaker end, in the case of cash crops like cocoa, is most likely comprised of farmers (H2.3).

With reference to the framework presented in Chapter 6, Chapter 7 provided a detailed analysis of price formation and risk allocation mechanisms in the Ghanaian cocoa sector, which served as a case study. The analysis was predominantly informed by material collected in semi-structured interviews with stakeholders in the Ghanaian cocoa sector and the global cocoa–chocolate industry. The information gathered was used to map the institutional structure of the cocoa chain, with working rules guiding transactions within the chain. It was shown, in confirmation of H2.1, that under working rules set by the FCC, the mode and matter of each transaction involving physical cocoa beans are largely pre-determined, and therefore, negotiations are limited. Thereby, the futures market is the key determining factor of the cocoa bean price level in the physical market. Hence, the physical market price is directly linked to the derivatives market. It was confirmed, with reference to H2.2, that farmers, who hold the least legal and economic power, definitely occupy the weakest end of the commodity chain. However, in the case of Ghana, it was found that price pressure and market risk are not directly passed on to cocoa farmers. Hence, H2.3 was rejected. This outcome arose due to the unique institutional structure of the Ghanaian cocoa chain. In the case of Ghana, Cocobod, which holds equal legal and economic power vis-à-vis multinational buyers, absorbs, at least partly, price pressure and market risk.

8.3 Implications

In light of the evidence presented in this thesis, I conclude that financial investments by traders without a commercial interest in the physical commodity—depending on the market weight of these traders and the trading strategies employed—can significantly alter price formation mechanisms in commodity futures markets. Since financial investment has a direct impact on derivatives markets, but not on physical markets, price dynamics in the physical and derivatives markets differ, thereby leading to a volatile and large market basis, undermining hedging effectiveness. Further, derivatives markets' price dynamics spill over to the physical market through arbitrage possibilities, traders' expectations formation and the commodity sector-specific institutional structure guiding price formation mechanisms. In the case of cocoa, any physical transaction executed in a bargaining relationship is linked to the futures exchange through existing working rules. Hence, the price at the cocoa futures exchange is a prime determinant for the price paid and received for a cocoa bean in the physical market. In the particular case of Ghana, the transaction relationship between cocoa farmers and multinational buyers is mediated by Cocobod and CMC in particular. Price pressure and market risk is thus not directly passed on to smallholder farmers, but partly absorbed by Cocobod. Several implications for theory and policy arise from these findings.

8.3.1 Implications for Theory

Price dynamics observed in global commodity markets challenge the validity of both general equilibrium and rational expectation theories. The discussion in Chapter 2 highlighted the necessity to consider price formation mechanisms in physical and derivatives markets in equal measure, as well as the complex interplay between these markets. Existing literature on price formation in commodity and asset markets provides only partial theories. These theories are incapable of fully capturing the commodity-specific interplay between physical and derivatives markets.

Although theories on price formation in commodity markets fail to provide an explanation for recent price dynamics in commodity derivatives markets, asset-pricing and market microstructure theories could help to explain these recent price dynamics. However, asset-pricing theories cannot provide any guidance on the direction of causation between price formation mechanisms in physical and derivatives markets. Econometric evidence presented in Chapter 4 highlights this shortcoming in existing theories. For the wheat market, the cash market is usually found to lead the futures market. However, the market adjustment after the episode of non-convergence in 2008–09 suggests that, at least during this time period, the direction of causation was reversed, as physical wheat prices went through the roof, after limits to spatial arbitrage were resolved. This observation calls for a deeper analysis of the complex feedback mechanisms between cash and futures markets, beyond mechanical arbitrage conditions.

Further, the findings presented in Chapters 4 and 5 call for a reconsideration of the interpretation of market basis and term structure. Although theories based on no-arbitrage conditions provide answers for a deviation between cash and futures markets, as well as simultaneously traded futures contracts, they are, by and large, based on the assumption that general equilibrium conditions in the physical market coincide with consensus expectations in the derivatives market. However, inspired by the theory of hedging pressure, this thesis puts forward a theory of 'index pressure', under which the intertemporal price relationship is not only driven by storage availability, but also by the micro structure of futures markets. The latter includes the market weight of index and other speculative traders. Under this theory, fundamental arbitrage is limited, and dynamic feedback mechanisms between derivatives and physical markets exist, which account for many of the recently observed anomalies, like large and volatile basis, non-convergence between cash and futures markets and exceptionally high market carry.

The insights gained in Chapter 7, regarding working rules that limit negotiation over matter and mode of transactions in the cocoa sector, lead to further questioning of the assumption of general equilibrium conditions that underlie price formation in the physical market—an assumption that is prevalent in theories on commodity-pricing reviewed in Chapter 2: Section 2.2. In the case of cocoa, any transaction that involves the transfer of ownership over the physical cocoa bean is linked to the price formed at the cocoa futures exchange. The only negotiated part of the bean price received by CMC—the monopoly seller of Ghanaian cocoa beans—is the differential or market basis. This linkage between the futures and the physical market is institutional, written into FCC standardised forward contracts and barely considered in existing theories on price formation in commodity markets.

Price formation mechanisms in chain approaches have been neglected so far. Although attempts have been made to disentangle the value added at each node of the chain—e.g., Gilbert (2008b)—the mechanisms of value creation are not well understood. Confirmed by the empirical evidence presented in Chapter 7, price formation mechanisms are institutionally determined by working rules that guide transactions in commodity sectors.

Further, it was argued in this thesis, with reference to Kaplinsky and Morris (2000), that an analysis of prices paid and received along the commodity chain does not allow for inference regarding the burdens and benefits accruing to stakeholders in the commodity chain. Instead, one has to look at income received by the stakeholder—that is, the real price received with input and labour costs subtracted. This thesis added an additional component. With reference to Commons' (1934) transaction framework, as outlined in Chapter 6, it was argued that not only income, but also risk exposure of each stakeholder with regard to the factors constituting her income in the long and short-run has to be considered.

8.3.2 Implications for Policy

With the futures market's price discovery function undermined, an institutional structure that links the commodity price level in the physical market directly to the futures market poses problems, especially for commodity producers and producing countries. Cocoa producers' incomes—and, in the case of Ghana, also the income of CMC—are directly dependent on the cocoa prices formed in the futures market. While the liquidity provided by index traders executes a positive price pressure, that benefits producers, worries arise over the consequences of a mass liquidation of index positions, other speculative ones and the resulting increased price volatility. Intermediaries, in contrast, are not concerned with the price level, but rather the relative price and the proximity of futures and physical market prices. Further, if large enough, they benefit from volatile price changes in the derivatives market through outright speculation. The close, and institutionally determined, relationship between futures and physical market prices is beneficial for intermediaries, as it ensures hedging effectiveness for their commercial positions. Despite the close link between futures and physical market price still being institutionally determined, it was shown in this thesis that hedging effectiveness declined with increasing and volatile markets basis. Since the basis risk remains with the intermediary, conflicting price signals in futures and physical commodity markets, brought about by financial liquidity, can result in great losses. Although index and other speculative traders are valuable liquidity providers, liquidity provided by those traders needs to be carefully managed in order to prevent those traders from exerting price pressure.

Liberalisation of commodity markets in the 1980s–90s was partly motivated by the conviction that with liberalised commodity sectors, market-based risk management would be provided by the private sector. This conviction has not materialised, resulting in the direct exposure of commodity producers, including cocoa farmers, to volatile world market prices. Several attempts made by international donors to introduce derivative-based risk management tools to farmers were largely unsuccessful. The opening of commodity exchanges in commodity producing countries benefitted many except for farmers. For instance, the Ethiopian ECX has yet to contribute to a decrease in price risk for commodity producers like coffee farmers (Jayne, et al. 2014; Paul 2011). Further, the evidence presented in this thesis questions the appropriateness of market-based risk management via derivative instruments for smallholder farmers.

In the particular case of Ghana, CMC manages the price risk on behalf of Ghanaian cocoa producers by forward selling the projected annual cocoa harvest. The forward selling works similarly to hedging via the exchange, with respect to price risk management, but with the important difference that CMC can enter into negotiations over the market basis. Multinational buyers are therefore forced into a bargaining transaction with CMC, instead of with smallholder farmers. CMC, which holds a monopoly over Ghanaian cocoa, has considerable economic power and is thus in equal negotiation positions vis-à-vis buyers. With its unique institutional structure, the CMC provides effective price risk management for stakeholders in the Ghanaian cocoa sector, and at the same time, is in a powerful position to negotiate a premium over the exchange price.

Farmers and other stakeholders in the sector are still exposed, however, to other risk factors including inflation, quantity, quality and long term price risks. Further, cocoa farmers are still in a relatively weak bargaining position compared to purchasing clerks and LBCs. Farmers' cooperatives, which are almost absent in Ghana, could potentially increase farmers' negotiation position.

8.4 Directions for Future Research

In light of the discussion and evidence presented in this thesis, three areas of future research are identified.

Firstly, an extension of the empirical analysis to other commodity futures markets and commodity sectors is desirable. Although the cocoa, coffee and wheat markets are interesting comparative case studies, a broadening of the analysis is crucial in order to establish whether evidence collected in those markets is representative across commodity markets. This is particularly important, given the novelty of the analytical framework used to assess the impact of financialisation on price formation mechanisms and the interplay between cash and futures markets. Since commodity markets differ greatly due to the physical features of their respective commodities, as well as the composition of traders in their markets and industry structures, a set of commodity-specific analyses is necessary, before drawing more specific policy advice.

The second area of research arises from the theoretical deliberations in Chapter 6 and analysis provided in Chapter 7. Firstly, a greater integration between existing chain approaches with institutional theories of price is desirable. Although a potential framework was drafted in Chapter 6, regarding an institutional theory of price, which has been amended by contributions to the chain literature, an institutional theory of risk is yet incomplete. Although Commons' (1934) emphasis on 'futurity' and the differentiation between matter and mode of transaction are important foundations for an institutional theory of risk within a transaction framework, the theory needs elaboration.

Additionally, the theoretical framework stresses that both mode and matter of a transaction are determined by the relative power of the agents involved in the going concern, i.e., the commodity chain. However, due to time and financial constraints, important stakeholders have been excluded from the analysis. Farmers and purchasing clerks have not been interviewed in person, since resources were insufficient for funding of a translator and additional excursions to cocoa farms. Moreover, consumers and retailers have not been considered in the analysis, due to time and space constraints.

Last but not least, a comparative case study between the institutional structure of the cocoa sector in Ghana with neighbouring cocoa producers in Ivory Coast, Nigeria and Cameroon would be highly insightful. A comparative analysis would reveal the full implications of the country-specific institutional settings on price formation and risk allocation mechanisms across cocoa sectors.

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Appendix

Appendix Chapter 2

Appendix 2.1 Discussion on the Validity of Equation (2.1)

Prove can be given if considering that an investor might hold a commodity over the time period *t* to *T* and short a futures contract over the same time frame. The stochastic return on physical storage plus the return on shorting the commodity yields a non-stochastic return, which must equal the risk-free rate times the cash outlay:

$$\left[(S_T - S_t) - w_{t,T}\right] + \left[F_{t,T} - S_T\right] = [F_{t,T} - S_t - w_{t,T} = r_{f,T}S_t]$$

This is the case as the stochastic element in the return on the shorted futures contract is the inverse of the stochastic element in the return on holding the commodity over the same time period. Since the two stochastic elements cancel each other out, one is left with a certain return.

However, this is only true if there is convergence between the cash and the futures price at maturity, that is: $F_{T,T} = S_T$. Otherwise the return on shorting a commodity would not equal $F_{t,T} - S_T$, but $F_{t,T} - F_{T,T}$. For clarification Pindyck (2001) suggests the distinction between spot price and cash price. While the spot price is only observable at the point of maturity (so that $[F_{T,T} = S_T]$ holds per definition), the cash price is the continuous price at the physical market.

Appendix 2.2 Discussion on Keynes's Own Rate of Interest

The own rate of interest as conceptualised by Keynes can best be explained with an example. Taking wheat for instance, assume x tons of cocoa now would be worth y tonnes of cocoa in a year time. If $x > y$ the own rate of interest is negative and if $y > x$ the rate is positive. Hence in cocoa terms $C_2 = C_1(1 + i_c)$ with $x = C_1$ and $y = C_1(1 + i_c) = C_2$. The same is rational is applicable to money. Since x USD today are worth y USD in a year we can write in money terms $M_2 = M_1(1 + i_m)$ with $x = M_1$ and $y = M_1(1 + i_M) = M_2$.

Kaldor referred to the convenience yield as the inverse of the own rate of interest, as Keynes estimated the own rate of interest in commodity terms, while the convenience yield is estimated in money terms. This leads to a switch in signs. Following Keynes example we assume that the cash price for wheat is £100/100g and the futures price for a year hence is

£107/100g with a 5 per cent money rate of interest. Hence £100 pounds would yield £105 in a year time. However, this £105 would only buy 98.13g wheat in a year time as then wheat is at £107 per 100g. The wheat rate of interest is thus -1.87 per cent. One could understand this as an appreciation of wheat terms against money terms. Putting the Equation in money terms only, the sign would switch as money depreciates against wheat: £107 = £100(1+0.05)(1+0.0187), with 1.87 per cent being the inverse of the wheat rate of interest.

Appendix 2.3 Empirical Studies on Price Level and Volatility

Source	Evidence	Markets	Methodology	Notes
Amanor-Boadu and Zereyesus (2009)	No Evidence for speculators driving **price changes**.	Corn, wheat, and soybeans N/A	**OLS and ARIMA(2,1,2)** models, regressing OI of non-commercial traders on prices (all in first differences).	Coefficients are all negative and only slightly significant for corn.
Amenc, Maffei and Till (2008)	Fundamentals only behind the **price level**.	Crude oil	**Qualitative** data analysis	Fundamental variables are the major source of the price spike in 2008.
Basu, Oomen and Stremme (2010)	Information on speculative activity helps to time the market.	Oil, copper 10/1992-05/2006 (weekly)	Designing a dynamically managed strategy with changing portfolio weights of S&P 500, T-bills, copper, and oil. Non-commercial, commercial, and non-reporting share of long positions in total open interest (hedging pressure) are considered as predictive variables.	Incorporating the predictive variables, one yields returns more than 12 times higher than if excluding those information. Non-commercial net-long positions are positively related to the weight of oil and copper in the portfolio. The strategy exits the copper market completely when hedging pressure fell.
Beckmann, Belke and Czudaj (2014)	Global liquidity has an impact on commodity **price level**.	Commodity Research Bureau (CRB) indices (total, foodstuff, metals, raw materials) 01/1980-06/2012 (monthly)	**Markov switching VECM** in order to test the effect of global liquidity on global commodity prices in different market regimes. Approximate global liquidity with first principal component of money supply in US and other European countries.	Find a significant long-run relationship between global liquidity and commodity prices. The underlying relationships are indeed characterized by regime-dependence, implying that the impact of a global liquidity measure on prices varies over time.
Bicchetti and Maystre (2013)	Evidence for high frequency trader enhancing **co-movement** between commodity and stock markets.	WTI oil, corn, wheat, sugar, soybeans, and live cattle 1997-2011 (intraday)	Analyse the intraday co-movements between commodity returns and stock market (S&P 500 futures) returns. Compute **rolling correlations** with different frequencies (1-hour, 5-minute, 10-seconds).	Find a synchronized structural break which starts in the course of 2008 and continues thereafter. They conclude that this is consistent with the idea that recent financial innovations on commodity futures exchanges, in particular the high frequency trading activities and algorithm strategies have an impact on these correlations.

Bos and van der Molen (2012)	Both fundamentals and speculation affect **price level**.	Coffee N/A	**Nonparametric** analysis; Extensive dataset on supply, demand, inventories, other 'fundamentals', commercial and non-commercial open interest.	At most times demand and supply, combined with other 'fundamentals' explains (close to) 100% of the coffee price. However, inefficiencies are contributable to long and short position of non-commercial speculators.
Brunetti and Reiffen (2014)	Index traders' positions have an impact on the **term structure**	Corn, soybeans, and wheat 07/2003-12/2008 (daily)	**Two-step regression**: 1) hedging cost on risk-free rate and days till maturity and 2) constant (average cost of hedging) and s.d. of the error term on index traders' positions and hedgers' cash positions. Using a non-public dataset containing daily traders' positions of hedgers and index traders (approximated by swap traders). Hedging costs defined as $(E_t(P_T) - P_t)/P_t$ with $E_T(P_T)$ taken as an unbiased proxy for $E_t(P_T)$.	Find that the roll of index traders increases the spread between the maturing and the next-to-maturity contract. Further they find that the price of hedging (which really is the inverse of holding a long position) decreases – assuming that hedgers are all short in the market
Brunetti, Büyükşahin and Harri (2010)	Speculative trading reduces **price volatility**.	Crude oil, natural gas, corn 01/2005-03/2009 (daily)	Non-public data on daily positions of individual traders (CFTC large trader reporting system); **Granger non-causality** testes between realised volatility, swap dealers, and money managers; **Impulse response** analysis.	The trading activities of swap dealers as well as hedge funds in all markets considered stabilize prices.
Büyükşahin and Robe (2011)	Evidence for speculation increasing **co-movement**.	1) S&P GSCI energy index, S&P 500 01/1991-05/2011 (weekly returns) 2) Crude oil, heating oil, and natural gas, 07/2000-03/2010 (daily)	Non-public data on daily positions of individual traders (CFTC large trader reporting system). 1) **Dynamic conditional correlation** between S&P GSCI energy index and S&P 500 index weekly returns. 2) **Auto regressive distributed lag** model.	Besides fundamentals, variations in the composition of open interest by hedge funds being active in both the commodity and equity markets explain fluctuations in the strength of energy-equity return linkages.

Büyükşahin and Robe (2014)	Evidence for speculation increasing **co-movement**.	Wheat, corn, soybeans, coffee, sugar, cocoa, lean hogs, live cattle, feeder cattle, heading oil, crude, oil, natural gas, copper, gold, silver 07/2000-03/2010 (daily)	Non-public data on daily positions of individual traders (CFTC large trader reporting system). **Auto regressive distributed lag** model.	Besides fundamentals, variations in the composition of open interest by hedge funds being active in both the commodity and equity markets explain fluctuations in the strength of energy-equity return linkages. No evidence can be found for an impact of index traders on cross-market linkages.
Cifarelli and Paladino (2010)	Evidence for the impact of speculative activities on **price level**.	Crude oil (WTI) 10/1992-06/2008 (weekly)	Looking for positive feedback trading patterns in price data by employing a **multivariate CAPM with GARCH-M specifications** and controlling for stock prices and exchange rates.	Positive feedback trading strategies may have caused considerable departure of the crude oil futures price from its fundamental value.
Coakley, Kellard and Tsvetanov (2015)	Evidence for **bubble** behaviour in the oil market.	WTI crude oil 09/1995-04/2012 (monthly)	**Recursive unit root (ADF) tests** over continuous series (closing prices of the last business day of each month) of simultaneous traded contracts with different maturity dates.	All series exhibit periods of bubble behaviour that end in late 2008. The dating algorithms establish that the bubbles in longer-dated contracts start much earlier and are longer lasting than the bubble in the spot contract.
Gilbert (2008a)	Some evidence for the impact of speculative activities on **price level** and **price changes**.	1) Nickel, copper, zinc, lead, tin, and aluminium / LME 02/2003-08/2008 (daily) 2) Corn, soybean, soybean oil, wheat /CBOT 01/2007-08/2008 (weekly)	1) **Unit root tests**. 2) **Granger non-causality tests** (returns, weekly changes in CIT index and non-commercial traders' open interest)	Finds explosive bubble behaviour in metal markets (all despite lead). Index investment is found to have a persistent effect on soybean futures returns.
Gilbert (2010b)	Some evidence for the impact of speculative activities on **price level** and **price changes**.	Crude oil, aluminium, copper, nickel, wheat, corn, and soybeans WTI, LME, CBOT 01/2000-06/2009 (monthly average), 01/2006-12/2008 (daily), 01/2000-12/2008 (daily for metals).	**Rolling unit root tests**. **Granger non-causality** tests (log returns and Corazzolla index for index traders' net OI based on information on agricultural commodity markets). **3 stage least square regression analysis** (dlog futures prices, market fundamentals, Corazzolla index)	Finds significant evidence for explosive bubble behaviour in the copper and soybean market. Index based investments are found to have a permanent price impact on oil and metal prices over 2006-2008, however, evidence is weaker for grain prices.

Gomez, et al. (2014)	Excessive speculation led to increase in **co-movement** across commodities.	Aluminium, bananas, barley, beef, coal, coffee, copper, cotton, gold, hides, lamb, lead, maize, natural gas, nickel, palm oil, crude oil, rice, rubber, silver, soybeans, soybean meal, soybean oil, sugar, tea, tin, tobacco, wheat, wool, zinc 12/1992-07/2010 (monthly)	**Network analysis:** Ordered correlation **matrix**, ordered according to closeness relation among its elements. Then construct a hierarchical network from it.	While there is no persistent increase in co-movement, from mid-2008 to end of 2009 co-movement almost doubled. They conclude that speculation and uncertainty are drivers of the sharp slump in commodity price synchronisation.
Holt and Irwin (2000)	No evidence for CTAs and hedge funds acting as noise traders. Evidence for positive effect on **volatility**.	Coffee, copper, corn, cotton, gold, live hog, natural gas, crude oil, soybeans. CSCE, COMEX, CBOT, NYCE, CME, NYMEX 04/1994-10/1994 (daily)	Simple **OLS regression** between volatility (daily standard deviation/Parkinson's extreme value estimator) and non-commercial traders' positions **Variance ratio tests** to identify noise trading periods. **OLS regression** between net positions and prices: testing for positive feedback trading.	Find a positive relationship between trading volume of large hedge funds and CTA's on market volatility. Only evidence for noise in the gold market. No evidence for destabilizing positive feedback trading by CTAs' and hedge funds.
ICCO (2006)	Fundamentals only behind the **price level**.	Cocoa NYBOT, LIFFE 01/1986-12/2005 (daily)	**VECM** between spot and futures prices at the LIFFE and NYBOT; **VAR and impulse response analysis** incorporating returns, price volatility, and investment positions of different trader types.	LIFFE and NYBOT instantaneously incorporate new market information and the price discovery process is efficient. Speculation reduces price volatility and had on average a slightly negative price impact.
Irwin and Sanders (2010)	Influence of speculation on **price changes** insignificant and negative on **volatility**.	Corn, soybeans, soybean oil, wheat, cotton, live cattle, feeder cattle, lean hogs, coffee, sugar, cocoa, crude oil, natural gas CBOT, KCBOT, NYBOT, CME 07/2006-12/2009 (weekly)	**Granger non-causality tests** between returns/implied volatility/realised volatility and net-long index open interest/percentage long of index in total OI long/Working's speculative index Using DCOT (swap dealers) and COT/CIT (index traders) data on open interest.	There is not significant relationship between index open interest and returns. For a few markets a negative and significant relationship between index investment and volatility is found. Working's T-index appears to be positively related to market volatility.

Irwin and Sanders (2012)	Influence of speculation insignificant for **price level** and **volatility**.	Corn, soybeans, soybean oil, wheat, cotton, live cattle, feeder cattle, lean hogs, coffee, sugar, cocoa, crude oil (WTI), gas (RBOB), heating oil, natural gas, gold, silver, copper 12/2007-04/2011 (quarterly)	**Cross-sectional analysis**: relationship between quarterly returns/implied volatility/realised volatility and growth rate of net-long open interest/growth rate of net-long notional value of index investors (lagged and contemporaneous). CFTC larger trader reporting system, special call for index investment data	Very little evidence for the impact of index traders positions on returns and volatility.
Juvenal and Petrella (2011)	Both speculation and fundamentals behind **price changes** and **co-movement**.	Crude oil, various variables covering market fundamentals. NYMEX 01/1971-12/2009 (quarterly)	**Factor augmented VAR** model and **impulse response analysis**: 1) Estimating unobserved factors and factor loadings using principal component methods; 2) Use estimated factors to estimate augment the conventional four variable VAR model.	Global demand shocks account for the largest and speculative demand for the second largest diver of price fluctuations and co-movement across commodities. Between 2004 and 2008 financial speculation played a highly significant role.
Karstanje, Wel and Dijk (2013)	Significant term structure **co-movement** across commodities	Brent crude oil, WTI crude oil, gas oil, heating oil, natural gas, gasoline, gold, silver, aluminium, copper, lead, nickel, zinc, cocoa, coffee, cotton, sugar, corn, soybeans, feeder cattle, lean hogs 01/1995-09/2012 (monthly)	Extended **Nelson and Siegel yield curve factor model** in order to extract level, slope, and curvature factors for each commodity. Assess the degree of co-movement across term structure factors of different commodities by distinguishing between global, sector and idiosyncratic components in **rolling principal component analysis**.	Find co-movement in common factors of commodity futures curves. For the level factor, the co-movement is mostly due to a global level component. For the slope and curvature factors the co-movement is both due to a global and sector specific component.
Kaufmann (2011)	Both speculation and fundamentals behind **price level**.	Crude oil	**Co-integration analysis** between WTI crude oil futures and Dubai-Fateh **spot prices**. **Co-integrating relationship between market fundamental** factors and the near month WTI crude oil contract.	Finds repeated and extended breakdowns of the co-integrating relationship between spot and futures prices starting from 2004. Find that the co-integrating relationship between crude oil futures and fundamental variables breaks down between 2007 and 2008.
Kesicki (2010)	Speculation only minor transitory effect on **price level**.	Crude oil (WTI) NYMEC, ICE London 2003-2008	**Qualitative** data analysis.	Speculation played only a limited and temporary role in accelerating price movements.

Lagi, et al. (2011)	Evidence for the impact of speculative activities on **price level**.	Food prices FAO food index 01/2004-04/2011	Constructing a **dynamic structural model** allowing for trend-following behaviour.	The dominant causes of price increases are investor speculation (price spikes) and ethanol conversion (underlying price trend). A structural break is found in 2000 where prices stopped to follow supply and demand relations.
Liao-Etienne, Irwin and Garcia (2012)	Evidence for **bubble** in grain markets. Partial evidence for link to index traders.	Corn, soybeans, KCBT wheat, and CBOT wheat 01/2004-02/2012 (weekly)	Firstly identifies periods of explosive growth with **recursive unit root (ADF) tests.** Secondly identify periods of explosive growth with dummy variable and test effect of changes in index net-long positions on returns in **Granger non-causality** framework.	Identify periods of explosive growth between the end of 2007 and first half of 2008 as well as second half of 2010. Find Granger causality for CBOT wheat in explosive and non-explosive periods. No Granger causality can be found for other commodities.
Liao-Etienne, Irwin and Garcia (2014)	No evidence for 'new' kind of speculative **bubbles**.	Corn, soybeans, soybean oil , wheat (CBOT and KCBT), feeder cattle, live cattle, lean hogs, cocoa, coffee, cotton, and sugar 1970-2011 (daily)	Identifying periods of explosive growth with **recursive unit root (ADF) tests** on individual futures contracts.	All markets experience bubbles. Bubble episodes represent a very small portion between 1.5 and 2% of price behaviour during the 42-year period. Most bubbles are short-lived with 80–90% lasting fewer than 10 days. Explosive periods did not become more common or longer lasting.
Manera, Nicolini and Vignati (2013)	Evidence for short-term speculation increasing **volatility**, but long-term speculation decreasing volatility.	WTI crude oil, heating oil, gasoline, natural gas, cocoa, coffee, corn, oats, soybean oil, soybeans, wheat 1986 – 2010 (weekly)	Distinguishes between short-run (volume/open interest) and long-run speculation (Working's T-index, market share of non-commercials, net-long positions of non-commercials) indices. **Return-GARCH model with macro factors** (S&P 500, T-bill, Junk Bond Yields) in the mean Equation and speculation variables in GARCH Equation.	Speculation significantly affects the volatility of returns: The scalping (short-term) index has a positive and significant coefficient in the variance Equation and the other long-term speculation indices have negative and partly significant coefficients.

Maurice and Davis (2011)	No evidence for speculation driving **price changes** and **co-movement**.	Cocoa, arabica coffee, robusta coffee LIFFE, ICE 01/1990-09/2011 (monthly)	**Granger non-causality** tests investigating the impact of oil futures returns on cocoa and coffee futures returns; **Co-integration analysis** between coffee / cocoa futures prices and **oil futures** prices. **Co-integration** analysis and **ECM** between coffee / cocoa futures and **spot prices**.	Oil prices are found to Granger-cause coffee as well as cocoa prices; Only cocoa prices are co-integrated with oil prices. Cocoa and coffee markets are efficient despite speculative activity with a high speed of adjustment between futures and spot prices.
Mayer (2009)	Evidence for the impact of index positions on **price changes**.	Maize, wheat, soybeans, soybean oil, copper, gold, crude oil, natural gas. CBOT, KCBOT 01/2002-06/2008 (weekly)	1) **Regressing by OLS** share of net non-commercial traders / share of net index traders in total open interest on indicators related to returns diversification considerations. 2) **Granger non-causality** of share of net non-commercial and share of net index traders in total open interest on returns.	Index as well as non-commercial traders follow returns; index positions are also influenced by roll yields. Evidence for changes in the position of index traders causing price changes for soybeans, soybean oil, copper and crude oil.
Mou (2011)	Finds prolonged impact of index roll on commodity **term structure**	WTI crude oil, heating oil, gasoline, live cattle, soybean meal, pork belly, propane and copper. 01/1980-03/2010 (annual average)	**Panel regression**: Regressing the annual average of the difference in the roll yields during the S&P GSCI index roll and else on different commodities with dummies indicating if the commodity is indexed plus control variables for commodity specific fundamentals. Designs two **trading strategies** which makes use of the roll impact (calendar spread) of index investors.	Finds that on average the roll yield is deflated by 0.36 percent after a commodity is included in the S&P GSCI which implies that the roll has a significant price impact. Both trading strategies yield a significant increase in excess returns and experience a highly significant surge in the 'Sharpe' ratios after 2000.
Ncube, Tessema and Gurara (2014)	No evidence for excessive **co-movement** between oil and grains/softs.	1) Coffee, cotton, cocoa, 2) Wheat, corn, and palm-oil	Analyse co-movement between two groups of commodities and crude oil. Account for fundamentals in **multivariate GARCH** framework and explore remaining **time-varying pair-wise covariance** i.e. co-movement between commodity pairs.	Joint movement in commodity prices is explained by common macroeconomic variables with the exception of periods of economic downturn. This is explained by changing expectations.

Power and Turvey (2011)	No evidence for the impact of speculative activities on price **volatility**.	Corn, soybeans, wheat, live cattle. CBOT, CME 01/1998-12/2006	**Two stage least square** model to analyse relationship between the trading volume of index traders (wavelet transformation of total futures volume excluding variations with a time horizon of less than one month) and price volatility (absolute returns).	No evidence for the impact of long-term index investment on price volatility for corn, soybeans and wheat; some evidence found for live cattle.
Redrado, et al. (2009)	Speculation can cause **prices level** to deviate from fundamental value for a prolonged period of time.	IFS aggregate food and aggregate metal index 01/1973-05/2008 (monthly)	**Smooth transition VAR models (STAR)**, with the no-linear transition function being determined by the size of the misalignment of the current price regarding its fundamental value.	Very large misalignments tend to be corrected relatively fast, while smaller misalignments persist over time without any endogenous correction in place. Those smaller misalignments are probably driven by market sentiments
Robles, Torero and von Braun (2009)	Speculation might have an impact on **price changes**.	Wheat, maize, soybeans, rice. CBOT 01/2002-05/2008 (monthly)	Speculation indicators: ratio of volume to OI, ratio between commercial and non-commercial traders, net index traders' positions. **Rolling Granger non-causality** tests between commodity prices and speculation indicators.	Speculation indicators are relatively stable over time. Some evidence for past values of speculative indicators being positively correlated with price changes. Speculation might be a consequence rather than a cause.
Sanders, Irwin and Merrin (2010)	Speculation was not excessive over the last decade.	Corn, soybeans, soybean oil, wheat, cotton, live cattle, feeder cattle, lean hogs CBOT, KCBOT	Assessing the 'adequacy of speculation' by **Working's T-Index** (estimated with COT, COT/CIT and CFTC bank participation report.	Speculation on commodity futures markets was not particularly high over the last years in historical comparison.
Schulmeister (2009)	Evidence for the profitability of noise traders.	Oil, corn, wheat, rice. 1994-2008	Investigating the performance of 1092 popular technical **trading strategies** and their potential price impact.	Technical trading strategies were highly profitable. Market entrance and exit impulses are given almost simultaneously across all strategies. High potential price impact.

Silvennoinen and Thorp (2013)	Evidence for speculation increasing **co-movement**	Corn, soybeans, soybean oil, wheat, lean hogs, live cattle, pork bellies, coffee, cotton, orange juice, sugar, gold, platinum, silver, aluminium, copper, nickel, lead, tin, zinc, brent oil, crude oil, heating oil, natural gas CBT, CME, CSCE, NYCE, COMEX, LME, NYMEX 05/1990-07/2009 (weekly)	**Time-varying (double) smooth transition conditional correlation GARCH ([D]SCC-GARCH)** models, logistic transition functions are conditioned on time, expected stock volatility (VIX) and non-commercial traders' OI.	Correlation between equity and commodity returns has increased for almost all commodities over time. This is more pronounced for commodities included in the major indices. Observe higher and more variable correlations when expected stock volatility is high.
Singleton (2014)	Evidence for the impact of speculative activities on oil **price changes**.	Crude oil 09/2006-01/2010 (weekly)	**OLS regression**: Including contracts of all maturities; Regressing the excess returns against returns on own lags, S&P500, MSCI Emerging Asia indices, overnight repo positions, thirteen-week change in positions of index investors and managed-money spread positions, aggregate open interest, and convenience yield.	The intermediate-term growth rates of index positions and managed-money spread positions had the largest impacts on futures prices. Found statistically significant predictive powers of changes in the index investor and managed money spread positions on excess returns. Increases in flows into index funds over the preceding three months predict higher subsequent futures prices.
Stoll and Whaley (2011)	No evidence for index traders affecting **price changes** (but non-commercial traders)	Cocoa, coffee, corn, cotton, wheat, soybean oil, crude oil, heating oil, natural gas, feeder cattle, lean hogs, live cattle, gold, and silver 01/2006-07/2009 (daily)/(weekly)	Comparing **contemporaneous correlation** of futures prices for indexed commodities; **OLS regression** calendar spread on index investment during times of rollover; **Granger non-causality** between index investment flows (dollar value) and commodity returns; **OLS regressing** weekly futures returns on contemporaneous non-commercial and index trader flows.	Prices of non-indexed commodities and commodities without futures markets behave similar to indexed commodities (only graphical comparison). Impact of index investment on calendar spread only high and significant for crude oil. Granger causality tests only significant for cotton, soybeans, and soybean oil. Non-commercial open interest across commodities is positively correlated with returns.

Tang and Xiong (2012)	Evidence for speculation increasing **co-movement**	Corn, wheat, soybean, soybean oil, soybean meal, live cattle, lean hogs, feed cattle, gold, silver, copper, coffee, cocoa, cotton, sugar, rice, oat, orange juice, lumber, platinum, palladium, pork belly 01/1998-10/2009 (monthly)	**Panel regression** with indexed and off-index commodity returns on the oil returns and a set of control variables (Morgan Stanley emerging market equity index, global shipping index, returns on the S&P500, JP Morgan Treasury bond index, US dollar index, CPI inflation rate) and a dummy for a structural break in 2004.	Futures prices of different commodities became increasingly correlated with each other and this trend was significantly more pronounced for indexed commodities. Correlation between non-energy commodities and oil increased significantly after 2004 and is stronger for index than for off-index commodities.
Timmer (2009)	Speculation only indirect impact on rice **price level**.	Rice, wheat, corn N/A	**VAR** models to assess the impact of other commodity prices, oil prices and exchange rate movement on commodity futures returns.	In the short-run, wheat and corn price dynamics are almost certainly caused by financial speculators. Rice is only affected through the speculation in other commodity markets which leads to hoarding as the rice futures market.
Vansteenkiste (2009)	Strong common macro-economic factors are behind **co-movement.**	Cocoa, coffee, tea, coconut/ groundnut/ palm/ linseed/ soybean oil, soybeans, copra, maize, rice, wheat, sugar, cotton, jute, rubber, wool, timber, aluminium, copper, lead, nickel, tin, and zinc 01/ 1957-05/2008 (quarterly)	**Dynamic common factor analysis**, employing Kalman filter techniques; Does not account for potential speculative impact.	Separating common and idiosyncratic factors for each commodity market it is found that there exists one common significant factor which has become increasingly important in driving non-fuel commodity prices: oil prices, USD exchange rates, US real interest rates, and global demand.
Vansteenkiste (2011)	Significant impact of speculators on **price level**.	WTI crude oil 01/1992 – 04/2011 (monthly)	**Two-Regime Markov-switching model**; switching between "fundamental-based" and "chartist-based" regimes. Regime switch is conditioned on degree of speculative activity measured by Working's T-index.	An increase in speculative activity increases the probability of remaining in the chartist regime. And the probability of being in this regime has significantly increased and from 2004 onwards the chartist regime appears to have prevailed.
Yung and Liu (2009)	Evidence for the impact of speculative activities on **price changes**.	Copper, gold, silver, crude oil, natural gas, and unleaded gas	**VECM**; Daily return and turnover	Find relatively strong and consistent evidence of overconfident trading among futures speculators only.

Appendix Chapter 3

Appendix 3.1: Overview CFTC Traders' Positions Reports

<table>
<tr><td colspan="5">CFTC Trader's Positions Data Sets</td></tr>
<tr><td></td><td>Trader Categories</td><td>Definition</td><td>Investors</td><td>Classification</td></tr>
<tr><td colspan="5">Commitment of Trader Report [COT]</td></tr>
<tr><td rowspan="3">Availability: Futures only, futures-and-options combined | January 1986
Frequency: Monthly (till 1992), Weekly (thereafter)</td><td>Commercial</td><td>Entity that it is commercially engaged in business activities hedged by the use of the futures or option markets.</td><td>Producers; Users, Intermediaries; Swap dealers (index and non-index)</td><td>Hedgers, active informed, active uninformed, passive uninformed</td></tr>
<tr><td>Non-Commercial</td><td>Entity that is not trading in commodity futures for the purpose of hedging.</td><td>All but the above (index and non-index)</td><td>Active informed, active uninformed, passive uninformed</td></tr>
<tr><td>Non-Reportable</td><td>Traders whose trading exposure is below a reporting level set by the CFTC.</td><td>All traders below reportable level</td><td>Active informed, active uninformed, passive uninformed</td></tr>
<tr><td colspan="5">Index Trader Supplement [CIT][1]</td></tr>
<tr><td rowspan="4">Availability: Futures-and-options combined | (backdated January 3, 2006)
Frequency: Weekly</td><td>Commercial</td><td>See COT exl. index</td><td>See COT exl. index</td><td>Hedgers, active informed, active uninformed</td></tr>
<tr><td>Non-Commercial</td><td>See COT exl. index</td><td>See COT exl. index</td><td>Active informed, active uninformed</td></tr>
<tr><td>Non-Reportable</td><td>See COT</td><td>See COT</td><td>Active informed, active uninformed, passive uninformed</td></tr>
<tr><td>Index Trader</td><td>Traders which entertain a passive strategy seeking exposure to commodity price movements by investing in a broad index of commodities, a sub-index of related commodities, or a single commodity index.</td><td>Index funds, swap dealers, pension and endowment funds (typically gain exposure through swap dealers), hedge funds and mutual funds. Also included are exchange traded funds and notes (ETFs and ETNs) and exchange traded products (ETPs).</td><td>Passive uninformed</td></tr>
<tr><td colspan="5">Index Investment Data [IID][2]</td></tr>
<tr><td>Availability: Futures,</td><td>Index Trader</td><td>See CIT</td><td>See CIT</td><td>Passive uninformed</td></tr>
</table>

Options and OTC **Frequency:** Monthly				
Disaggregated Commitment of Trader Report [DCOT]				
Availability: Futures only, futures-and-options combined | September 4 2009 (backdated: June 13, 2006) **Frequency:** Weekly	Producer/ Merchants/ Processor/ User	Entities that predominantly engage in the production, packaging, and handling of the physical commodity. Use the futures market to hedge.	Producers; merchants; processors; users.	Hedgers, active informed
	Swap Dealer	Deals primarily in swaps and use the futures market to manage or hedge their risk.	Swap traders (often facilitating index investment for their clients)	Passive uninformed, active uninformed
	Money Manager	Managing and conducting organised futures trading on behalf of clients.	CTAs; CPOS; and unregistered funds.	Active uninformed; active informed
	Other Reportable	Every other reportable trader that is not placed into one of the other three categories.	All but the above (e.g. pension and investment funds, investment banks).	Passive uninformed, active informed, active uninformed
Traders in Financial Futures Report [TFF]				
Availability: Futures only, futures-and-options combined | (backdated: June 13 2006) **Frequency:** Weekly *Only commodity indices but not single commodity market.	Dealer/ Intermediary	Agents that design various financial assets which they sell to clients. Risks are offset across markets and clients; futures are part of the risk management.	Lager banks; dealers in securities, swaps and other derivatives.	Passive uninformed, "hedgers"
	Asset Manager/ Institutional	Institutional investors	Pension funds; endowments; insurance companies; mutual funds.	Passive uninformed
	Leveraged Fund	Entities which employ strategies which involve outright positions; arbitrage within and across markets on their behalves or behalves of speculative clients.	Hedge funds; various types of money managers like CTAs, CPOs, or unregistered funds.	Active uninformed, active informed
	Other Reportable	Mostly traders who use the market to hedge business risk (foreign exchange, equities, interest rate).	Corporate treasuries; central banks; mortgage originators; credit unions.	Passive uninformed, active informed, active uninformed
Large Trader Net Position Changes				
Availability: Futures net position changes January 2009 to May 2011 **Frequency:** Weekly[3]	Same as DCOT	Same as DCOT	Same as DCOT	Same as DCOT
<u>Note:</u> The COT/CIT/DCOT/TFF reports provide a breakdown of each Tuesday's open interest for markets in which 20 or more traders hold positions equal to or above the reporting levels established by the CFTC. A trading entity generally gets classified by filing a statement with the Commission, on CFTC Form 40: Statement of Reporting Trader.				

COT/DCOT data are available for futures and options and futures combined.

[1] The long report, in addition to the information in the short report, also groups the data by crop year, where appropriate, and shows the concentration of positions held by the largest four and eight traders. The Supplemental report is published for futures and options combined in selected agricultural markets and, in addition to showing all the information in the short format, shows positions of Index Traders.

[2] In contrast to the CIT report the IID report shows index based positions only. If the preponderance of a trader's trading is index related all her positions are classified as index positions in the CIT report. Hence the CIT report might under/overstate the true index based positions. The IID data is based on a "special call" for index traders and shows only those positions purely linked to index trading.

[3] Simple weekly average of the aggregated daily net positions of reportable traders.

Appendix 3.2: Technical Overview over Empirical Literature

Study	Frequency	Dependent (Y)	Independent (X)
Sanders, Boris, and Manfredo (2004)	Weekly	$nl\_pct_{i,t} = \frac{long_{i,t} - short_{i,t}}{long_{i,t} + short_{i,t}}$, with i={com, ncom}	• $R_t = \ln(\frac{f_t^1}{f_{t-1}^1})$, returns
Domanski and Heath (2007)	Monthly	$nl\_pct_{i,t} = \frac{long_{i,t} - short_{i,t}}{OI_t}$, with i=ncom	Return • $R_t^1 = \frac{f_t^1 - f_{t-1}^1}{f_{t-1}^1}$, returns • $Roll_t = \sum_{i=0}^{12} \frac{f_{t-i}^1 - f_{t-i}^3}{f_{t-i}^1}$, average size of the roll return over the previous 12 months. • $Vol_t = \sqrt{\frac{\sum_{i=0}^{20}(R_{t-i}^3 - \bar{R}_t^3)^2}{20-1}}$, volatility defined as the 20 months standard deviation of three-month futures returns. • $Int_t = \sum_{j=1}^{6} r_j$, with r=three-month interest rate and j={Canada, Germany, Japan, Sweden, UK, US}. Diversification • $Corr_t = \frac{\sum_{i=0}^{60}[(R_{t-i}^1 - \bar{R}_t^1)(MS_{t-i} - \overline{MS}_t)]}{\sqrt{\sum_{i=0}^{60}(R_{t-i}^1 - \bar{R}_t^1)^2 \sum_{i=0}^{60}(MS_{t-i} - \overline{MS}_t)^2}}$, correlation between returns and Morgan Stanley world equity price index over the last 5 years. • $Infl_t = bond_t^{nom} - bond_t^{real}$, inflation expectations defined as the difference between nominal and real 10=year US bonds.
Mayer (2009)	Monthly	$nl\_pct_{i,t} = \frac{long_{i,t} - short_{i,t}}{OI_t}$, with i={ncom, index}	Return • $R_t^1 = \frac{f_t^1 - f_{t-1}^1}{f_{t-1}^1}$, returns • $Roll_t = \sum_{i=0}^{12} \frac{f_{t-i}^1 - f_{t-i}^3}{f_{t-i}^1}$, average size of the roll return over the previous 12 months. • $Vol_t = \sqrt{\frac{\sum_{i=0}^{12}(R_{t-i}^3 - \bar{R}_t^3)^2}{12-1}}$, volatility defined as the 12 months standard deviation of three-month futures returns. • $Int_t = \sum_{j=1}^{6} r_j$, with r=three-month interest rate and j={Canada, Germany, Japan, Sweden, UK, US}. Diversification • $Corr_t = \frac{\sum_{i=0}^{12}[(R_{t-i}^1 - \bar{R}_t^1)(SP_{t-i} - \overline{SP}_t)]}{\sqrt{\sum_{i=0}^{12}(R_{t-i}^1 - \bar{R}_t^1)^2 \sum_{i=0}^{12}(SP_{t-i} - \overline{SP}_t)^2}}$, correlation between returns and Standard and Poor 500 equity price index over the last year.

			• $Infl_t = bond_t^{nom} - bond_t^{real}$, inflation expectations defined as the difference between nominal and real 10=year US bonds. • Euro-Dollar exchange rate.
Mayer (2012)	Monthly	$nl\_pct_{i,t} = \frac{long_{i,t} - short_{i,t}}{OI_t}$, with i={ncom, index}	Return • $R_t^1 = \frac{\ln(f_t^1/f_{t-1}^1)}{\ln(f_{t-1}^1)}$, returns • $Roll_t = \sum_{i=0}^{12} \frac{\ln(f_{t-i}^1/f_{t-i}^3)}{\ln(f_{t-i}^1)}$, average size of the roll return over the previous 12 months. • $Vol_t = \sqrt{\frac{\sum_{i=0}^{12}(R_{t-i}^3 - \bar{R}_t^3)^2}{12-1}}$, volatility defined as the 12 months standard deviation of three-month futures returns • $Int_t = \sum_{j=1}^{6} r_j$, with r=three-month interest rate and j={Canada, Germany, Japan, Sweden, UK, US} Diversification • $Corr_t = \frac{\sum_{i=0}^{12}[(R_{t-i}^1 - \bar{R}_t^1)(R_{t-i}^{SP} - \bar{R}_t^{SP})]}{\sqrt{\sum_{i=0}^{12}(R_{t-i}^1 - \bar{R}_t^1)^2 \sum_{i=0}^{12}(R_{t-i}^{SP} - \bar{R}_t^{SP})^2}}$, correlation between returns and Standard and Poor 500 equity price index returns over the last year. • $Infl_t = bond_t^{nom} - bond_t^{real}$, inflation expectations defined as the difference between nominal and real 10=year US bonds. • US-Dollar exchange rate index (geometrically weighted index of currencies of major trading partners).
McAller and Radalji (2013)	Weekly	$nl_{i,t} = long_{i,t} - short_{i,t}$, with i=nrep	• $R_t = \ln(\frac{f_t^1}{f_{t-1}^1})$, returns • $OI_t = \frac{\sum short_{i,t} + \sum long_{i,t} + 2 * \sum spread_{i,t}}{2}$, total open interest. Intentional herding • $nl_{ncom,t-1}$, lagged net-long positions of commercial traders.
Wang (2003)	Monthly	$\Delta nl_{i,t+1}$, with i={com, ncom}	Investor sentiments • Δsi_t, which is the change in the Consensus Index published by Consensus Inc. Return • $R_t^1 = \frac{f_t^1 - f_{t-1}^1}{f_{t-1}^1}$, with (t-1) being one month lag. Common information variables • Expected inflation = monthly yield on 3-months T-bills • Premium of default risk = Monthly yield on Moody's BBA-rated long-term minus AAA-rated corporate bonds. • Signal for risk premium = Monthly dividend yield on the S&P 500 index.

Rouwenhorst and Tang (2012)	Weekly	$Q_t = \frac{\Delta nl_{i,t}}{OI_{t-1}}$, with i={com, ncom| com, mm, swap, other | com, ncom, index}	• $R_t^1 = \frac{f_t^1 - f_{t-1}^1}{f_{t-1}^1}$, excess returns with f_t^1 being the nearest to maturity contract not maturing in month t. • $Basis_t = \sum_{i=0}^{52} \frac{f_{t-i}^1 - f_{t-i}^2}{f_{t-i}^1}$, annualised percentage price difference between the front month and the next to maturity month as a proxy for the average market basis.
Note: *com* refers to commercial trader or producer and consumer in the DCOT report, *ncom* refers to non-commercial traders in the COT and CIT report, *mm* stand for money managers, *swap* for swap traders, and *others* for other non-commercial traders in the DCOT report, *index* stands for index traders as in the CIT supplement.			

Appendix 3.3: Extrapolative Trading Indicators and Index Creation

Technical traders look at a variety of different indicators. However, most indicators are based on settlement prices, open interest and volume which are provided by the respective exchanges. Indicators aim at identifying trends in the data that is regularities which historically coincided with the market moving in a particular direction. Predicting this direction gives the trader an edge over others. In order to develop a variable that captures extrapolation and could be used in a time series analysis, four different indicators, two based on past prices and two on open interest and volume data, are used. The timing of buy and sell-signals based on these indicators is then captured in a single variable. While those indicators cannot do justice to highly complex trading algorithms, they are believed to still serve as benchmark indicators considered by many market practitioners.

Relative Strength Index:

Relative strength [RS] is a measure which captures the ratio between the average of closing prices on days which saw a rise and the average of closing prices on days which saw a fall. Exponential moving averages are commonly used.

$$RS_t^\tau = \frac{EMA\_UP_t^\tau}{EMA\_DOWN_t^\tau}$$

With the exponential moving average of closing prices above [$EMA\_UP_t^\tau$] and below [$EMA\_DOWN_t^\tau$] the previous closing price:

$$EMA\_UP_t^\tau = \sum_{i=0}^{\tau}[w_i * x_{t-i}],$$

$$EMA\_DOWN_t^\tau = \sum_{j=0}^{\tau}[w_j * y_{t-j}].$$

τ is the number of trading days over which the exponential moving average is calculated and w are exponentially declining weights. For the calculation of the indicator $\tau = 10$, which means that the exponential moving average is calculated over the last 10 trading days. x_t and y_t are the closing prices chosen as following:

$$x_t = \begin{cases} |\Delta p_t|, & if\ p_t - p_{t-1} > 0 \\ 0, & if\ p_t - P_{t-1} \leq 0 \end{cases}$$

$$y_t = \begin{cases} |\Delta p_t|, & if\ p_t - p_{t-1} < 0 \\ 0, & if\ p_t - P_{t-1} \geq 0 \end{cases}$$

The relative strength index [RSI] standardises the RS so that RSI $\in [0; 100]$.

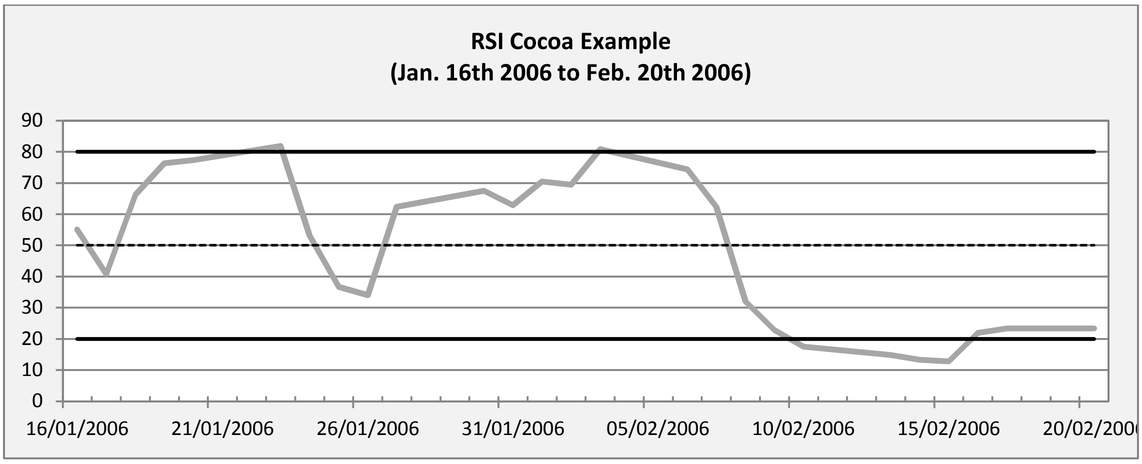
$$RSI_t^\tau = 100 - \frac{100}{1+RS_t^\tau}$$

As a rule of thumb, traders assume lower and upper boundaries, commonly define at [20; 80]. If the RSI crosses the upper threshold the asset is through to be over-bought. If the lower threshold is crossed the asset is thought to be over-sold. The former amounts to a sell-signal and the latter to a buy-signal. Hence, whenever the RSI is greater than 80 a sell-signal is counted for and if it is lower than 20 a buy-signal is counted for.

$$B_t = \begin{cases} 1, if\ RSI_t \leq 20 \\ 0, if\ RSI_t > 20 \end{cases}$$

$$S_t = \begin{cases} 1, if\ RSI_t \geq 80 \\ 0, if\ RSI_t < 80 \end{cases}$$

The below graphic depicts the RSI for cocoa from mid-January 2006 to end of February 2006. The line in light grey is the RSI while the strait lines at 20 and 80 represent the boundaries.



Moving Average Convergence Divergence:

Similarly to the RSI the Moving Average Convergence Divergence [MACD] signals whether the market is over-bough or over-sold. MACD is calculated by the difference between two exponential past price averages over different time periods.

$$EMA_t^{\tau} = \sum_{i=0}^{\tau} [w_i * p_{t-i}]$$

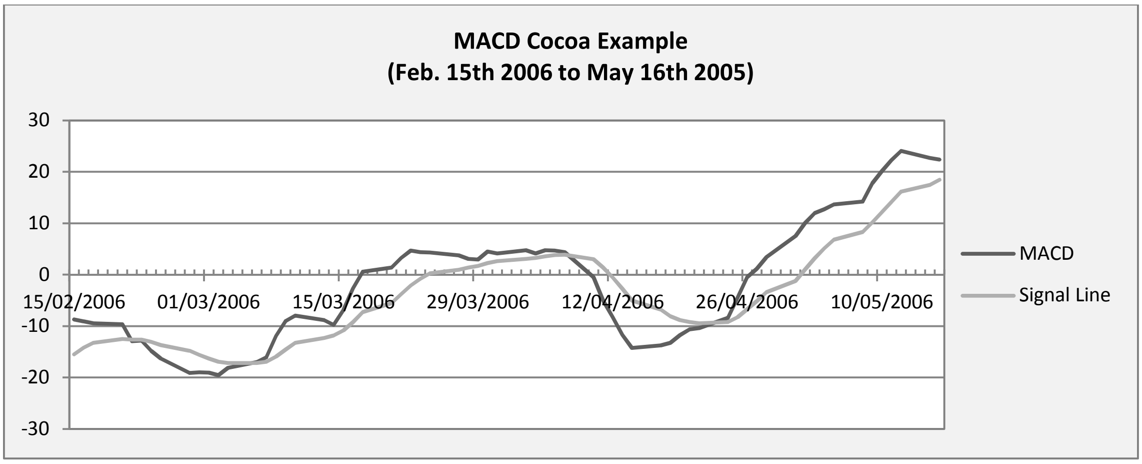
$$MACD_t = EMA_t^{\tau_{small}} - EMA_t^{\tau_{large}}$$

with p_t being the closing price at a particular point in time. For the calculation of the indicator τ_{small} is chosen to be 12 days and τ_{large} is chosen to be 26 days. The MACD is then plotted against its own 9-day exponential moving average, which is commonly referred to as the "signal line". If the MACD crosses its signal line from below it is considered to be a bullish signal. If it crosses from above it is considered to be bearish. The buy and sell indicator is then estimated from the difference between the MACD and its signal line [$D_t = MACD_t - EMA_t^9$].

$$B_t = \begin{cases} 1, if\ D_t > 0\ and\ D_{t-1} < 0 \\ 0, \quad otherwise \end{cases}$$

$$S_t = \begin{cases} 1, if\ D_t < 0\ and\ D_{t-1} > 0 \\ 0, \quad otherwise \end{cases}$$

The indicators are hence only picking up the moment at which the signal line is crossed. An example from the cocoa market is depicted below.

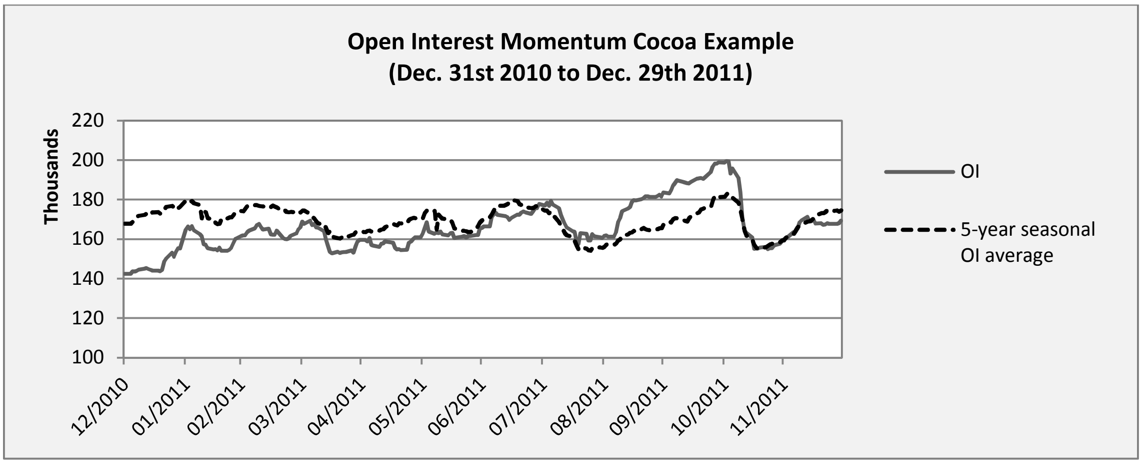


Open Interest Momentum

In combination with prices indices, open interest and volume data are almost always considered in addition. Open interest only varies if a new contract is created or an old ceases to exist, but not if contracts which had previously been in the market are resold or rebought (this is captured by volume). In many markets, especially in commodity markets, open interest is highly cyclical as hedgers enter the market in particular months. Hence, a good way to see whether open interest is particularly high or low is to plot open interest against its 5-year seasonal average. A particularly low open interest signals that a current price trend is likely to come to an end soon, while a relatively high open interest signals support for the present trend. The support is estimated taking on one if current open interest is above its 5-year seasonal average and zero otherwise.

$$Sup_{OI} = \begin{cases} 1, if\ \frac{\sum_{i=1}^{5} OI_{i,t}}{5} < OI_{1,t} \\ 0, \quad otherwise \end{cases}$$

with i indicating the particular year and t the particular day of the year. If the buy or sell indicator is positive, the open interest support is added to the indicator. If there is no buy or sell-signal, the open interest support is not added. The graphic below shows open interest and the 5 year seasonal average for the cocoa market over the time period December 2010 to December 2011.



Volume Oscillator

Volume data, similar to open interest, gives important additional information about whether a current trend is supported. A commonly used index is the volume oscillator which is the simple difference between a shorter and a longer exponential moving average.

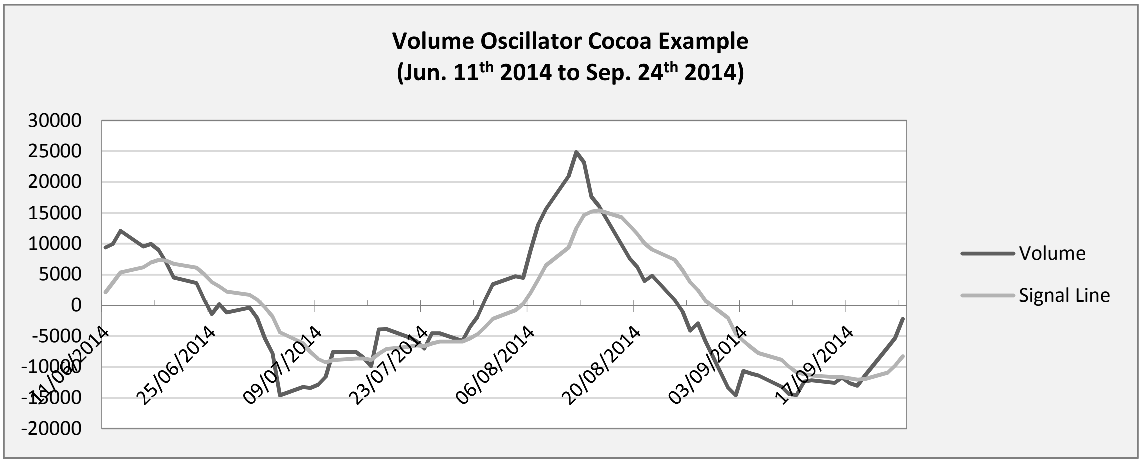
$$EMA_t^{\tau} = \sum_{i=0}^{\tau}[w_i * VM_{t-i}]$$

$$VO_t = EMA_t^{\tau_{small}} - EMA_t^{\tau_{large}}$$

As for MACD, 12 and 26 days are chosen for the small and large period exponential moving average. The volume oscillator, similar to the MACD, is then compared to its 9-day exponential moving average. If the current volume is above the signal line, it is considered as support for the current price trend. The difference between the two trends [$D_t = VO_t - EMA_t^9$] is then used to calculate the support indicator.

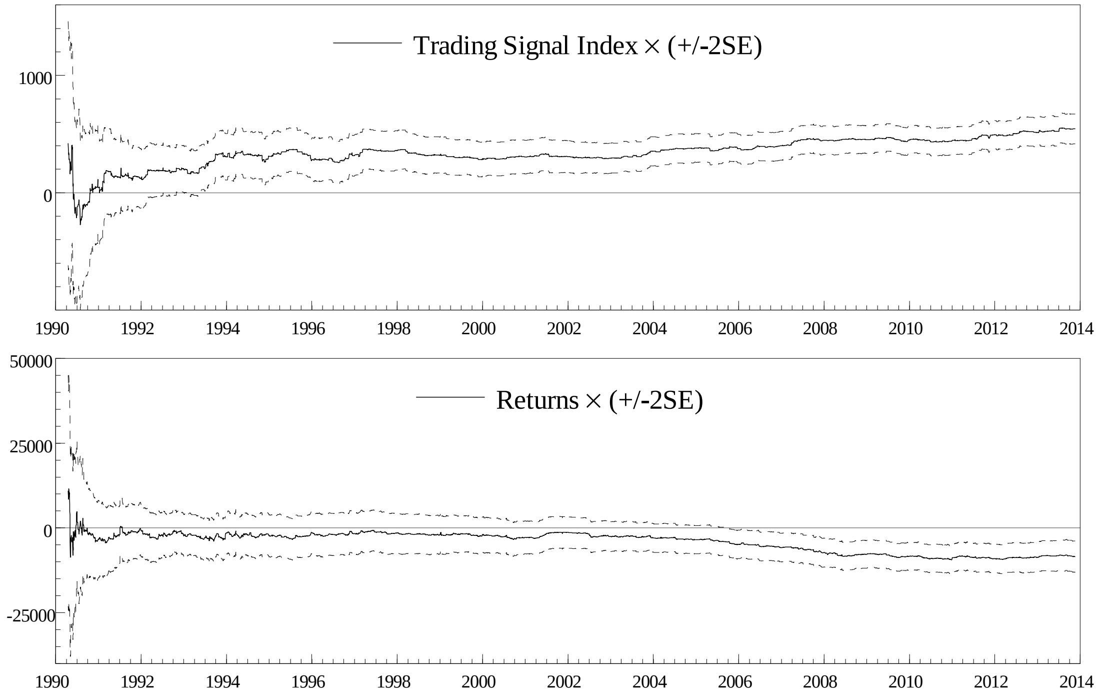
$$Sup_{VM} = \begin{cases} 1, if D_t < 0 \\ 0, otherwise \end{cases}$$

If the support indicator coincides with a buy or sell-signal, it is added to the indicator.



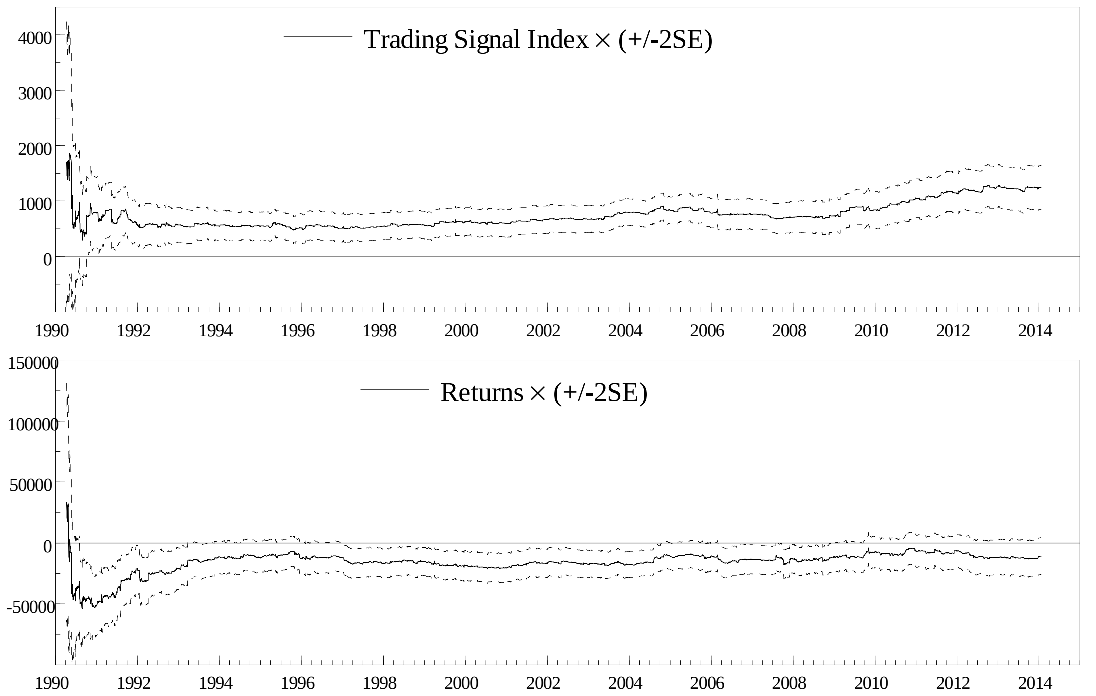
Appendix 3.4: Recursive Coefficient Estimates Equations 3.6-7

Figure 3.4.1: Contemporaneous Estimation Rolling Coefficients Cocoa



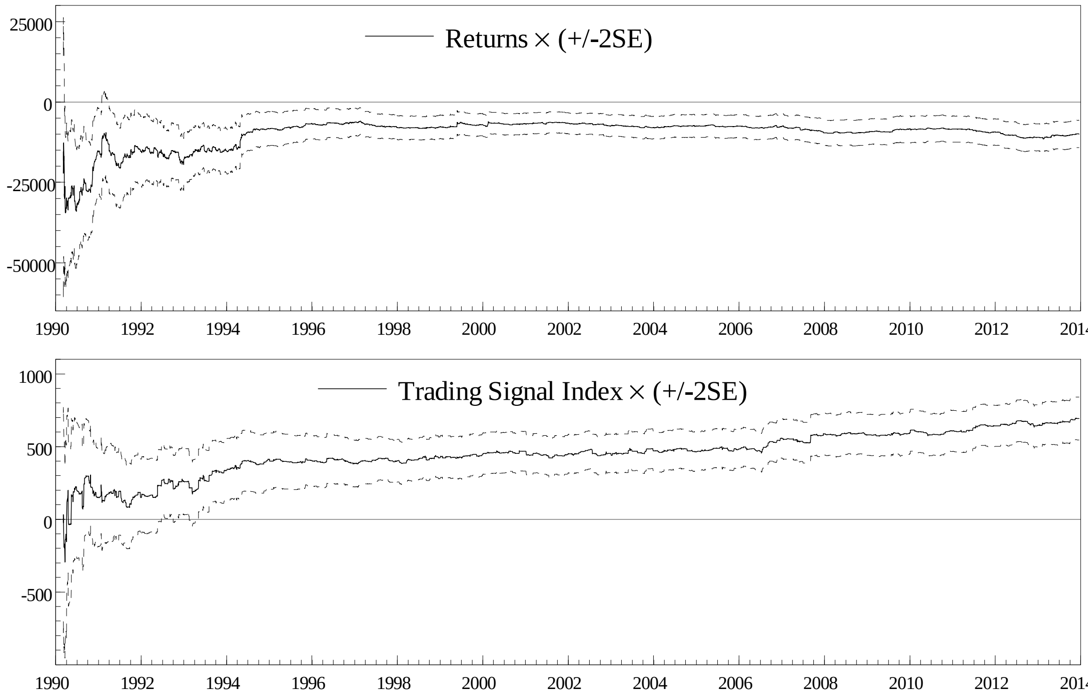
Source: author's estimation.

Figure 3.4.2: Contemporaneous Estimation Rolling Coefficients Wheat



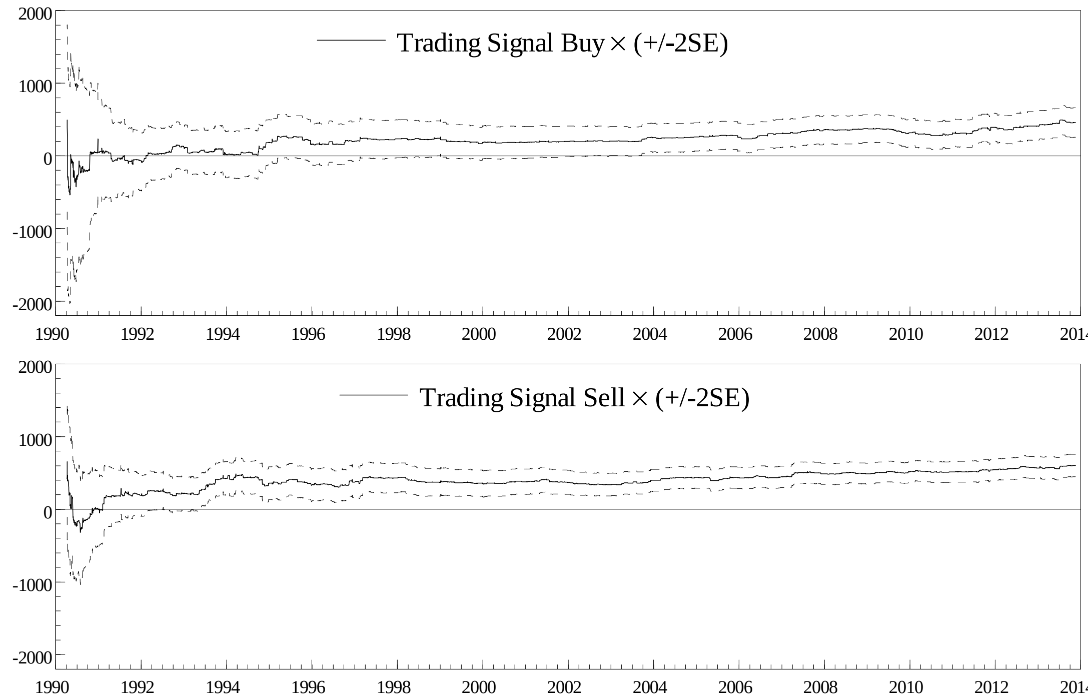
Source: author's estimation.

Figure 3.4.3: Contemporaneous Estimation Rolling Coefficients Coffee



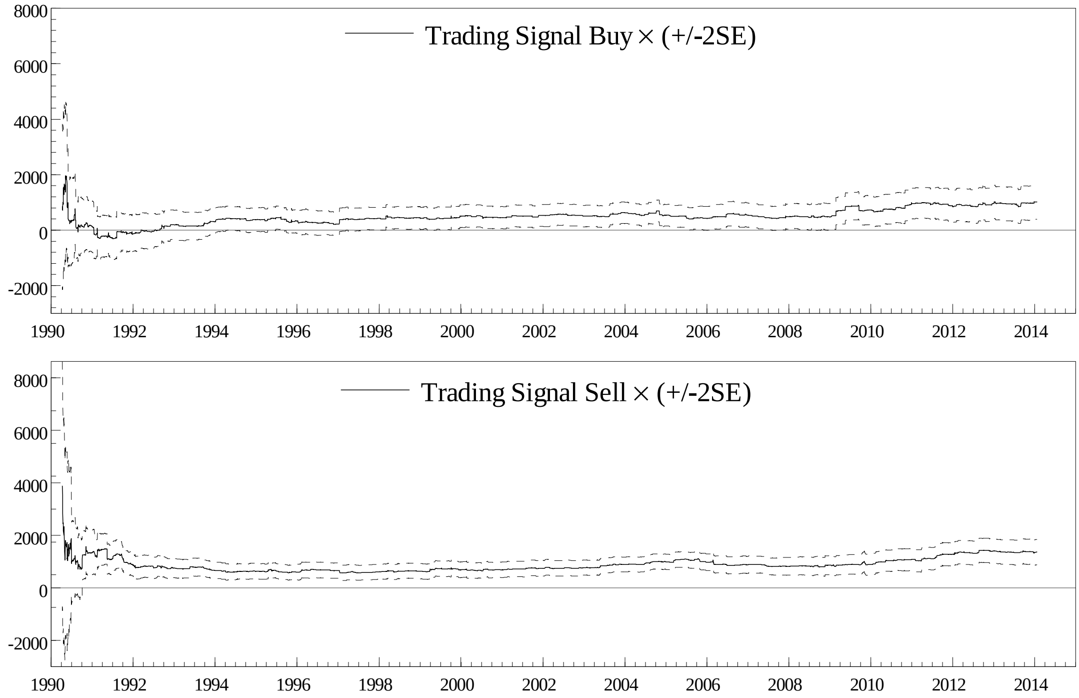
Source: author's estimation.

Figure 3.4.4: Recursive Coefficients for Buy and Sell Indicators Cocoa



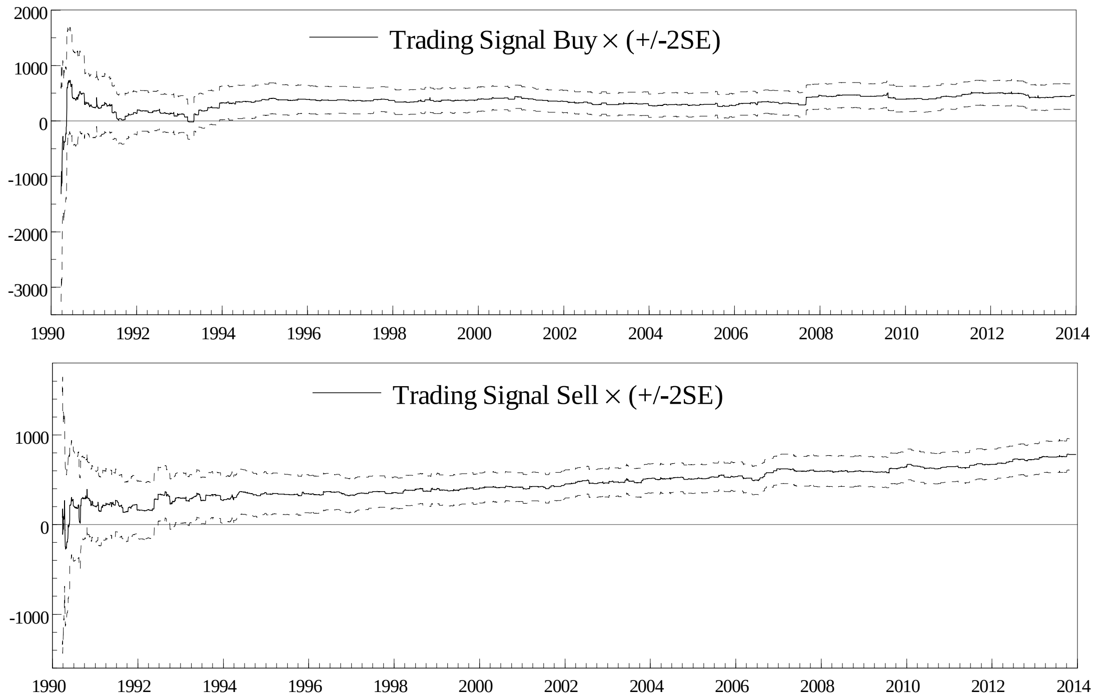
Source: author's estimation.

Figure 3.4.5: Recursive Coefficients for Buy and Sell Indicators Wheat



Source: author's estimation.

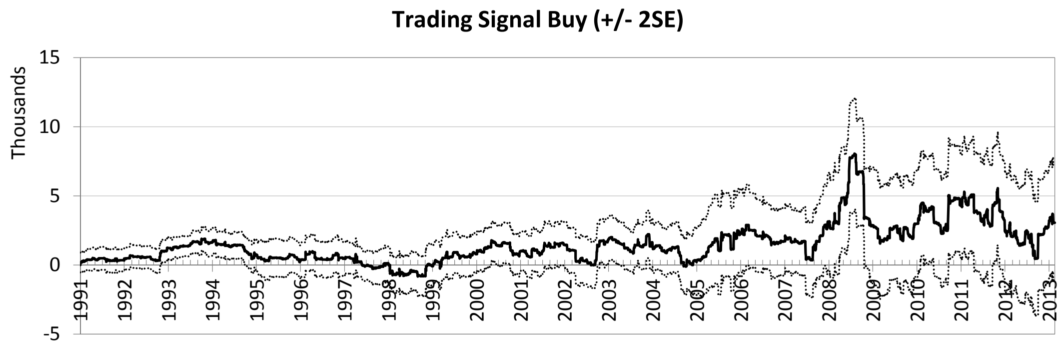
Figure 3.4.6: Recursive Coefficients for Buy and Sell Indicators Coffee

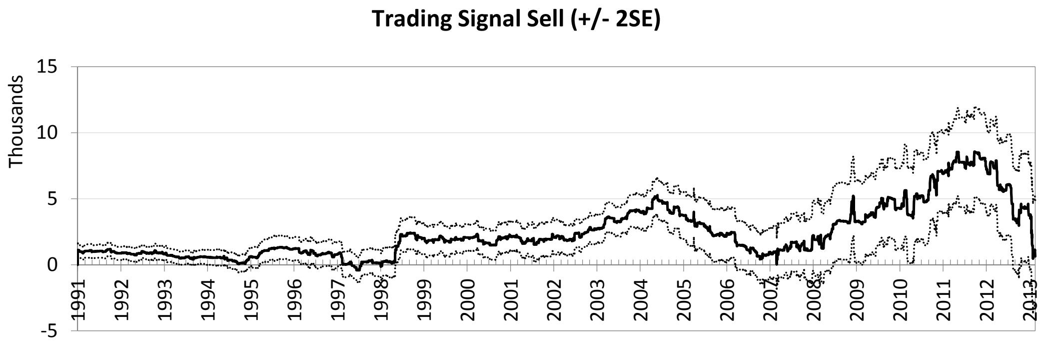


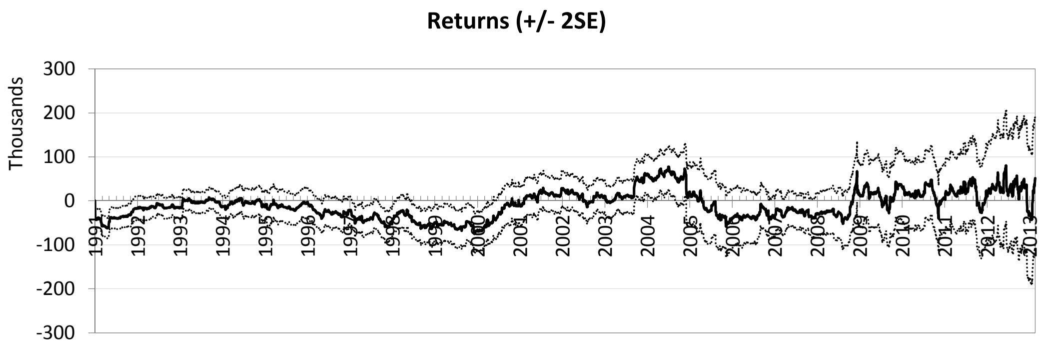
Source: author's estimation.

Appendix 3.5: Rolling Window Coefficient Estimates Equation 3.7

Figure 3.5.1: Rolling 500-Days Window Coefficient Estimates for Buy and Sell Indicators Wheat

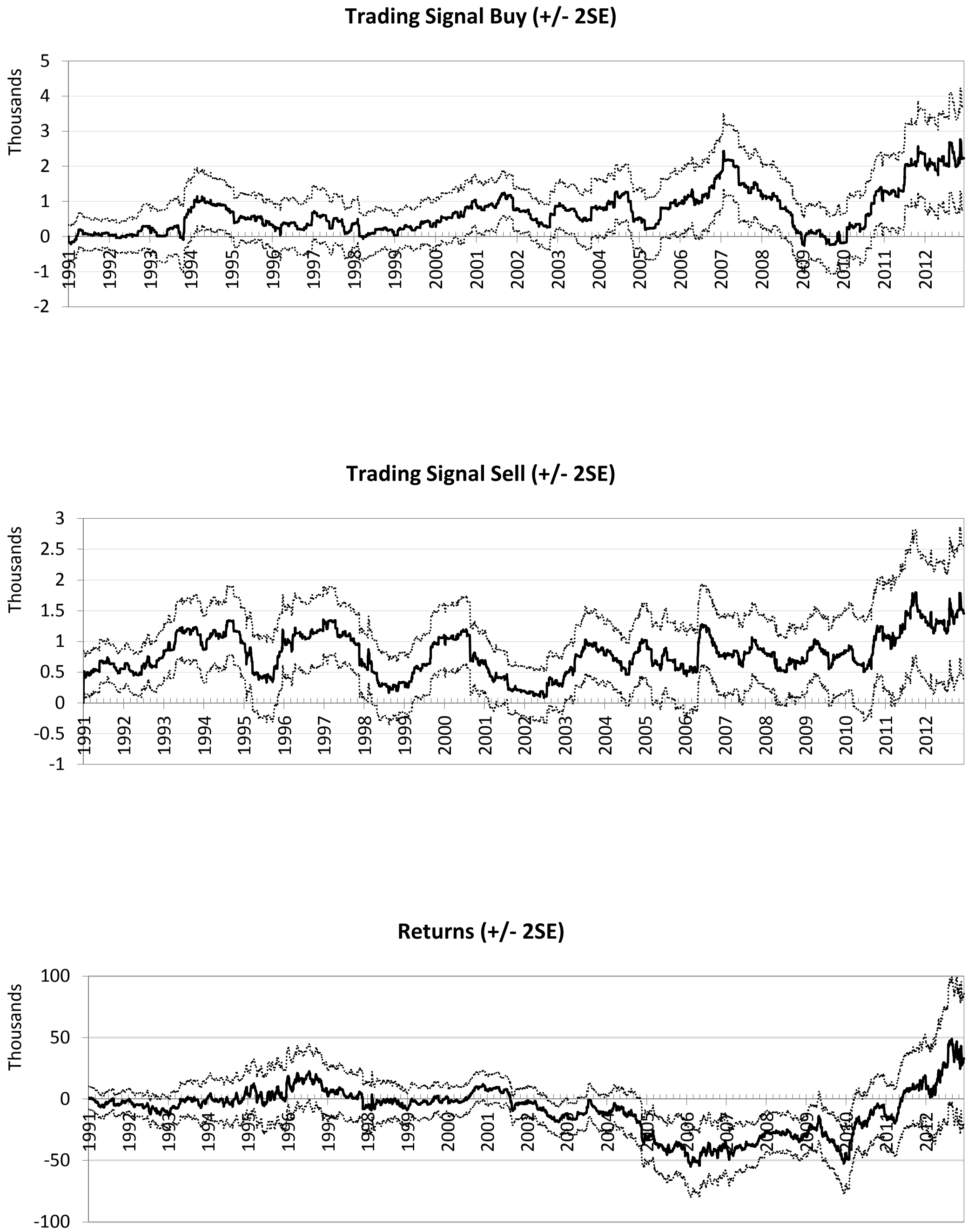






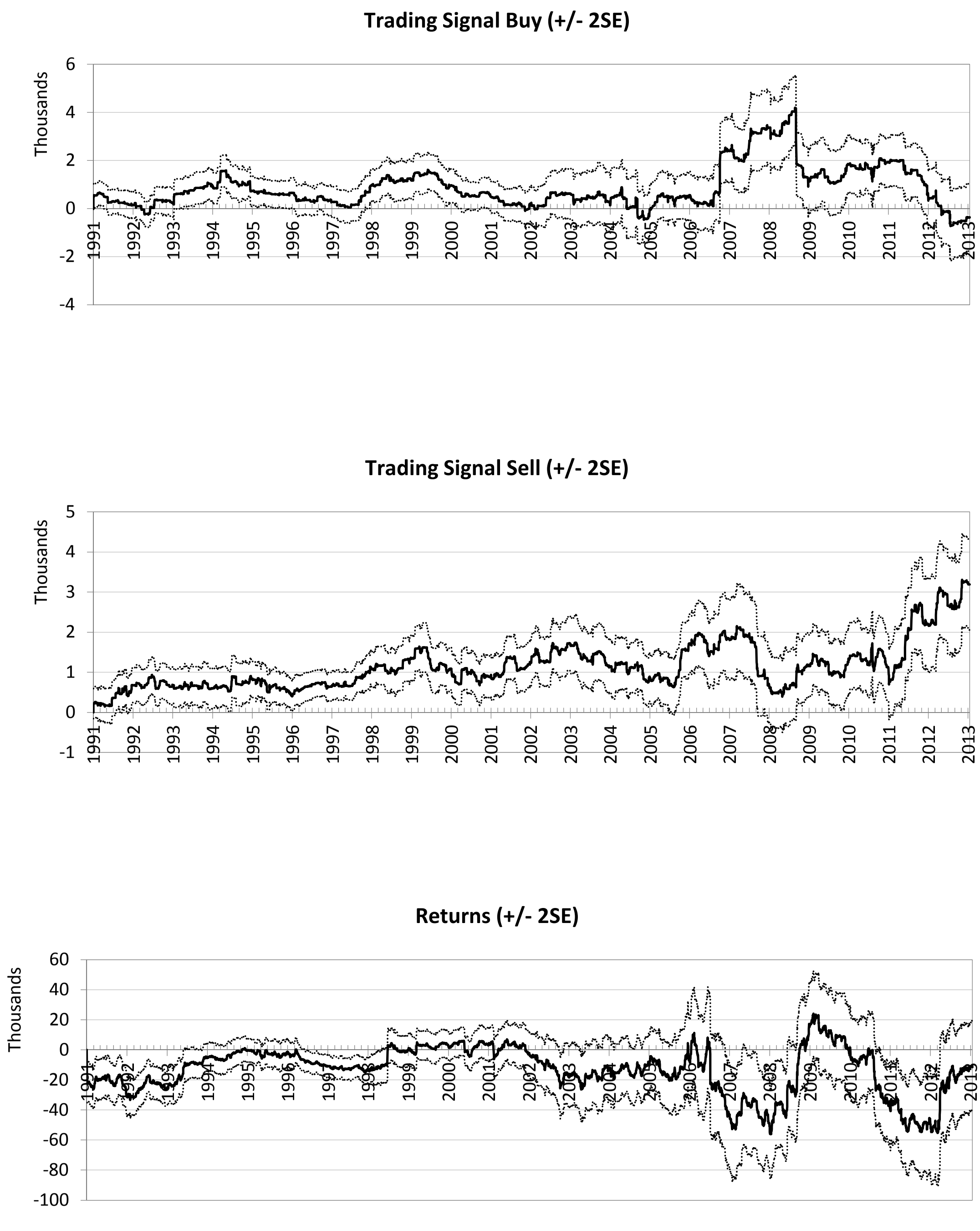
Source: author's estimation.

Figure 3.5.2: Rolling 500-Days Window Coefficient Estimates for Buy and Sell Indicators Cocoa



Source: author's estimation.

Figure 3.5.3: Rolling 500-Days Window Coefficient Estimates for Buy and Sell Indicators Coffee



Source: author's estimation.

Appendix 3.6: Correlation of Large Traders' Positions

Table 3.6.1a: Correlation Net-long Positions DCOT Wheat 2006 -2014							
Net-long	pm	swap	mm	other	nrep	lt_4	lt_8
pm							
swap	-0.70						
mm	-0.76	0.13					
other	0.39	-0.30	-0.56				
nrep	0.20	-0.47	-0.09	0.31			
lt_4	**0.29**	**0.22**	-0.39	-0.29	-0.43		
lt_8	0.06	**0.47**	-0.30	-0.40	-0.41	0.88	

Table 3.6.1b: Correlation Long and Short Positions DCOT Wheat 2006 -2014							
short long	pm	swap	mm	other	nrep	lt_4	lt_8
pm		0.20	-0.50	0.23	0.63	**0.95**	**0.92**
swap	0.11		-0.02	-0.06	0.10	0.28	0.30
mm	0.11	-0.32		-0.16	-0.25	-0.35	-0.22
other	0.54	-0.25	0.53		0.03	0.21	0.18
nrep	0.43	0.41	0.28	0.42		0.54	0.52
lt_4	0.15	**0.96**	-0.33	-0.25	0.42		0.97
lt_8	0.21	**0.97**	-0.28	-0.17	0.43	0.97	

Table 3.6.2a: Correlation Net-long Positions DCOT Cocoa 2006 -2014							
Net-long	pm	swap	mm	other	nrep	lt_4	lt_8
pm							
swap	-0.16						
mm	-0.97	-0.03					
other	0.16	0.17	-0.31				
nrep	-0.83	0.13	0.78	-0.22			
lt_4	**0.66**	-0.05	-0.66	0.20	-0.62		
lt_8	**0.78**	-0.09	-0.74	0.10	-0.73	0.92	

Table 3.6.2b: Correlation Long and Short Positions DCOT Cocoa 2006 -2014							
short long	pm	swap	mm	other	nrep	lt_4	lt_8
pm		0.13	-0.16	0.66	-0.08	**0.77**	**0.86**
swap	0.13		0.22	0.32	0.31	0.27	**0.44**
mm	-0.37	0.20		-0.18	0.57	-0.09	0.03
other	0.22	0.19	0.47		-0.07	0.63	0.62
nrep	-0.09	0.32	0.72	0.42		-0.18	0.04
lt_4	**0.46**	**0.49**	0.17	0.30	0.26		0.91
lt_8	**0.62**	**0.48**	0.20	0.35	0.28	0.94	

Table 3.6.3a: Correlation Net-long Positions DCOT Coffee 2006 -2014							
Net-long	pm	swap	mm	other	nrep	lt_4	lt_8
pm							
swap	-0.34						
mm	-0.87	-0.11					
other	-0.04	0.12	-0.24				
nrep	-0.63	0.31	0.42	0.18			
lt_4	**0.39**	0.05	-0.40	-0.04	-0.34		
lt_8	**0.37**	0.07	-0.38	-0.06	-0.37	0.94	

Table 3.6.3b: Correlation Long and Short Positions DCOT Coffee 2006 -2014							
short long	pm	swap	mm	other	nrep	lt_4	lt_8
pm		0.24	-0.54	0.10	-0.48	**0.73**	**0.81**
swap	-0.32		-0.55	-0.35	-0.39	-0.22	-0.13
mm	-0.05	0.37		0.17	0.54	-0.28	-0.24
other	0.24	0.11	0.05		0.00	0.17	0.17
nrep	-0.14	0.23	0.22	0.50		-0.31	-0.30
lt_4	-0.10	**0.46**	0.13	**0.47**	0.33		0.96
lt_8	-0.13	**0.57**	0.21	**0.39**	0.31	0.96	

Table 3.6.4a: Correlation Net-long Positions COT Wheat 1993-2014					
	com	ncom	nrep	lt_4	lt_8
com					
ncom	-0.91				
nrep	-0.61	0.22			
lt_4	**0.82**	-0.59	-0.79		
lt_8	**0.83**	-0.59	-0.83	0.95	
Table 3.6.4b: Correlation Long and Short Positions COT Wheat 1993 -2014					
short long	com	ncom	nrep	lt_4	lt_8
com		0.41	0.60	**0.91**	**0.94**
ncom	0.60		0.01	0.26	0.34
nrep	-0.04	0.34		0.67	0.69
lt_4	**0.93**	0.64	0.14		0.99
lt_8	**0.96**	0.67	0.06	0.99	

Table 3.6.5a: Correlation Net-long Positions COT Cocoa 1993-2014					
	com	ncom	nrep	lt_4	lt_8
com					
ncom	-0.98				
nrep	-0.39	0.18			
lt_4	**0.58**	-0.61	-0.02		
lt_8	**0.69**	-0.69	-0.19	0.93	
Table 3.6.5b: Correlation Long and Short Positions COT Cocoa 1993 -2014					
short long	com	ncom	nrep	lt_4	lt_8
com		0.36	-0.15	**0.86**	**0.93**
ncom	0.29		0.01	0.35	0.46
nrep	-0.36	-0.02		-0.20	-0.18
lt_4	**0.71**	0.32	0.02		0.95
lt_8	**0.85**	0.50	-0.17	0.93	

Table 3.6.6a: Correlation Net-long Positions COT Coffee 1993-2014					
	com	ncom	nrep	lt_4	lt_8
com					
ncom	-0.98				
nrep	-0.25	0.06			
lt_4	0.27	-0.19	-0.46		
lt_8	0.21	-0.09	-0.63	0.90	
Table 3.6.6b: Correlation Long and Short Positions COT Cocoa 1993 -2014					
short long	com	ncom	nrep	lt_4	lt_8
com		0.43	-0.20	**0.89**	**0.94**
ncom	0.84		0.10	0.44	0.51
nrep	-0.45	-0.26		-0.20	-0.19
lt_4	**0.89**	**0.85**	-0.35		0.98
lt_8	**0.93**	**0.89**	-0.40	0.99	

Appendix 3.7: Augmented Dickey Fuller Test Results

Table 3.7.1: Augmented Dickey Fuller Test Wheat			
	Lags	t-test	AIC- up to 12 lags
CIT: ADF tests (T=102, Constant; 5%=-2.89 1%=-3.50)			
Commercial	0	-3.400*	-6.071
Non-commercial	0	-3.953**	-6.252
Index trader	0	-4.012**	-6.621
DCOT: ADF tests (T=97, Constant; 5%=-2.89 1%=-3.50)			
Producer/Merchants	0	-3.098*	-5.824
Managed Money	0	-3.802**	-5.630
Other non-commercial	0	-3.807**	-7.834
Swap trader	0	-2.322	-7.016
IID: ADF tests (T=49, Constant; 5%=-2.92 1%=-3.57)			
Index trader	0	-2.955*	-6.616
Note: Estimated as net-long traders' positions normalised by total OI; null hypothesis is that the variable has a unit root; * indicates significant at the 5 % level and ** indicates significant at the 1 % level; lag length is determined by AIC with a maximum lag length of 12 months.			

Table 3.7.2: Augmented Dickey Fuller Test Cocoa			
	Lags	t-test	AIC- up to 12 lags
CIT: ADF tests (T=102, Constant; 5%=-2.89 1%=-3.50)			
Commercial	0	-3.105*	-5.378
Non-commercial	0	-2.609	-5.652
Index trader	0	-3.014*	-7.744
DCOT: ADF tests (T=97, Constant; 5%=-2.89 1%=-3.50)			
Producer/Merchants	0	-2.571	-5.413
Managed Money	2	-2.943*	-5.563
Other non-commercial	0	-3.144*	-8.654
Swap trader	0	-3.720**	-8.095
IID: ADF tests (T=49, Constant; 5%=-2.92 1%=-3.57)			
Index trader	0	-3.368*	-7.985
Note: Estimated as net-long traders' positions normalised by total OI; null hypothesis is that the variable has a unit root; * indicates significant at the 5 % level and ** indicates significant at the 1 % level; lag length is determined by AIC with a maximum lag length of 12 months.			

Table 3.7.3: Augmented Dickey Fuller Test Coffee			
	Lags	t-test	AIC- up to 12 lags
CIT: ADF tests (T=102, Constant; 5%=-2.89 1%=-3.50)			
Commercial	0	-2.578	-5.468
Non-commercial	0	-2.537	-5.690
Index trader	0	-3.303*	-6.897
DCOT: ADF tests (T=97, Constant; 5%=-2.89 1%=-3.50)			
Producer/Merchants	0	-2.445	-5.235
Managed Money	0	-2.714	-5.248
Other non-commercial	1	-4.816**	-7.737
Swap trader	3	-2.568	-6.981
IID: ADF tests (T=49, Constant; 5%=-2.92 1%=-3.57)			
Index trader	0	-3.092*	-7.194
Note: Estimated as net-long traders' positions normalised by total OI; null hypothesis is that the variable has a unit root; * indicates significant at the 5 % level and ** indicates significant at the 1 % level; lag length is determined by AIC with a maximum lag length of 12 months.			

Appendix 3.8: Full Estimation Results Heterogeneity

Table 3.8.1a: Heterogeneity Results Wheat

	Return	Roll	Volatility	Interest	Correlation	Inflation	Ex.-rate	Adj. R^2	AR(1) r^2
CIT (Jan. 2006 – Oct. 2014)									
Com	-0.323	2.229	0.278	-0.015**	-0.032	-0.004	-0.000	0.735	0.3936
	[0.205]	[1.280]	[1.008]	[0.006]	[0.020]	[0.005]	[0.001]		
Ncom	0.631**	-0.698	0.541	0.004	0.007	-0.005	0.001	0.662	0.2897
	[0.189]	[1.145]	[1.139]	[0.004]	[0.018]	[0.005]	[0.001]		
Index	-0.396*	-2.706**	-1.138	0.020**	0.030*	0.012*	-0.000	0.663	0.2743
	[0.192]	[0.823]	[0.781]	[0.005]	[0.012]	[0.005]	[0.001]		
DCOT (Jun. 2006 – Oct. 2014)									
Pm	-0.703**	2.113	-0.389	-0.019**	-0.034	-0.004	0.002	0.708	0.2318
	[0.222]	[1.601]	[1.614]	[0.007]	[0.028]	[0.007]	[0.002]		
Mm	0.909**	1.072	0.556	0.009	0.034	-0.001	0.000	0.637	0.2733
	[0.251]	[1.273]	[1.735]	[0.007]	[0.030]	[0.008]	[0.001]		
Other	-0.097	-0.026	0.115	-0.011**	-0.014	-0.008**	0.000	0.655	0.2411
	[0.118]	[0.494]	[0.439]	[0.003]	[0.009]	[0.003]	[0.001]		
Swap	-0.262	-4.086**	-0.698	0.030**	0.017	0.018*	-0.002*	0.801	0.2225
	[0.169]	[1.127]	[0.869]	[0.008]	[0.015]	[0.007]	[0.001]		
IID (Jun. 2010 – Oct. 2014)									
Index	-0.110	-10.89*	-4.068	0.003	-0.048*	-0.051	-0.002	0.643	AR(0)
	[0.300]	[4.241]	[3.195]	[0.056]	[0.023]	[0.033]	[0.004]		

Table 3.8.1b: Heterogeneity Results Wheat Passive Trader Stronger Assumptions

	Return	Roll	Volatility	Interest	Correlation	Inflation	Ex.-rate	Adj. R^2	AR(1) r^2
CIT (Jan. 2006 – Oct. 2014)									
Index	0.130	-3.248**	-0.620	0.020**	0.007	0.012*	-0.001	0.609	0.3427
	[0.434]	[0.835]	[0.890]	[0.005]	[0.009]	[0.005]	[0.001]		
DCOT (Jun. 2006 – Oct. 2014)									
Swap	0.074	-4.795**	-0.199	0.028**	-0.006	0.017*	-0.002*	0.776	0.2164
	[0.304]	[1.133]	[1.026]	[0.009]	[0.011]	[0.007]	[0.001]		
IID (Jun. 2010 – Oct. 2014)									
Index	-0.705	-12.34**	-4.925	-0.029	0.019	-0.050	-0.003	0.630	AR(0)
	[1.048]	[4.485]	[3.555]	[0.062]	[0.022]	[0.036]	[0.004]		

Notes: Newey-West robust standard error, lag truncation 12. All independent variables are lagged once and the regression is estimated as an AR(1) process (the lag is excluded if found insignificant). Residuals are tested for normality, autocorrelation and heteroscedasticity. The null hypothesis of spherical residuals cannot be rejected at the 5 % level in all cases. * indicates significance at the 1 % level, and ** at the 5% level respectively.

Table 3.8.2a: Heterogeneity Results Cocoa

	Return	Roll	Volatility	Interest	Correlation	Inflation	Ex.-rate	Adj. R^2	AR(1) r^2
CIT (Jan. 2006 – Oct. 2014)									
Com	0.087	22.54	-11.19*	0.015	0.093*	0.003	-0.001	0.684	0.5598
	[0.813]	[15.77]	[5.018]	[0.010]	[0.043]	[0.012]	[0.002]		
Ncom	0.107	-12.87	7.462	-0.009	-0.077	-0.004	0.002	0.753	0.6132
	[0.602]	[13.59]	[4.576]	[0.008]	[0.041]	[0.010]	[0.002]		
Index	-0.055	-5.266	1.269	-0.003	0.008	0.003	-0.003**	0.822	0.2458
	[0.117]	[4.100]	[1.498]	[0.003]	[0.011]	[0.003]	[0.001]		
DCOT (Jun. 2006 – Oct. 2014)									
Pm	-0.229	27.34	-10.04	0.016	0.098*	-0.004	-0.003	0.714	0.5531
	[0.893]	[15.96]	[5.616]	[0.010]	[0.044]	[0.013]	[0.002]		
Mm	0.348	-18.81	6.562	-0.012	-0.076	-0.001	0.003	0.753	0.6220
	[0.674]	[14.19]	[5.428]	[0.008]	[0.041]	[0.011]	[0.002]		
Other	0.193	-1.288	-1.067	-0.002	0.007	0.004*	0.000	0.618	0.2603
	[0.097]	[2.268]	[0.978]	[0.002]	[0.006]	[0.002]	[0.000]		
Swap	-0.156	-3.211	1.835	0.000	-0.008	0.004	-0.001	0.663	0.5182
	[0.143]	[3.477]	[1.199]	[0.002]	[0.009]	[0.003]	[0.001]		
IID (Jan. 2010 – Oct. 2014)									
Index	-0.024	-14.15*	-2.039	0.038*	0.049**	0.038	0.003	0.633	AR(0)
	[0.337]	[6.976]	[1.924]	[0.019]	[0.011]	[0.025]	[0.002]		

Table 3.8.2b: Heterogeneity Results Cocoa Passive Trader Stronger Assumptions

	Return	Roll	Volatility	Interest	Correlation	Inflation	Ex.-rate	Adj. R^2	AR(1) r^2
CIT (Jan. 2006 – Oct. 2014)									
Index	0.091	-4.585	1.153	-0.001	0.014*	0.004	-0.004**	0.843	0.2571
	[0.157]	[3.421]	[1.171]	[0.004]	[0.007]	[0.002]	[0.001]		
DCOT (Jun. 2006 – Oct. 2014)									
Swap	-0.063	-0.973	0.955	0.002	0.004	-0.001	0.001	0.658	0.4780
	[0.206]	[3.380]	[0.862]	[0.003]	[0.003]	[0.001]	[0.001]		
IID (Jun. 2010 – Oct. 2014)									
Index	0.096	-19.26*	-1.850	0.0004	0.032**	0.015**	-0.002	0.713	AR(0)
	[0.500]	[9.720]	[2.619]	[0.019]	[0.006]	[0.005]	[0.001]		

Notes: Newey-West robust standard error, lag truncation 12. All independent variables are lagged once and the regression is estimated as an AR(1) process (the lag is excluded if found insignificant). Residuals are tested for normality, autocorrelation and heteroscedasticity. The null hypothesis of spherical residuals cannot be rejected at the 5 % level in all cases. * indicates significance at the 1 % level, and ** at the 5% level respectively.

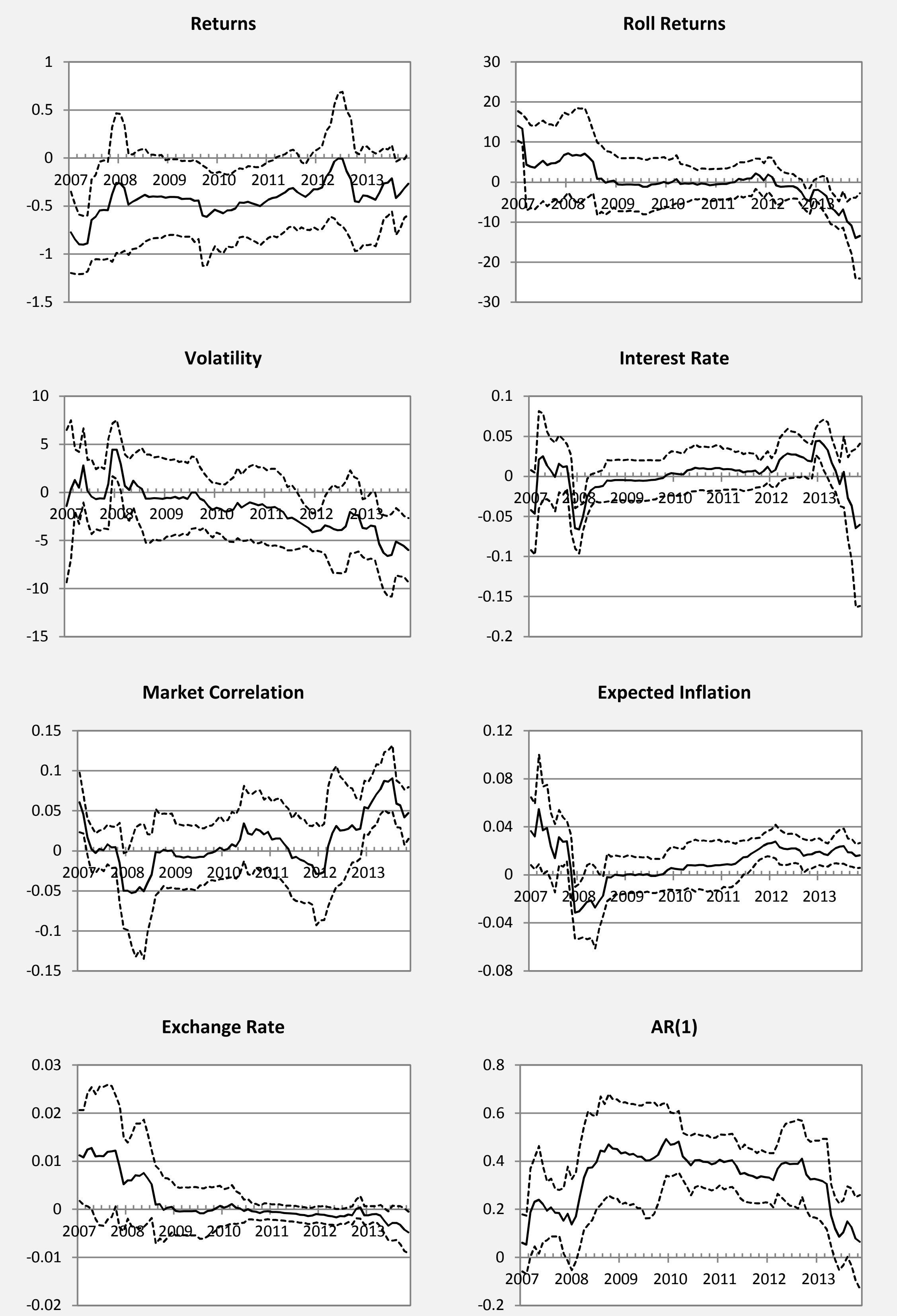
Table 3.8.3a: Heterogeneity Results Coffee									
	Return	Roll	Volatility	Interest	Correlation	Inflation	Ex.-rate	Adj. R^2	AR(1) r^2
CIT (Jan. 2006 – Oct. 2014)									
Com	-0.030 [0.318]	12.78* [4.940]	-1.531 [1.680]	-0.000 [0.010]	-0.027* [0.013]	-0.006 [0.010]	0.004 [0.003]	0.718	0.6070
Ncom	0.059 [0.368]	-4.783 [3.837]	0.716 [1.784]	0.003 [0.009]	0.016 [0.015]	0.004 [0.008]	-0.001 [0.002]	0.684	0.5729
Index	-0.102 [0.190]	-8.698** [1.959]	0.259 [0.914]	-0.005 [0.003]	0.007 [0.008]	0.006 [0.004]	-0.004** [0.001]	0.682	0.4721
DCOT (Jun. 2006 – Oct. 2014)									
Pm	0.168 [0.457]	11.13* [5.153]	-0.243 [2.070]	0.007 [0.012]	-0.024 [0.017]	0.003 [0.012]	0.003 [0.003]	0.752	0.5927
Mm	0.396 [0.499]	-5.545 [4.573]	3.028 [2.328]	0.007 [0.012]	0.022 [0.020]	0.006 [0.012]	-0.002 [0.003]	0.686	0.5313
Other	-0.125 [0.134]	-0.871 [1.348]	-0.275 [0.540]	-0.003 [0.002]	0.005 [0.006]	-0.003 [0.003]	0.001 [0.001]	0.525	0.5675
Swap	-0.101 [0.155]	-5.794** [1.989]	-1.515 [0.947]	-0.003 [0.003]	-0.002 [0.008]	0.001 [0.004]	-0.003** [0.001]	0.807	0.5816
IID (Jun. 2010 – Oct. 2014)									
Index	-0.404* [0.154]	-7.670 [5.000]	0.992* [0.369]	-0.015 [0.041]	-0.037* [0.018]	-0.022 [0.027]	-0.006 [0.004]	0.553	0.4233

Table 3.8.3b: Heterogeneity Results Coffee Passive Trader Stronger Assumptions									
	Return	Roll	Volatility	Interest	Correlation	Inflation	Ex.-rate	Adj. R^2	AR(1) r^2
CIT (Jan. 2006 – Oct. 2014)									
Index	0.153 [0.296]	-11.27** [1.648]	1.448 [0.799]	-0.000 [0.003]	0.009** [0.003]	0.030* [0.008]	-0.005** [0.001]	0.714	0.5273
DCOT (Jun. 2006 – Oct. 2014)									
Swap	0.248 [0.304]	-7.985** [1.940]	-0.705 [0.760]	0.001 [0.003]	0.021* [0.009]	0.003 [0.003]	-0.004** [0.001]	0.820	0.5890
IID (Jun. 2010 – Oct. 2014)									
Index	0.405 [0.596]	-0.670 [5.713]	0.609 [0.476]	-0.035 [0.044]	-0.013 [0.025]	-0.034 [0.031]	-0.005 [0.004]	0.402	0.5165

Notes: Newey-West robust standard error, lag truncation 12. All independent variables are lagged once and the regression is estimated as an AR(1) process (the lag is excluded if found insignificant). Residuals are tested for normality, autocorrelation and heteroscedasticity. The null hypothesis of spherical residuals cannot be rejected at the 5 % level in all cases. * indicates significance at the 1 % level, and ** at the 5% level respectively.

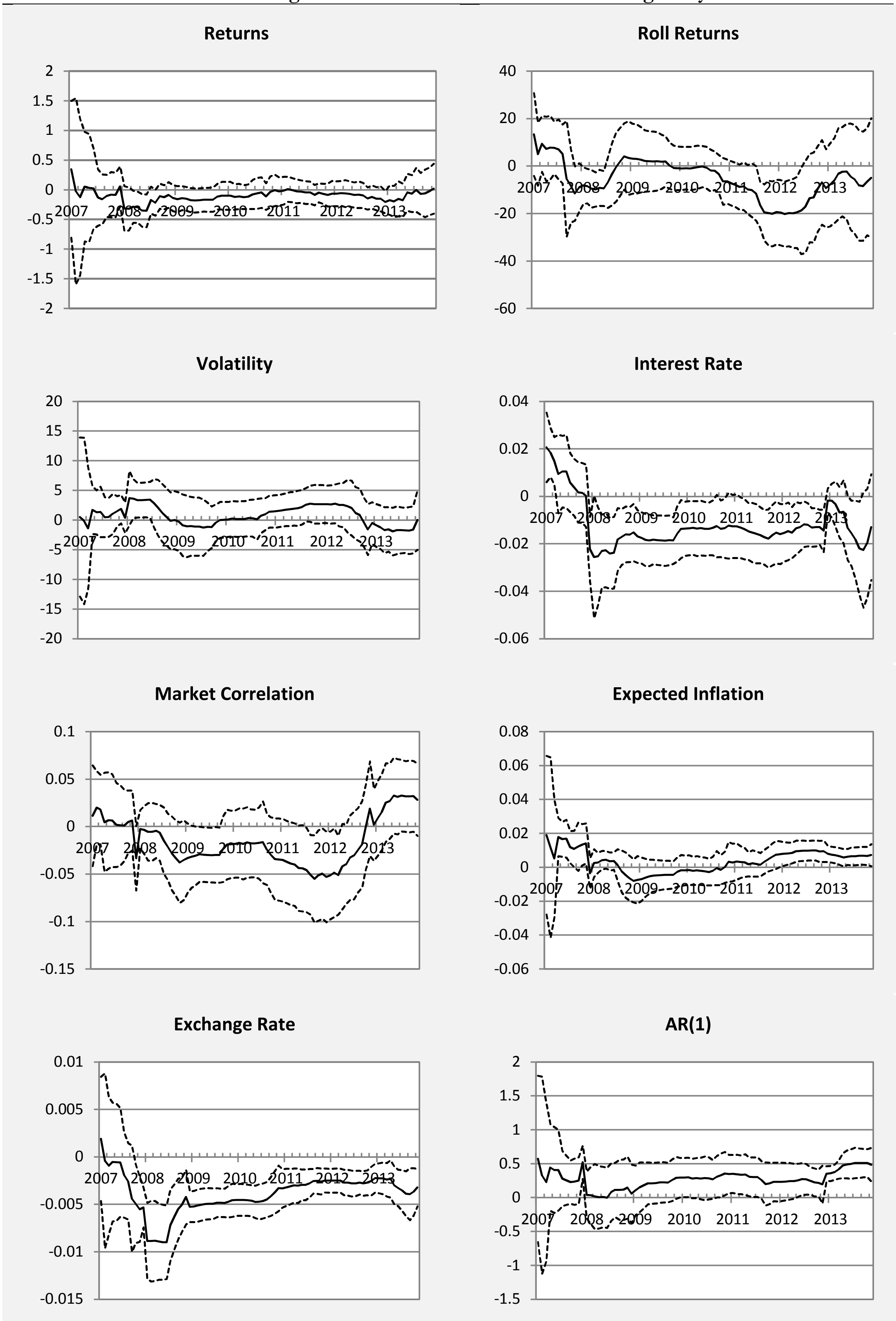
Appendix 3.9: Rolling Window Coefficient Estimates Heterogeneity

Table 3.7.1: Rolling Window Coefficient Estimates Heterogeneity Wheat



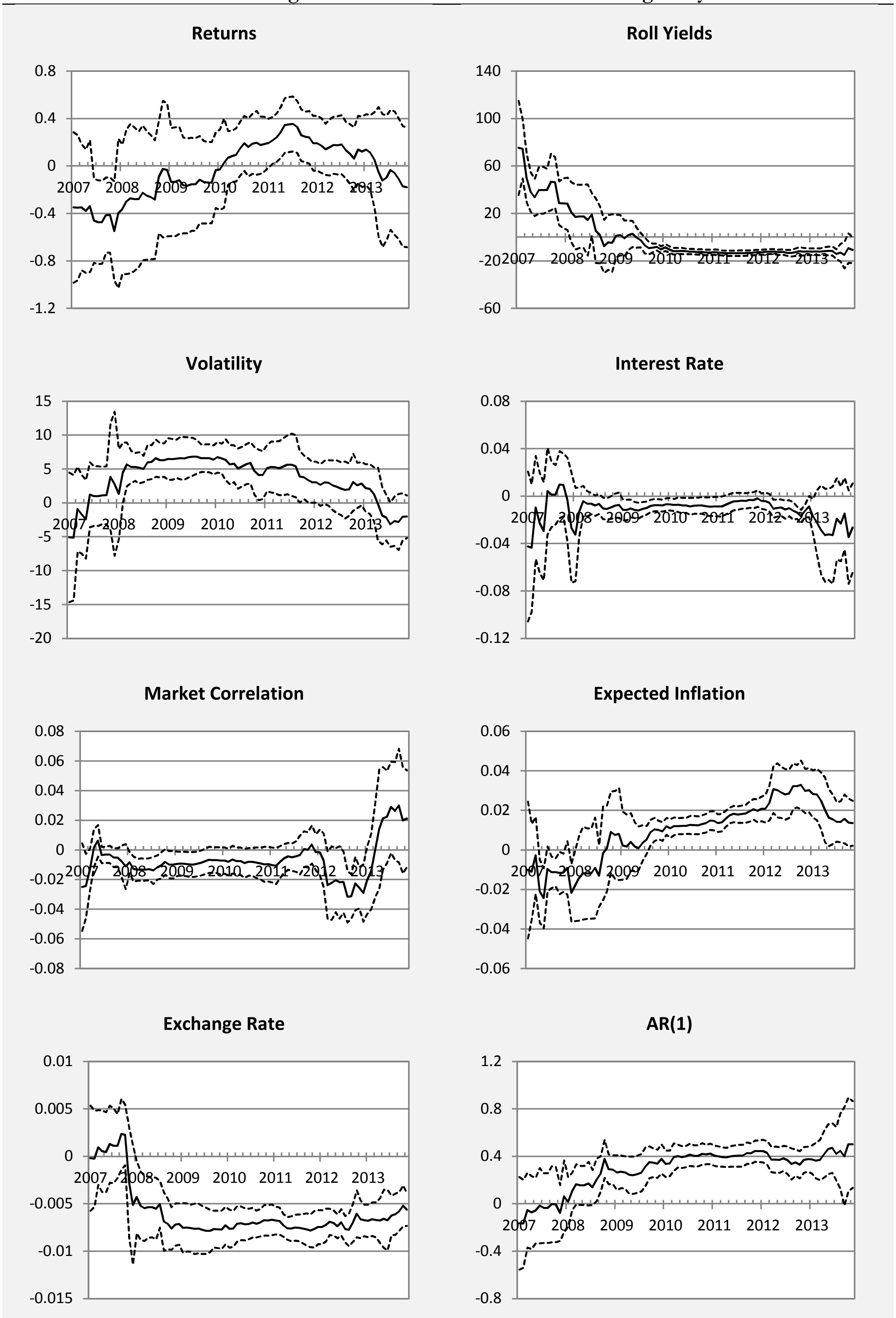
Notes: Rolling window of 60 months (5 years) is used; dotted lines represent the 5 % significance interval ($\widehat{\beta}_i$+/-2*SE).

Table 3.7.2: Rolling Window Coefficient Estimates Heterogeneity Cocoa



Notes: Rolling window of 60 months (5 years) is used; dotted lines represent the 5 % significance interval ($\widehat{\beta}_t$+/-2*SE).

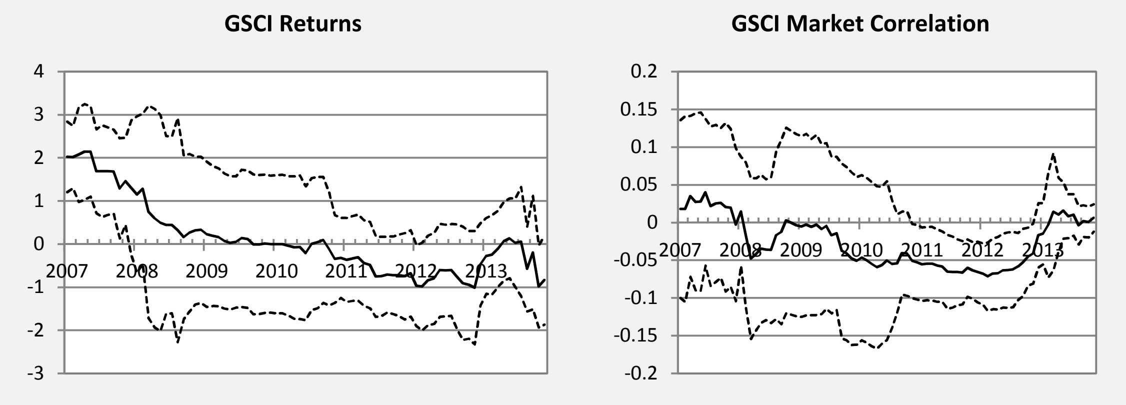
Table 3.7.3: Rolling Window Coefficient Estimates Heterogeneity Coffee



Notes: Rolling window of 60 months (5 years) is used; dotted lines represent the 5 % significance interval ($\widehat{\beta_i}$+/-2*SE).

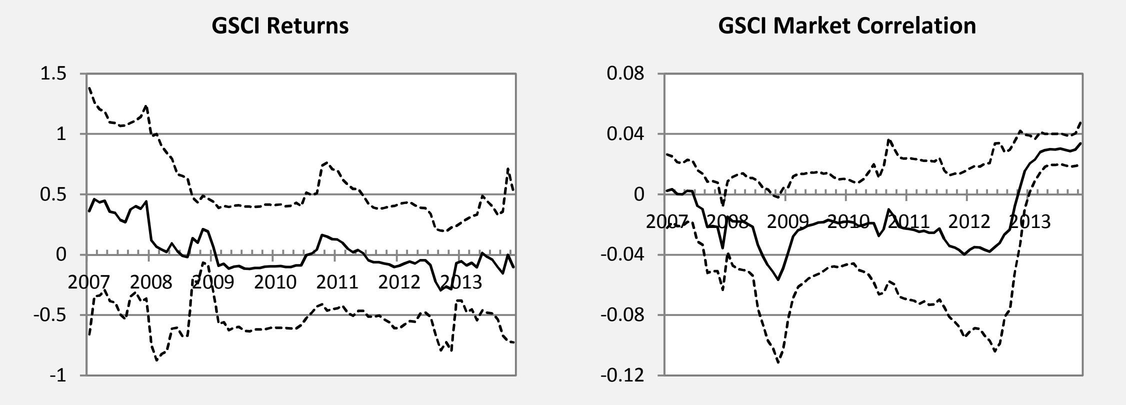
Appendix 3.10: Rolling Window Coefficient Estimates Heterogeneity Alternative

Table 3.8.1: Rolling Window Coefficient Estimates Heterogeneity Alternative Variables Wheat



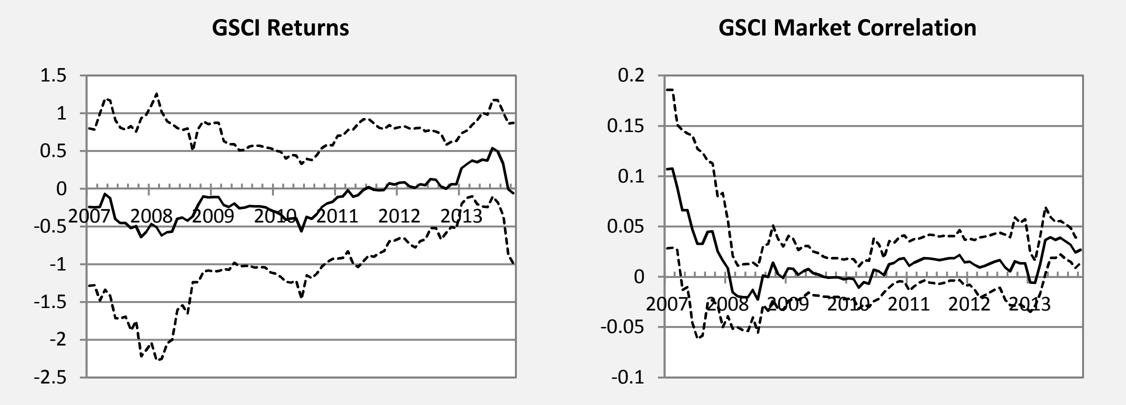
Notes: Rolling window of 60 months (5 years) is used; dotted lines represent the 5 % significance interval ($\widehat{\beta_t}$+/-2*SE).

Table 3.8.2: Rolling Window Coefficient Estimates Heterogeneity Alternative Variables Cocoa



Notes: Rolling window of 60 months (5 years) is used; dotted lines represent the 5 % significance interval ($\widehat{\beta_t}$+/-2*SE).

Table 3.8.3: Rolling Window Coefficient Estimates Heterogeneity Alternative Variables Coffee



Notes: Rolling window of 60 months (5 years) is used; dotted lines represent the 5 % significance interval ($\widehat{\beta_t}$+/-2*SE).

Appendix Chapter 4

Appendix 4.1 Empirical Studies on Lead–Lag Relationship

Source	Evidence	Markets	Methodology	Notes
(Asche and Guttormsen 2002)	Futures market leading	Gas oil, other oil derivatives, crude oil International Petroleum Exchange 04/1981-09/2001 (monthly)	Multivariate Johansen VECM models	Futures lead spot prices; futures with longer time to expiration lead futures with shorter time to expiration; always the longest contract binds the price series in the long-run.
(Baldi, Peri and Vandone 2011)	Futures market leading	Corn, soybeans CBOT for futures and USDA for spot 01/2004-09/2010 (weekly)	Co-integration tests using Keiryval and Perron's (2009) methodology to test for structural breaks Granger non-causality tests using Toda and Yamamoto's (1995) methodology	Normally spot prices are discovered in the futures market, but in more volatile times there is some bi-directional effect
(Crain and Lee 1996)	Futures market leading	Wheat Kansas City Board of Trade for spot and CBOT for futures prices 01/1950-12/1993 (daily)	Granger non-causality tests (price volatility)	Find that the futures volatility causes the spot volatility. However, findings are not robust through time
(Garbade and Silber 1983)	Futures markets leading	Wheat, corn, oats, frozen orange juice concentrates, copper, gold, silver CBOT, New York Cotton Exchange and ComEX.	ECM	High importance of futures market in determining spot prices founds; lesser importance of futures markets for oats due to smaller market size and lower liquidity.
(Hernandez and Torero 2010)	Futures market leading	Corn, wheat, soybeans FAO for spot Kansas City Board of Trade for futures prices 01/1994-06/2009 (weekly)	Linear and non-linear Granger non-causality test (returns and price volatility)	The results indicate that spot prices are generally discovered in futures markets. In particular, we find that changes in futures prices lead changes in spot prices more often than the reverse
(Ivanov and Cho 2011)	Futures market leading	42 different futures contracts including currencies, equities, and	VECM	All futures price leading cash prices with cocoa and sugar having the minimum information share of

		commodities.		slightly more than 50 percent and crude oil and natural gas the highest with 100 percent.
(Kuiper, Pennings and Meulenberg 2002)	Futures market leading	Potatoes CBOT and Amsterdam Exchange 12/1989-04/1992 (weekly)	VECM	Reveals that the spot price adjusts fully to its new equilibrium level if the price-discovery function of the futures market works well.
(Lagi, et al. 2011)	Bidirectional	Food prices (index)	Granger non-causality tests	Bidirectional
(Mahalik, Acharya and Babum 2009)	Bidirectional	Energy, agricultural, aggregate commodities, and metal future price indices Multi Commodity Exchange Mumbai 06/2005-12/2008 (daily)	Johansen co-integration analysis; VECMs; exponential general autoregressive conditional heteroscedasticity	All despite the metal price index serve as a source of price discovery for the spot market; volatility spills from the futures to the spot market for all indices despite the agricultural one.
(Mohan and Love 2004)	Cash market leading	Coffee LIFFE and NYBOT 03/1991-05/2003 (daily)	Granger non-causality tests (price changes)	Results demonstrate that changes in spot prices are not explained by changes in futures prices. It emerges, futures prices tend to adapt to the prevailing spot prices.
(Quan 1992)	Cash market leading	Crude oil	ECM	Critique on earlier studies ignoring unit root of price time series
(Silvapulle and Moosa 1999)	Bidirectional	Crude oil	Linear and non-linear Granger non-causality tests	Linear causality tests reveal that futures prices lead spot prices, but non-linear causality tests reveals a bidirectional effect; suggesting that both markets react to new information simultaneously and the pattern of lead and lags changes over time.

Appendix 4.2 Unit-Root Test Results

MacKinnon (1996) critical values are used since under the null hypothesis of a unit root the test statistic does not follow a conventional student t-distribution. If the test-statistic is greater than the MacKinnon critical value the null hypothesis of a unit root can be rejected. The length of time lags included in the test is determined by SIC allowing for a maximal lag length of 12.

Table 4.2.1: Cocoa Apr 1995 – Dec 2013 Dataset (N=225)				
Annual Difference ADF Unit Root test (null hypothesis: time series has a unit root)				
Series	Level		First difference	
t-statistic (lag)	Intercept	Intercept & Trend	Intercept	Intercept & Trend
L(Fcont)	-2.838212 (12)	-2.842529 (12)	-4.970755 (11)**	-4.956381 (11)**
L(Fwa)	-2.879569 (12)*	-2.896351 (12)	-5.054187 (11)**	-5.033493 (11)**
L(Spot)	-2.796155 (12)	-2.797591 (12)	-5.099411 (11)**	-5.079757 (11)**
Inventory	-2.446942 (12)	-2.491171 (12)	-7.212567 (11)**	-7.188203 (11)**
S*LIBOR	-3.152530 (13)*	-3.173039 (13)	-4.979253 (12)**	-4.966000 (12)**
Hcom	-3.264164 (12)*	-3.367493 (12)	-7.329625 (11)**	-7.344799 (11)**
SPcor	-4.580383 (2)*	-4.650880 (2)**	-3.914420 (13)**	-3.896969 (13)*
MacKinnon (1996) critical values & SIC lag length (max 12).				

Table 4.2.2: Cocoa Apr 1995 – Dec 2005 Dataset (N=130)				
Annual Difference ADF Unit Root test (null hypothesis: time series has a unit root)				
Series	Level		First difference	
t-statistic (lag length)	Intercept	Intercept & Trend	Intercept	Intercept & Trend
L(Fcont)	-2.642541 (12)	-2.633335 (12)	-2.777655(11)*	-2.763464 (11)
L(Fwa)	-2.298381 (12)	-2.322437 (12)	-3.381240 (11)*	-3.363441 (11)
L(Spot)	-2.471012 (12)	-2.477842 (12)	-3.109759 (11)*	-3.092464 (11)
Inventory	-1.336645 (0)	-1.304783 (0)	-4.752534 (11)**	-4.929972 (11)**
S*LIBOR	-3.543007 (3)**	-3.505622 (3)*	-4.629361 (1)**	-4.602582 (1)**
Hcom	-3.769475 (4)**	-4.040982 (4)*	-10.87679 (1)**	-10.83661 (1)**
SPcor	-3.542476 (1)**	-3.528431 (1)*	-2.326695 (0) [1]	-2.270301 (0) [1]
MacKinnon (1996) critical values & SIC lag length (max 12). [1] Stationary at the second difference but not the first.				

Table 4.2.3: Cocoa Jan 2006 – Dec 2013 Dataset (N=95)				
Annual Difference ADF Unit Root test (null hypothesis: time series has a unit root)				
Series	Level		First difference	
t-statistic (lag length)	Intercept	Intercept & Trend	Intercept	Intercept & Trend
L(Fcont)	-2.260587 (1)	-2.539078 (1)	-14.25156 (0)**	-14.17185 (0)**
L(Fwa)	-3.205626 (0)*	-3.668145 (0)*	-12.30851 (0)**	-12.24079 (0)**
L(Spot)	-2.780868 (0)	-3.210663 (0)	-12.04556 (0)**	-11.98014 (0)**
Inventory	-2.474973 (1)	-2.427914 (1)	-7.909684 (0)**	-7.905395 (0)**
S*LIBOR	-2.390287 (3)	-2.368510 (3)	-3.571909 (2)**	-3.557778 (2)*
Hcom	-2.754671 (0)	-2.744246 (0)	-5.192774 (11)**	-5.265083 (11)**
Hcom (CIT)	-2.526528 (0)	-2.503431 (0)	-9.926421 (0)**	-9.955265 (0)**
Hix	-2.861929 (0)	-2.882730 (0)	-10.46323 (0)**	-10.39681 (0)**
% index	-2.800528 (0)	-3.136932 (0)	-10.05964 (0)**	-9.996625 (0)**
SPcor	-3.152278 (2)*	-3.253918 (2)	-2.698505 (1) [1]	-2.654472 (1) [1]
MacKinnon (1996) critical values & SIC lag length The Philips-Perron test was run in addition but results remain the same. [1] Stationary at the second difference but not the first.				

Table 4.2.4: Wheat Apr 1995 – Dec 2013 Dataset (N=225)				
Annual Difference ADF Unit Root test (null hypothesis: time series has a unit root)				
Series	Level		First difference	
t-statistic (lag)	Intercept	Intercept & Trend	Intercept	Intercept & Trend
L(Fcont)	-2.468179 (12)	-2.521047 (12)	-7.309582 (11)**	-7.298095 (11)**
L(Fwa)	-2.486915 (12)	-2.532291 (12)	-7.310294 (11)**	-7.300021 (11)**
L(Spot)	-2.746444 (12)	-2.843293 (12)	-6.860696 (11)**	-6.848529 (11)**
Inventory	-3.521571 (4)**	-3.597126 (4)*	-4.783082 (3)**	-4.799553 (3)**
S*LIBOR	-2.784594 (12)	-2.769057 (12)	-6.325895 (11)**	-6.308292 (11)**
Hcom	-3.698859 (13)**	-3.682720 (13)*	-6.780324 (12)**	-6.776407 (12)**
SPcor	-4.002363 (1)**	-4.042189 (1)**	-3.995553 (0)**	-3.982472 (0)*
MacKinnon (1996) critical values & SIC lag length.				

Table 4.2.5: Wheat Apr 1995 – Dec 2005 Dataset (N=130)				
Annual Difference ADF Unit Root test (null hypothesis: time series has a unit root)				
Series	Level		First difference	
t-statistic (lag length)	Intercept	Intercept & Trend	Intercept	Intercept & Trend
L(Fcont)	-3.329842 (0)*	-3.853005 (0)*	-5.884460 (11)**	-5.878193 (11)**
L(Fwa)	-3.344109 (0)*	-3.853488 (0)*	-10.83630 (0)**	-10.91470 (0)**
L(Spot)	-3.211344 (0)*	-3.610502 (0)*	-9.629880 (1)**	-9.630985 (1)**
Inventory	-2.597380 (4)	-3.046844 (4)	-3.812335 (3)**	-3.815935 (3)*
S*LIBOR	-3.520096 (3)**	-3.453044 (3)*	-7.068674 (0)**	-7.038682 (0)**
Hcom	-6.211783 (0)**	-6.170652 (0)**	-11.67557 (1)**	-11.62031 (1)**
SPcor	-3.093906 (4)*	-4.071344 (4)**	-2.712088 (2)[1]	-2.648988 (2)[1]

MacKinnon (1996) critical values & SIC lag length.
[1] Second difference stationary

Table 4.2.6: Wheat Jan 2006 – Dec 2013 Dataset (N=95)				
Annual Difference ADF Unit Root test (null hypothesis: time series has a unit root)				
Series	Level		First difference	
t-statistic (lag length)	Intercept	Intercept & Trend	Intercept	Intercept & Trend
L(Fcont)	-2.112032 (0)	-2.316606 (0)	-9.110963 (0)**	-9.079057 (0)**
L(Fwa)	-2.060992 (0)	-2.291340 (0)	-5.190578 (11)**	-5.195496 (11)**
L(Spot)	-2.286667 (0)	-2.340201 (0)	-8.683434 (0)**	-8.651932 (0)**
Inventory	-2.471977 (4)	-2.479974 (4)	-2.718095 (3)[1]	-2.723864 (3)[1]
S*LIBOR	-3.538208 (7)**	-3.532991 (7)*	-3.054913 (2)*	-3.042925 (2)[3]
Hcom	-3.056045 (0)*	-3.178410 (0)	-10.23419 (0)**	-10.21242 (0)**
Hcom (CIT)	-4.919752 (11)**	-4.972316 (11)**	-2.352280 (11)[4]	-2.463495 (11)[4]
Hix	-3.154325 (0)*	-3.141475 (0)	-7.221887 (2)**	-7.209117 (2)**
% index	-2.882625 (0)	-3.651163 (0)*	-9.236663 (0)**	-6.144991 (11)**
SPcor	-2.959421 (1)*	-3.393921 (1)	-2.598476 (0)[2]	-2.661874 (0)[2]

MacKinnon (1996) critical values & SIC lag length. The Philips-Perron test was run in addition but results remain the same.
[1] Second difference stationary.
[2] Second difference stationary.
[3] Second difference stationary.
[4] Second difference stationary.

Appendix 4.3 Granger Non-causality Test Results

Table 4.3.1: Granger Non-Causality Test								
Null		**(Monthly Level - fcont)**				**(Monthly Level fwav)**		
S does not Granger Cause F								
F does not Granger Cause S		**Chi-Square**	**Probability**	**Lags**		**Chi-Square**	**Probability**	**Lags**
Cocoa								
Apr. 1995 – Dec. 2013	S – F	0.020033	0.8874	1		0.092002	0.7616	1
	F – S	**1187.286**	**0.0000**	**1**		0.099083	0.7529	1
Apr. 1995 – Dec. 2005	S – F	0.144488	0.7039	1		0.055035	0.8145	1
	F – S	**1099.446**	**0.0000**	**1**		0.003618	0.9520	1
Jan. 2006 – Dec. 2013	S – F	0.769370	0.3804	1		0.081765	0.7749	1
	F – S	**343.5164**	**0.0000**	**1**		0.060903	0.8051	1
Wheat								
Apr. 1995 – Dec. 2013	S – F	**2.867710**	**0.0904**	**1**		**2.853607**	**0.0912**	**1**
	F – S	0.127385	0.7212	1		0.206659	0.6494	1
Apr. 1995 – Dec. 2005	S – F	1.708850	0.1911	1		1.547999	0.2134	1
	F – S	1.264815	0.2607	1		1.160050	0.2815	1
Jan. 2006 – Dec. 2013	S – F	**5.164511**	**0.0231**	**1**		**5.352980**	**0.0207**	**1**
	F – S	0.609294	0.4351	1		0.676684	0.4107	1

Appendix 4.4 Co-integration Analysis CRADF and KPSS

Table 4.4.1: Cocoa Co-integration Regression ADF/PP/KPSS				
	Fcont-Spot		**Fwa-Spot**	
	Forward (Y=S)	Backward (Y=F)	Forward (Y=S)	Backward (Y=F)
April 1996 – Dec 2013				
Coefficient (1&4)	0.792006	0.956182	0.979233	0.969802
ADF/PP Test-statistic p-value*	-4.447418 0.0000	-4.641020 0.0000	-5.328209[H] 0.0000	-5.527037[H] 0.0000
KPSS LM-statistic**	0.115232	0.070190	0.054679	0.057703
April 1996 – Dec 2006				
Coefficient (3&4)	0.804599	1.016781	0.967508	1.016582
ADF/PP Test-statistic p-value*	-3.286757 0.0012	-3.044623 0.0026	-3.105947[H] 0.0021	-3.246289[H] 0.0014
KPSS LM-statistic**	0.101524	0.107217	0.230377	0.237843
Jan 2006 – Dec 2013				
Coefficient (5&6)	0.757801	0.820546	1.008815	0.868620
ADF/PP Test-statistic p-value*	-5.332587 0.0000	-9.898409 0.0000	-3.989571[H] 0.0001	-4.336929[H] 0.0000
KPSS LM-statistic**	0.498298	0.242214	0.080094	0.068558

*MacKinnon (1996) one-sided p-values are reported.
**Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)
1% level 0.739000
5% level 0.463000
10% level 0.347000
[H] PP instead since heteroscedasticity is detected.
***Schwarz information criteria is used to detect lag length.

Table 4.4.2: Wheat Co-integration Regression ADF/PP/KPSS				
	Fcont-spot		**Fwav-spot**	
	Forward (Y=S)	Backward (Y=F)	Forward (Y=S)	Backward (Y=F)
April 1996 – Dec 2013				
Coefficient (1&2)	1.072399	0.810777	1.118556	0.762998
ADF/PP Test-statistic p-value*	-2.533986 0.0113	-4.993759[H] 0.0000	-2.507929 0.0121	-2.362553 0.0179
KPSS LM-statistic**	0.110453	0.129696	0.119557	0.139069
April 1996 – Dec 2005				
Coefficient (3&4)	1.047145	0.811107	1.098843	0.758269
ADF/PP Test-statistic p-value*	-3.717532 0.0003	-3.823864 0.0002	-3.514283 0.0006	-3.674699 0.0003
KPSS LM-statistic**	0.128222	0.041650	0.154374	0.047655
Jan 2006 – Dec 2013				
Coefficient (5&6)	1.088462	0.799148	1.133814	0.752263
ADF/PP Test-statistic p-value*	-3.352343 0.0010	-3.213816 0.0016	-3.169607 0.0018	-2.995386 0.0031
KPSS LM-statistic**	0.480372	0.605599	0.508324	0.654796

*MacKinnon (1996) one-sided p-values are reported.
**Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)
1% level 0.739000
5% level 0.463000
10% level 0.347000
[H] PP instead since heteroscedasticity is detected.
***Schwarz information criteria is used to detect lag length.

Appendix 4.5 Derivation of an ECM from an ARDL Model

If there is an equilibrium relationship between the futures and the cash market price, following Equation 4.1, the long-run relationship between the two time series can be written as following: $F_t = \gamma_1 + \gamma_2 S_t$. The deviation in each time period from the equilibrium is hence given by: $F_t - \gamma_1 - \gamma_2 S_t = e_t$. If modelling the relationship between the two time series as a simple autoregressive distributed lag model [ARDL] the past period's long-term equilibrium error can be incorporated by transforming the model into an unrestricted ECM. For an ARDL(1,1):

$$F_t = \beta_0 + \beta_1 F_{t-1} + \beta_2 S_t + \beta_3 S_{t-1} + \varepsilon_t.$$

$$\therefore F_t = \beta_0 + \beta_1 F_{t-1} + \beta_2 S_t + \beta_3 S_{t-1} + \varepsilon_t \mid \pm F_{t-1}$$

$$\therefore \Delta F_t = \beta_0 + (\beta_1 - 1) F_{t-1} + \beta_2 S_t + \beta_3 S_{t-1} + \varepsilon_t \mid \pm \beta_2 S_{t-1}$$

$$\therefore \Delta F_t = \beta_0 + (\beta_1 - 1) F_{t-1} + \beta_2 \Delta S_t + (\beta_3 + \beta_2) S_{t-1} + \varepsilon_t$$

With rearranging one gets:

$$\therefore \Delta F_t = \beta_2 \Delta S_t + (\beta_1 - 1)[F_{t-1} - \frac{\beta_0}{(1-\beta_1)} - \frac{(\beta_3+\beta_2)}{(1-\beta_1)} S_{t-1}] + \varepsilon_t$$

$$\therefore \Delta F_t = \beta_2 \Delta S_t + \rho[F_{t-1} - \gamma_1 - \gamma_2 S_{t-1}] + \varepsilon_t$$

With $\frac{\beta_0}{(1-\beta_1)} = \gamma_1$, $\frac{(\beta_3+\beta_2)}{(1-\beta_1)} = \gamma_2$, and $(\beta_1 - 1) = \rho$. The [.] enclose the long-run equilibrium error for the last time period. This way the long-run coefficients are nested in the error correction term.

Appendix 4.6 Co-integration ECM t-test Results

Table 4.6.1: Cocoa Co-integration ECM t-test Results

	(fcont-spot)				(fwa-spot)			
April 1996 – Dec 2013								
Critical value for n=250: -3.25^	Forward (Y=S)		Backward (Y=F)		Forward (Y=S)		Backward (Y=F)	
	ECM(2) n: 210		ECM(0) n: 212		ECM(6) n:206		ECM(6) n:206	
	Coefficient	t-value	Coefficient	t-value	Coefficient	t-value	Coefficient	t-value
	-0.545931	-7.03678	-0.634101	-3.611841	-0.276555	-5.357284	-0.307334	-5.497186
AR 1-6 test:[1] Normality test:[2] Hetero test:[3]	1.374919 [0.2264] 28.00693 [0.0000]** 0.392470 [0.9061]		0.794580 [0.5751] 1.005465 [0.6049] 0.430333 [0.7315]		2.757757 [0.0137]* 36.58527 [0.0000]** 2.788209 [0.0006]**		2.404889 [0.0292]* 24.56825 [0.0000]** 3.077955 [0.0002]**	
April 1996 – Jan 2006								
Critical value for n=100: -3.27^	ECM(1) n:115		ECM(0) n: 116		ECM(4) n:112		ECM(3) n:113	
	Coefficient	t-value	Coefficient	t-value	Coefficient	t-value	Coefficient	t-value
	-0.760347	-8.67657	-1.321752	-4.288075	-0.122314	-2.355222	-0.128270	-2.433113
AR 1-6 test:[1] Normality test:[2] Hetero test:[3]	2.000567 [0.0712] 4.243652 [0.1198] 0.713926 [0.6141]		1.020394 [0.4162] 3.286464 [0.1934] 0.324545 [0.8076]		2.088020 [0.0618] 0.780011 [0.6771] 1.770173 [0.0692]		1.120004 [0.3564] 2.134687 [0.3439] 1.703589 [0.0975]	
Feb 2006 – Dec 2013								
Critical value for n=100: -3.27^	ECM(1) n:96		ECM(0) n: 96		ECM(5) n:96		ECM(5) n:96	
	Coefficient	t-value	Coefficient	t-value	Coefficient	t-value	Coefficient	t-value
	-0.666480	-7.41894	-0.366582	-1.678772	-0.240532	-2.881594	-0.284805	-3.112506
AR 1-6 test:[1] Normality test:[2] Hetero test:[3]	2.077681 [0.0644] 3.076503 [0.2148] 1.905815 [0.1011]		0.913575 [0.4892] 0.180637 [0.9136] 0.324052 [0.8080]		2.082063 [0.0651] 0.696469 [0.7059] 2.637063 [0.0040]**		0.963196 [0.4559] 0.045545 [0.9775] 2.060837 [0.0254]*	

^ Banerjee, Dolado, and Mestre (1998) five percent critical values are used, which is -3.23 for a dataset of 500 and -3.27 for a sample of 100 with one regressor; [1] Breusch-Godfrey Serial Correlation LM F-test; [2] Jarque-Bera normality test; [3] Breusch-Pegan-Godfrey F-test.

Table 4.6.2: Wheat Co-integration ECM t-test Results

	(fcont-spot)				(fwa-spot)			
April 1996 – Dec 2013								
Critical value for n=250: -3.25^	Forward (Y=S)		Backward (Y=F)		Forward (Y=S)		Backward (Y=F)	
	ECM(0) n: 212		ECM(0) n: 212		ECM(0) n: 212		ECM(0) n: 212	
	Coefficient	t-value	Coefficient	t-value	Coefficient	t-value	Coefficient	t-value
	-0.205749	-4.80273	-0.208186	-5.098849	-0.185943	-4.514275	-0.191189	-4.847591
AR 1-6 test:[1] Normality test:[2] Hetero test:[3]	1.989192 [0.0692] 51.14572 [0.0000]** 1.099934 [0.3618]		1.567979 [0.1587] 10.25742 [0.0059]** 1.404624 [0.2055]		1.348987 [0.2375] 64.14658 [0.0000]** 0.885589 [0.4918]		1.163294 [0.3278] 13.43940 [0.0012]** 1.485614 [0.1962]	
April 1996 – Jan 2006								
Critical value for n=100: -3.27^	ECM(0) n: 116		ECM(0) n: 116		ECM(3) n: 113		ECM(3) n: 113	
	Coefficient	t-value	Coefficient	t-value	Coefficient	t-value	Coefficient	t-value
	-0.233342	-3.84292	-0.220905	-3.588450	-0.199626	-2.658844	-0.266778	-3.340571
AR 1-6 test:[1] Normality test:[2] Hetero test:[3]	1.176178 [0.3259] 1.030959 [0.5972] 1.393636 [0.2333]		0.861866 [0.5261] 0.213259 [0.8989] 1.180811 [0.3241]		1.715540 [0.1261] 1.145193 [0.5641] 0.602479 [0.6981]		1.560768 [0.1675] 0.084717 [0.9585] 0.455550 [0.8083]	
Feb 2006 – Dec 2013								
Critical value for n=100:-3.27^	ECM(0) n: 96		ECM(0) n: 96		ECM(0) n: 96		ECM(0) n: 96	
	Coefficient	t-value	Coefficient	t-value	Coefficient	t-value	Coefficient	t-value
	-0.200698	-3.15911	-0.208593	-3.519369	-0.184829	-3.045461	-0.189252	-3.372875
AR 1-6 test:[1] Normality test:[2] Hetero test:[3]	1.321826 [0.2571] 9.433037 [0.0090]** 0.614440 [0.7817]		1.381431 [0.2316] 0.721478 [0.6972] 0.647922 [0.6638]		2.093361 [0.0624] 11.0.6657 [0.0040]** 0.530714 [0.7525]		1.229854 [0.2993] 1.478366 [0.4775] 0.682264 [0.6380]	

^ Banerjee, Dolado, and Mestre (1998) five percent critical values are used, which is -3.23 for a dataset of 500 and -3.27 for a sample of 100 with one regressor; [1] Breusch-Godfrey Serial Correlation LM F-test; [2] Jarque-Bera normality test; [3] Breusch-Pegan-Godfrey F-test.

Appendix 4.7 Cocoa Unrestricted ECM Estimation Results

Table 4.7.1: Cocoa ECM Estimation Results Fcont Index and Hedging Pressure (D12)								
April 1995 – Dec 2013								
	Forward (Y=S)				**Backward (Y=F)**			
	ECM(0)				ECM(0)			
	Coeff.	t-val.	p-val.	part-r	Coeff.	t-val.	p-val.	part-r
X	0.0480472	2.23	0.0268*	0.0245	0.510390	2.23	0.0268*	0.0245
DSLIBOR	0.195809	1.74	0.0831	0.0151	-0.409797	-1.11	0.2668	0.0062
DInventory	0.0052288	0.569	0.5698	0.0016	0.0279514	0.935	0.3509	0.0044
DInvent_1	-0.0447380	-4.81	0.0000**	0.1048	0.0101808	0.318	0.7507	0.0005
DSPCOR3Y	0.0155263	0.404	0.6865	0.0008	0.142268	1.14	0.2559	0.0065
Dcom_H	-0.0386280	-1.38	0.1703	0.0095	0.116026	1.27	0.2065	0.0080
Y_1	-0.828776	-30.0	0.0000**	0.8199	-0.715061	-3.71	0.0003**	0.0651
X_1	0.777947	29.9	0.0000**	0.8187	0.617255	2.98	0.0033**	0.0428
SLIBOR_1	-0.029157	-0.732	0.4652	0.0027	-0.265640	-2.06	0.0403*	0.0211
Inventory_1	0.013486	3.10	0.0022**	0.0463	0.002608	0.180	0.8575	0.0002
SPCOR3Y_1	-0.0137598	-2.31	0.0218*	0.0263	0.0259035	1.32	0.1872	0.0088
com_H_1	0.0066014	0.399	0.6902	0.0008	-0.0185584	-0.344	0.7310	0.0006
AR 1-7:	F(7,191) = 2.2435 [0.0325]*				F(7,191) = 1.9575 [0.0628]			
ARCH 1-7:	F(7,184) = 0.77750 [0.6069]				F(7,184) = 2.8531 [0.0075]**			
Normality:	Chi^2(2) = 3.8508 [0.1458]				Chi^2(2) = 0.83910 [0.6573]			
Hetero:	F(24,173) = 0.75511 [0.7878]				F(24,173) = 1.1916 [0.2555]			
RESET23:	F(1,197) = 0.000621 [0.9802]				F(1,197) = 0.47139 [0.4932]			
April 1995 – Dec 2005								
	ECM(0)				ECM(0)			
	Coeff.	t-val.	p-val.	part-r	Coeff.	t-val.	p-val.	part-r
X	0.0707134	3.07	0.0027**	0.0847	1.19812	3.07	0.0027**	0.0847
DSLIBOR	0.388703	2.28	0.0246*	0.0486	-0.184732	-0.257	0.7976	0.0006
DInventory	0.0136951	1.25	0.2136	0.0151	0.08888	2.00	0.0486*	0.0376
DInvent_1	-0.0242812	-2.34	0.0211*	0.0511	0.012458	0.285	0.7765	0.0008
DSPCOR3Y	0.0257031	0.333	0.7395	0.0011	0.868015	2.84	0.0054**	0.0733
Dcom_H	0.0060664	0.222	0.8247	0.0005	0.161968	1.46	0.1487	0.0203
Y_1	-0.920306	-28.4	0.0000**	0.8876	-1.34485	-4.02	0.0001**	0.1370
X_1	0.829620	27.8	0.0000**	0.8834	1.35043	3.60	0.0005**	0.1128
SLIBOR_1	-0.0332563	-0.719	0.4739	0.0050	-0.284481	-1.51	0.1350	0.0218
Inventory_1	0.0113786	1.98	0.0509	0.0369	0.024497	1.02	0.3105	0.0101
SPCOR3Y_1	-0.0128198	-1.30	0.1956	0.0164	0.016332	0.400	0.6899	0.001
com_H_1	0.0645971	2.94	0.0041**	0.0781	0.077747	0.828	0.4095	0.0067
AR 1-7:	F(7,95) = 0.89472 [0.5140]				F(7,95) = 0.92780 [0.4888]			
ARCH 1-7:	F(7,88) = 1.8913 [0.0804]				F(7,88) = 0.80180 [0.5879]			
Normality:	Chi^2(2) = 10.835 [0.0044]**				Chi^2(2) = 3.2275 [0.1991]			
Hetero:	F(24,77) = 0.50279 [0.9700]				F(24,77) = 0.98471 [0.4953]			
RESET23:	F(1,101) = 0.20062 [0.6552]				F(1,101) = 0.48238 [0.4889]			
Jan 2006 – Dec 2013								
	ECM(0)				ECM(0)			
	Coeff.	t-val.	p-val.	part-r	Coeff.	t-val.	p-val.	part-r
X	0.0131131	0.347	0.7294	0.0014	0.110502	0.347	0.7294	0.0014
DSLIBOR	0.0304140	0.190	0.8496	0.0004	-0.429558	-0.930	0.3551	0.0103
DInventory	-0.0068618	-0.459	0.6476	0.0025	-0.040418	-0.935	0.3527	0.0104
DInvent_1	-0.0642402	-4.31	0.0000**	0.1830	0.020773	0.435	0.6650	0.0023
DSPCOR3Y	0.0105891	0.204	0.8388	0.0005	0.032537	0.216	0.8296	0.0006
Dcom_H	-0.0423313	-0.745	0.4584	0.0066	-0.136204	-0.826	0.4110	0.0082
Y_1	-0.746885	-16.5	0.0000**	0.7672	-0.595306	-2.16	0.0338*	0.0532
X_1	0.767344	15.5	0.0000**	0.7442	0.365191	1.36	0.1778	0.0218
SLIBOR_1	-0.0309593	-0.466	0.6425	0.0026	-0.332561	-1.75	0.0832	0.0357
Inventory_1	0.0211257	3.10	0.0026**	0.1038	-0.007821	-0.375	0.7089	0.0017
SPCOR3Y_1	-0.0182976	-2.27	0.0258*	0.0585	0.023020	0.960	0.3398	0.0110
com_H_1	0.0022974	0.0768	0.9390	0.0001	-0.099392	-1.15	0.2519	0.0158
AR 1-7:	F(6,77) = 0.94828 [0.4659]				F(6,77) = 0.80505 [0.5691]			
ARCH 1-7:	F(6,71) = 1.0247 [0.4165]				F(6,71) = 1.9456 [0.0852]			
Normality:	Chi^2(2) = 1.3008 [0.5218]				Chi^2(2) = 0.20214 [0.9039]			
Hetero:	F(24,58) = 0.83711 [0.6774]				F(24,58) = 0.85387 [0.6571]			
RESET23:	F(1,82) = 0.066952 [0.7965]				F(1,82) = 0.016640 [0.8977]			

Table 4.7.1: Cocoa ECM Estimation Results Fcont Index and Hedging Pressure (D12) (cont.)								
Jan 2006 – Dec 2013 (alternative)								
	ECM(0)				ECM(0)			
	Coeff.	t-val.	p-val.	part-r	Coeff.	t-val.	p-val.	part-r
X	0.0018647	0.0447	0.9645	0.0000	0.01599	0.0447	0.9645	0.0000
DSLIBOR	0.0603900	0.362	0.7188	0.0019	-0.37991	-0.780	0.4384	0.0090
DInventory	-0.0116263	-0.643	0.5224	0.0061	-0.08159	-1.56	0.1224	0.0352
DInvent_1	-0.0648576	-3.62	0.0006**	0.1635	0.01723	0.300	0.7648	0.0013
DSPCOR3Y	-0.0322455	-0.474	0.6369	0.0033	0.29782	1.52	0.1335	0.0333
DH_index	0.123562	0.808	0.4220	0.0096	-0.58415	-1.32	0.1930	0.0252
DH_com	-0.0891571	-1.07	0.2881	0.0168	-0.06997	-0.285	0.7767	0.0012
Y_1	-0.748587	-15.6	0.0000**	0.7843	-0.64806	-2.07	0.0419*	0.0603
X_1	0.768254	13.4	0.0000**	0.7269	0.28617	0.953	0.3441	0.0134
SLIBOR_1	-0.0268453	-0.245	0.8070	0.0009	-0.92143	-3.07	0.0031**	0.1233
Inventory_1	0.0126079	1.66	0.1022	0.0394	-0.01683	-0.743	0.4599	0.0082
SPCOR3Y_1	-0.0330315	-2.94	0.0045**	0.1141	0.05724	1.67	0.0995	0.0400
H_index_1	0.349222	2.66	0.0097**	0.0956	-0.46268	-1.16	0.2515	0.0196
H_com_1	-0.126814	-2.32	0.0236*	0.0742	-0.13578	-0.819	0.4155	0.0099
AR 1-7:	F(5,62) = 1.7117 [0.1452]				F(5,62) = 1.3089 [0.2719]			
ARCH 1-7:	F(5,57) = 1.0332 [0.4070]				F(5,57) = 1.1544 [0.3428]			
Normality:	Chi^2(2) = 0.89128 [0.6404]				Chi^2(2) = 0.44840 [0.7992]			
Hetero:	F(28,38) = 0.84727 [0.6725]				F(28,38) = 0.48171 [0.9763]			
RESET23:	F(1,66) = 0.075850 [0.7839]				F(1,66) = 0.027575 [0.8686]			

Notes: ** indicates significance at the 1% level, * indicates significance at the 5% level.
D12 indicates annual differences, D indicates first difference, _1 indicates lagged one period; SLIBOR is the cash price times interest rate, Inventory is level of inventories; SPCOR3Y is systematic risk; com_H is hedging pressure using the COT data; H_com is hedging pressure using CIT data; H_index denotes index pressure using CIT data.

Table 4.7.2: Cocoa ECM Estimation Results Fwa Index and Hedging Pressure (D12)								
April 1995 – Dec 2013								
	Backward (Y=F)				**Forward (Y=S)**			
	ECM(6)				ECM(6)			
	Coeff.	t-val.	p-val.	part-r	Coeff.	t-val.	p-val.	part-r
X	0.99718	37.7	0.0000**	0.9001	0.90262	37.7	0.0000**	0.9001
DSLIBOR	0.00001	0.03	0.9773	0.0000	0.00031	0.32	0.7514	0.0006
DInventory	0.02972	3.79	0.0002**	0.0834	-0.02691	-3.59	0.0004**	0.0755
DInvent_1	0.02530	3.13	0.0021**	0.0585	-0.02325	-3.02	0.0029**	0.0546
DSPCOR3Y	-0.15305	-1.61	0.1092	0.0162	0.15118	1.67	0.0962	0.0174
Dcom_H	-0.00465	-0.19	0.8507	0.0002	-0.03654	-1.57	0.1181	0.0154
Y_1	-0.29952	-4.83	0.0000**	0.1286	-0.28637	-4.83	0.0000**	0.1286
X_1	0.29388	4.70	0.0000**	0.1226	0.27867	4.71	0.0000**	0.1230
SLIBOR_1	0.00017	0.41	0.6843	0.0010	-0.00041	-1.04	0.3008	0.0068
Inventory_1	0.00136	0.32	0.7526	0.0006	-0.00264	-0.64	0.5208	0.0026
SPCOR3Y_1	0.00670	0.66	0.5081	0.0028	-0.00238	-0.25	0.8048	0.0004
com_H_1	-0.01142	-0.55	0.5837	0.0019	-0.00785	-0.40	0.6925	0.0010
AR 1-7:	F(7,151) = 1.5247 [0.1629]				F(7,151) = 1.8551 [0.0808]			
ARCH 1-7:	F(7,144) = 4.8553 [0.0001]**				F(7,144) = 6.0720 [0.0000]**			
Normality:	Chi^2(2) = 9.7494 [0.0076]**				Chi^2(2) = 10.760 [0.0046]**			
Hetero:	F(94,63) = 0.51090 [0.9985]				F(94,63) = 0.47668 [0.9995]			
RESET23:	F(1,157) = 0.016204 [0.8989]				F(1,157) = 0.34669 [0.5568]			
April 1995 – Dec 2005								
	ECM(0)				ECM(0)			
	Coeff.	t-val.	p-val.	part-r	Coeff.	t-val.	p-val.	part-r
X	1.04663	57.6	0.0000**	0.9662	0.92318	57.6	0.0000**	0.9662
DSLIBOR	0.00088	1.03	0.3029	0.0091	-0.00039	-0.49	0.6233	0.0021
DInventory	-0.00037	-0.07	0.9475	0.0000	0.00160	0.31	0.7583	0.0008
DInvent_1	0.01515	2.87	0.0050**	0.0661	-0.01307	-2.62	0.0100**	0.0558
DSPCOR3Y	-0.06407	-1.26	0.2102	0.0135	0.09105	1.92	0.0568	0.0309
Dcom_H	-0.02224	-1.51	0.1336	0.0193	0.01176	0.85	0.3998	0.0061
Y_1	-0.22851	-4.08	0.0001**	0.1257	-0.21879	-4.07	0.0001**	0.1251
X_1	0.23403	4.09	0.0001**	0.1262	0.21039	3.99	0.0001**	0.1208
SLIBOR_1	0.00072	2.15	0.0338*	0.0383	-0.00073	-2.33	0.0215*	0.0447
Inventory_1	0.00032	0.15	0.8850	0.0002	0.00042	0.20	0.8419	0.0003
SPCOR3Y_1	0.00143	0.23	0.8166	0.0005	0.00001	0.01	0.9908	0.0000
com_H_1	-0.00304	-0.24	0.8075	0.0005	0.00773	0.66	0.5092	0.0038
AR 1-7:	F(7,109) = 1.7895 [0.0965]				F(7,109) = 2.1633 [0.0430]*			
ARCH 1-7:	F(7,102) = 0.77159 [0.6124]				F(7,102) = 0.58616 [0.7658]			
Normality:	Chi^2(2) = 3.9532 [0.1385]				Chi^2(2) = 1.9131 [0.3842]			
Hetero:	F(24,91) = 0.53018 [0.9609]				F(24,91) = 0.60857 [0.9170]			
RESET23:	F(1,115) = 1.3857 [0.2416]				F(1,115) = 2.6111 [0.1089]			
Jan 2006 – Dec 2013								
	ECM(0)				ECM(0)			
	Coeff.	t-val.	p-val.	part-r	Coeff.	t-val.	p-val.	part-r
X	0.96879	17.3	0.0000**	0.8134	0.83958	17.3	0.0000**	0.8134
DSLIBOR	-0.00053	-0.31	0.7543	0.0014	-0.00026	-0.16	0.8702	0.0004
DInventory	0.08682	4.88	0.0000**	0.2563	-0.06589	-3.76	0.0003**	0.1703
DInvent_1	0.04358	2.30	0.0245*	0.0712	-0.05442	-3.18	0.0022**	0.1280
DSPCOR3Y	-0.10044	-1.74	0.0868	0.0419	0.08502	1.57	0.1201	0.0346
Dcom_H	0.01942	0.61	0.5458	0.0053	-0.04480	-1.53	0.1317	0.0326
Y_1	-0.58491	-6.12	0.0000**	0.3516	-0.50797	-5.80	0.0000**	0.3279
X_1	0.53708	5.67	0.0000**	0.3177	0.53533	5.96	0.0000**	0.3398
SLIBOR_1	-0.00033	-0.61	0.5440	0.0054	0.00010	0.20	0.8404	0.0006
Inventory_1	0.01620	1.95	0.0551	0.0523	-0.01465	-1.89	0.0627	0.0493
SPCOR3Y_1	0.03711	3.19	0.0021**	0.1285	-0.02981	-2.70	0.0087**	0.0957
com_H_1	0.04303	0.65	0.5199	0.0060	-0.16511	-2.81	0.0065**	0.1024
AR 1-7:	F(5,64) = 1.7297 [0.1405]				F(5,64) = 2.1903 [0.0661]			
ARCH 1-7:	F(5,59) = 0.78556 [0.5642]				F(5,59) = 0.44958 [0.8119]			
Normality:	Chi^2(2) = 1.4121 [0.4936]				Chi^2(2) = 1.6767 [0.4324]			
Hetero:	F(24,44) = 0.52507 [0.9535]				F(24,44) = 0.91597 [0.5817]			
RESET23:	F(1,68) = 0.31309 [0.5776]				F(1,68) =0.0088272 [0.9254]			

Table 4.7.2: Cocoa ECM Estimation Results Fwa Index and Hedging Pressure (D12) (cont.)								
Jan 2006 – Dec 2013 (alternative)								
	ECM(0)				ECM(0)			
	Coeff.	t-val.	p-val.	part-r	Coeff.	t-val.	p-val.	part-r
X	0.95903	18.3	0.0000**	0.8378	0.87356	18.3	0.0000**	0.8378
DSLIBOR	-0.00237	-1.32	0.1914	0.0261	0.00208	1.22	0.2285	0.0222
DInventory	0.09257	5.26	0.0000**	0.2983	-0.07740	-4.39	0.0000**	0.2290
DInvent_1	0.04987	2.73	0.0082**	0.1027	-0.05805	-3.42	0.0011**	0.1528
DSPCOR3Y	-0.24717	-3.30	0.0016**	0.1436	0.24779	3.50	0.0009**	0.1584
DH_index	0.37001	2.63	0.0106*	0.0963	-0.42579	-3.25	0.0018**	0.1400
DH_com	-0.16659	-2.09	0.0405*	0.0630	0.03770	0.48	0.6324	0.0035
DCITindpct	0.05982	0.14	0.8903	0.0003	0.03294	0.08	0.9366	0.0001
Y_1	-0.66702	-7.02	0.0000**	0.4314	-0.69002	-7.00	0.0000**	0.4296
X_1	0.69537	6.55	0.0000**	0.3974	0.61297	6.58	0.0000**	0.4000
SLIBOR_1	0.00058	0.86	0.3943	0.0112	-0.00108	-1.71	0.0926	0.0429
Inventory_1	0.02385	2.51	0.0145*	0.0885	-0.02631	-2.95	0.0044**	0.1182
SPCOR3Y_1	0.01686	1.30	0.1979	0.0254	-0.00916	-0.73	0.4654	0.0082
H_index_1	0.44058	2.97	0.0042**	0.1195	-0.45698	-3.27	0.0017**	0.1412
H_com_1	-0.07023	-1.19	0.2373	0.0214	0.01369	0.24	0.8103	0.0009
CITindpct_1	-0.64819	-1.36	0.1782	0.0277	0.95477	2.14	0.0358*	0.0660
AR 1-7:	F(5,60) = 1.5350 [0.1926]				F(5,60) = 1.8110 [0.1243]			
ARCH 1-7:	F(5,55) = 0.87642 [0.5030]				F(5,55) = 0.65157 [0.6615]			
Normality:	Chi^2(2) = 0.43727 [0.8036]				Chi^2(2) = 0.20259 [0.9037]			
Hetero:	F(32,32) = 0.50617 [0.9708]				F(32,32) = 0.60316 [0.9209]			
RESET23:	F(1,64) = 0.39230 [0.5333]				F(1,64) = 0.095879 [0.7578]			

Notes: ** indicates significance at the 1% level, * indicates significance at the 5% level.
D12 indicates annual differences, D indicates first difference, _1 indicates lagged one period; SLIBOR is the cash price times interest rate, Inventory is level of inventories; SPCOR3Y is systematic risk; com_H is hedging pressure using the COT data; H_com is hedging pressure using CIT data; H_index denotes index pressure using CIT data.

Appendix 4.8 Wheat Unrestricted ECM Estimation Results

Table 4.8.1: Wheat ECM Estimation Results Fcont Index and Hedging Pressure (D12)								
April 1995 – Dec 2013								
	Forward (Y=S)				**Backward (Y=F)**			
	ECM(0)				ECM(0)			
	Coeff.	t-val.	p-val.	part-r	Coeff.	t-val.	p-val.	part-r
X	1.05204	20.1	0.0000**	0.6717	0.63843	20.1	0.0000**	0.6717
DSLIBOR	0.41049	1.65	0.1012	0.0135	0.05107	0.261	0.7942	0.0003
DInventory	-180.879	-1.01	0.3130	0.0051	110.325	0.791	0.4298	0.0032
DInventory_1	41.3408	0.238	0.8125	0.0003	-5.33073	-0.0393	0.9687	0.0000
DSPCOR3Y	-0.06107	-0.738	0.4616	0.0027	0.02428	0.376	0.7073	0.0007
Dcom_H	0.11527	1.07	0.2852	0.0058	-0.47735	-6.21	0.0000**	0.1629
Y_1	-0.255189	-5.55	0.0000**	0.1344	-0.23721	-5.43	0.0000**	0.1295
X_1	0.192833	3.29	0.0012**	0.0519	0.18782	5.20	0.0000**	0.1200
SLIBOR_1	-0.008029	-0.119	0.9052	0.0001	0.05877	1.12	0.2625	0.0063
Inventory_1	-17.4116	-0.548	0.5842	0.0015	5.80505	0.234	0.8149	0.0003
SPCOR3Y_1	0.035349	2.32	0.0213*	0.0265	0.00222	0.185	0.8537	0.0002
com_H_1	-0.119879	-1.02	0.3111	0.0052	-0.18618	-2.04	0.0427*	0.0206
AR 1-7:	F(7,191) = 1.4006 [0.2071]				F(7,191) = 1.5238 [0.1613]			
ARCH 1-7:	F(7,184) = 4.0754 [0.0004]**				F(7,184) = 1.9640 [0.0622]			
Normality:	Chi^2(2) = 26.114 [0.0000]**				Chi^2(2) = 9.8783 [0.0072]**			
Hetero:	F(24,173) = 2.6366 [0.0002]**				F(24,173) = 1.2630 [0.1962]			
RESET23:	F(1,197) = 1.1595 [0.2829]				F(1,197) = 3.5457 [0.0612]			
April 1995 – Dec 2005								
	ECM(0)				ECM(0)			
	Coeff.	t-val.	p-val.	part-r	Coeff.	t-val.	p-val.	part-r
X	0.946981	12.0	0.0000**	0.5854	0.61822	12.0	0.0000**	0.5854
DSLIBOR	1.09732	3.28	0.0014**	0.0953	-0.21245	-0.749	0.4555	0.0055
DInventory	-66.2447	-0.387	0.6992	0.0015	-50.4407	-0.365	0.7158	0.0013
DInventory_1	57.4140	0.360	0.7197	0.0013	24.4995	0.190	0.8497	0.0004
DSPCOR3Y	-0.00447283	-0.046	0.9639	0.0000	0.08456	1.07	0.2877	0.0111
Dcom_H	0.0862607	0.824	0.4117	0.0066	-0.41632	-5.61	0.0000**	0.2361
Y_1	-0.323484	-4.28	0.0000**	0.1520	-0.35127	-4.55	0.0000**	0.1688
X_1	0.335518	3.38	0.0010**	0.1005	0.22487	3.60	0.0005**	0.1125
SLIBOR_1	-0.0222340	-0.254	0.8002	0.0006	-0.01244	-0.176	0.8609	0.0003
Inventory_1	-36.1545	-0.843	0.4014	0.0069	1.59779	0.0459	0.9635	0.0000
SPCOR3Y_1	0.00898877	0.547	0.5856	0.0029	0.01033	0.779	0.4376	0.0059
com_H_1	0.0778520	0.664	0.5084	0.0043	-0.27862	-3.07	0.0028**	0.0844
AR 1-7:	F(7,95) = 1.3715 [0.2264]				F(7,95) = 1.2079 [0.3061]			
ARCH 1-7:	F(7,88) = 1.0108 [0.4293]				F(7,88) = 1.8909 [0.0805]			
Normality:	Chi^2(2) = 6.6760 [0.0355]*				Chi^2(2) = 12.134 [0.0023]**			
Hetero:	F(24,77) = 1.1321 [0.3318]				F(24,77) = 0.67375 [0.8616]			
RESET23:	F(1,101) = 0.64224 [0.4248]				F(1,101) = 0.075915 [0.7835]			
Jan 2006 – Dec 2013								
	ECM(2)				ECM(2)			
	Coeff.	t-val.	p-val.	part-r	Coeff.	t-val.	p-val.	part-r
X	1.21831	13.3	0.0000**	0.7261	0.59599	13.3	0.0000**	0.7261
DSLIBOR	-0.0508053	-0.122	0.9032	0.0002	0.25604	0.885	0.3795	0.0115
DInventory	-372.452	-0.770	0.4438	0.0088	359.169	1.07	0.2901	0.0167
DInventory_1	-295.549	-0.593	0.5550	0.0052	285.773	0.822	0.4139	0.0100
DSPCOR3Y	0.0768687	0.344	0.7322	0.0018	-0.30222	-1.99	0.0511	0.0556
Dcom_H	0.708120	1.98	0.0514	0.0554	-1.16294	-5.43	0.0000**	0.3057
Y_1	-0.298942	-3.31	0.0015**	0.1402	-0.26847	-3.31	0.0015**	0.1409
X_1	0.194318	1.58	0.1179	0.0361	0.21408	3.40	0.0011**	0.1470
SLIBOR_1	0.424972	1.99	0.0507	0.0558	-0.36932	-2.51	0.0144*	0.0862
Inventory_1	122.489	1.37	0.1748	0.0273	-145.985	-2.40	0.0191*	0.0793
SPCOR3Y_1	-0.0125249	-0.274	0.7849	0.0011	0.06837	2.21	0.0302*	0.0682
com_H_1	0.0890100	0.264	0.7929	0.0010	-0.53593	-2.36	0.0212*	0.0768
AR 1-7:	F(5,62) = 2.3852 [0.0482]*				F(5,62) = 1.7233 [0.1425]			
ARCH 1-7:	F(5,57) = 2.0010 [0.0922]				F(5,57) = 1.7151 [0.1459]			
Normality:	Chi^2(2) = 2.8013 [0.2464]				Chi^2(2) = 1.2925 [0.5240]			
Hetero:	F(32,34) = 1.2467 [0.2638]				F(32,34) = 0.66429 [0.8761]			
RESET23:	F(1,66) = 0.43520 [0.5117]				F(1,66) = 1.2504 [0.2675]			

Table 4.8.1: Wheat ECM Estimation Results Fcont Index and Hedging Pressure (D12) (cont.)

Jan 2006 – Dec 2013 (alternative)

	ECM(2)				ECM(0)			
	Coeff.	t-val.	p-val.	part-r	Coeff.	t-val.	p-val.	part-r
X	1.12755	13.7	0.0000**	0.7553	0.66793	14.1	0.0000**	0.7544
DSLIBOR	-0.0241697	-0.0547	0.9566	0.0000	0.09399	0.286	0.7755	0.0013
DInventory	-556.897	-1.10	0.2771	0.0193	790.772	2.15	0.0357*	0.0661
DInventory_1	-334.802	-0.620	0.5375	0.0063	41.3145	0.108	0.9142	0.0002
DSPCOR3Y	0.110562	0.526	0.6007	0.0045	-0.16204	-1.02	0.3100	0.0158
DH_index	0.0354718	0.0961	0.9237	0.0002	-0.03159	-0.123	0.9022	0.0002
DH_com	14.4001	0.551	0.5838	0.0049	-40.4234	-2.15	0.0351*	0.0665
DCITindpct	-0.643035	-1.12	0.2683	0.0201	0.53503	1.24	0.2202	0.0230
Y_1	-0.317349	-3.18	0.0023**	0.1423	-0.26376	-3.35	0.0014**	0.1469
X_1	0.221265	1.83	0.0726	0.0519	0.25698	4.00	0.0002**	0.1974
SLIBOR_1	0.355573	1.53	0.1320	0.0368	-0.20419	-1.21	0.2304	0.0221
Inventory_1	86.0659	0.984	0.3290	0.0156	-48.1383	-0.728	0.4690	0.0081
SPCOR3Y_1	-0.0041532	-0.0873	0.9307	0.0001	0.03876	1.09	0.2807	0.0179
H_index_1	0.120997	0.223	0.8239	0.0008	-0.79884	-1.99	0.0509	0.0574
H_com_1	30.2634	0.850	0.3989	0.0117	-38.7652	-1.51	0.1368	0.0337
CITindpct_1	0.184712	0.281	0.7799	0.0013	0.01180	0.0233	0.9815	0.0000
AR 1-7:	F(5,56) = 2.3218 [0.0550]				F(5,60) = 3.3262 [0.0102]*			
ARCH 1-7:	F(5,51) = 1.6441 [0.1652]				F(5,55) = 0.34166 [0.8854]			
Normality:	Chi^2(2) = 2.9320 [0.2308]				Chi^2(2) = 1.4046 [0.4954]			
Hetero:	F(40,20) = 0.92051 [0.6011]				F(32,32) = 0.75966 [0.7794]			
RESET23:	F(1,60) = 0.32454 [0.5710]				F(1,64) = 0.40121 [0.5287]			

Notes: ** indicates significance at the 1% level, * indicates significance at the 5% level.
D12 indicates annual differences, D indicates first difference, _1 indicates lagged one period; SLIBOR is the cash price times interest rate, Inventory is level of inventories; SPCOR3Y is systematic risk; com_H is hedging pressure using the COT data; H_com is hedging pressure using CIT data; H_index denotes index pressure using CIT data.
Residuals were tested for non-stationarity with ADF without intercept and found stationary in all cases.

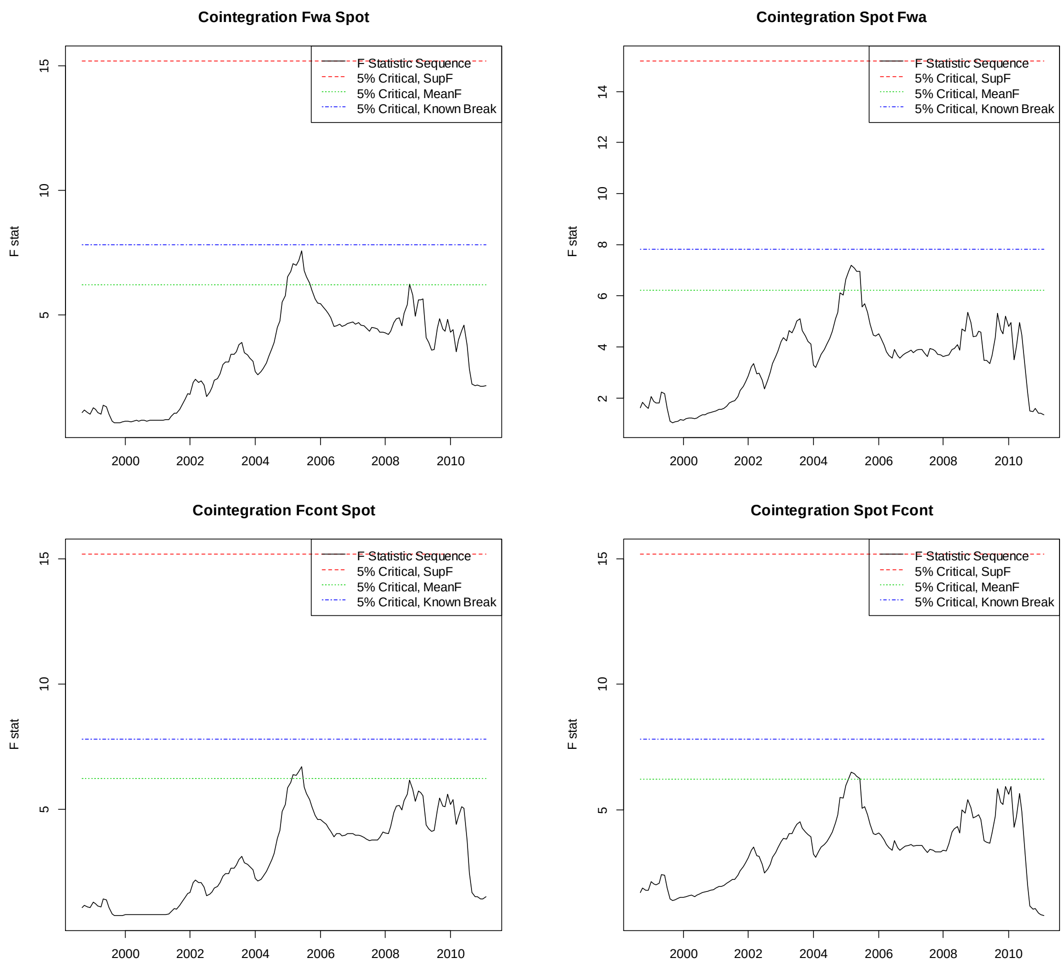
Table 4.8.2: Wheat ECM Estimation Results Fwa Index and Hedging Pressure (D12)								
April 1995 – Dec 2013								
	Forward (Y=S)				**Backward (Y=F)**			
	ECM(0)				ECM(0)			
	Coeff.	t-val.	p-val.	part-r	Coeff.	t-val.	p-val.	part-r
X	0.59712	20.0	0.0000**	0.6689	1.12013	20.0	0.0000**	0.6689
DSLIBOR	0.07436	0.41	0.6862	0.0008	0.38170	1.52	0.1290	0.0116
DInventory	0.00009	0.69	0.4938	0.0024	-0.00016	-0.91	0.3623	0.0042
DInventory_1	0.00003	0.26	0.7943	0.0003	-0.00001	-0.04	0.9714	0.0000
DSPCOR3Y	-0.00261	-0.04	0.9657	0.0000	-0.03236	-0.39	0.6974	0.0008
Dcom_H	-0.50642	-7.03	0.0000**	0.1999	0.17977	1.64	0.1022	0.0134
Y_1	-0.21561	-5.30	0.0000**	0.1244	-0.24628	-5.53	0.0000**	0.1336
X_1	0.16811	5.12	0.0000**	0.1168	0.18157	3.13	0.0020**	0.0470
SLIBOR_1	0.06055	1.22	0.2226	0.0075	-0.01043	-0.15	0.8783	0.0001
Inventory_1	0.00002	0.89	0.3743	0.0040	-0.00003	-1.01	0.3136	0.0051
SPCOR3Y_1	-0.00015	-0.01	0.9897	0.0000	0.03754	2.48	0.0140*	0.0301
com_H_1	-0.18456	-2.17	0.0309*	0.0233	-0.11101	-0.95	0.3455	0.0045
AR 1-7:	F(7,191) = 1.0665 [0.3866]				F(7,191) = 0.92589 [0.4876]			
ARCH 1-7:	F(7,197) = 1.1824 [0.3145]				F(7,197) = 2.6704 [0.0116]*			
Normality:	Chi^2(2) = 9.1659 [0.0102]*				Chi^2(2) = 29.692 [0.0000]**			
Hetero:	F(24,186) = 1.5107 [0.0679]				F(24,186) = 3.3065 [0.0000]**			
RESET23:	F(2,196) = 2.2110 [0.1123]				F(2,196) = 1.0467 [0.3531]			
April 1995 – Dec 2005								
	ECM(0)				ECM(0)			
	Coeff.	t-val.	p-val.	part-r	Coeff.	t-val.	p-val.	part-r
X	0.58854	11.8	0.0000**	0.5761	0.97881	11.8	0.0000**	0.5761
DSLIBOR	-0.16368	-0.60	0.5513	0.0035	1.07899	3.20	0.0018**	0.0904
DInventory	-0.00004	-0.26	0.7924	0.0007	-0.00008	-0.46	0.6498	0.0020
DInventory_1	0.00005	0.36	0.7205	0.0012	0.00004	0.24	0.8108	0.0006
DSPCOR3Y	0.03823	0.51	0.6133	0.0025	0.03445	0.35	0.7241	0.0012
Dcom_H	-0.44183	-6.21	0.0000**	0.2721	0.12037	1.13	0.2631	0.0121
Y_1	-0.30121	-4.06	0.0001**	0.1377	-0.30171	-4.05	0.0001**	0.1372
X_1	0.18120	3.04	0.0030**	0.0823	0.31540	3.21	0.0018**	0.0908
SLIBOR_1	0.01643	0.24	0.8110	0.0006	-0.05230	-0.59	0.5546	0.0034
Inventory_1	0.00002	0.66	0.5124	0.0042	-0.00006	-1.34	0.1821	0.0172
SPCOR3Y_1	0.01125	0.88	0.3792	0.0075	0.00714	0.43	0.6657	0.0018
com_H_1	-0.26718	-3.08	0.0026**	0.0846	0.08308	0.71	0.4773	0.0049
AR 1-7:	F(7,96) = 1.7471 [0.1071]				F(7,96) = 2.0725 [0.0538]			
ARCH 1-7:	F(7,102) = 1.8168 [0.0919]				F(7,102) = 1.1383 [0.3453]			
Normality:	Chi^2(2) = 13.456 [0.0012]**				Chi^2(2) = 6.6152 [0.0366]*			
Hetero:	F(24,91) = 1.0799 [0.3818]				F(24,91) = 1.5458 [0.0731]			
RESET23:	F(2,101) = 0.19502 [0.8231]				F(2,101) = 1.3586 [0.2617]			
Jan 2006 – Dec 2013								
	ECM(3)				ECM(3)			
	Coeff.	t-val.	p-val.	part-r	Coeff.	t-val.	p-val.	part-r
X	0.54996	12.0	0.0000**	0.6899	1.25436	12.0	0.0000**	0.6899
DSLIBOR	-0.04270	-0.15	0.8842	0.0003	0.22842	0.52	0.6056	0.0041
DInventory	0.00017	0.65	0.5153	0.0065	-0.00027	-0.67	0.5051	0.0069
DInventory_1	-0.00030	-0.95	0.3474	0.0136	0.00051	1.08	0.2843	0.0176
DSPCOR3Y	-0.05296	-0.32	0.7470	0.0016	-0.28236	-1.15	0.2526	0.0201
Dcom_H	-1.18263	-6.10	0.0000**	0.3641	0.65938	1.84	0.0700	0.0496
Y_1	-0.20073	-2.95	0.0045**	0.1177	-0.44893	-5.90	0.0000**	0.3490
X_1	0.26324	4.95	0.0000**	0.2737	0.18238	1.70	0.0937	0.0426
SLIBOR_1	-0.77632	-4.89	0.0000**	0.2688	1.04116	4.18	0.0001**	0.2120
Inventory_1	-0.00024	-4.01	0.0002**	0.1981	0.00029	3.15	0.0025**	0.1325
SPCOR3Y_1	0.11024	3.22	0.0020**	0.1377	-0.05450	-0.99	0.3275	0.0148
com_H_1	-0.32298	-1.33	0.1867	0.0267	-0.08422	-0.23	0.8208	0.0008
AR 1-7:	F(6,59) = 1.3596 [0.2459]				F(6,59) = 0.39088 [0.8820]			
ARCH 1-7:	F(6,83) = 0.95033 [0.4640]				F(6,83) = 0.71737 [0.6367]			
Normality:	Chi^2(2) = 0.93541 [0.6264]				Chi^2(2) = 4.2420 [0.1199]			
Hetero:	F(58,36) = 0.82839 [0.7427]				F(58,36) = 1.0750 [0.4147]			
RESET23:	F(2,63) = 1.6627 [0.1978]				F(2,63) = 0.62854 [0.5367]			

Table 4.8.2: Wheat ECM Estimation Results Fwa Index and Hedging Pressure (D12) (cont.)								
Jan 2006 – Dec 2013 (alternative)								
	ECM(1)				ECM(0)			
	Coeff.	t-val.	p-val.	part-r	Coeff.	t-val.	p-val.	part-r
X	1.27021	11.8	0.0000**	0.6891	0.54297	11.7	0.0000**	0.6784
DSLIBOR	-0.0225032	-0.0517	0.9589	0.0000	0.12672	0.450	0.6544	0.0031
DInventory	-480.469	-0.915	0.3638	0.0131	709.882	2.16	0.0344*	0.0670
DInventory_1	-335.788	-0.650	0.5181	0.0067	42.7790	0.134	0.8935	0.0003
DSPCOR3Y	0.272620	1.09	0.2790	0.0186	-0.50347	-3.32	0.0015**	0.1451
DH_index	0.226196	0.612	0.5429	0.0059	-0.34728	-1.44	0.1533	0.0311
DH_com	42.7663	1.19	0.2385	0.0220	-50.8062	-2.23	0.0292*	0.0711
DCITindpct	-1.03857	-1.73	0.0880	0.0455	0.97862	2.54	0.0136*	0.0901
Y_1	-0.347108	-3.61	0.0006**	0.1716	-0.42374	-5.54	0.0000**	0.3204
X_1	0.343820	2.45	0.0171*	0.0869	0.23590	4.10	0.0001**	0.2058
SLIBOR_1	0.287674	1.24	0.2203	0.0238	-0.21864	-1.51	0.1356	0.0339
Inventory_1	96.7295	0.958	0.3417	0.0144	-139.780	-2.21	0.0308*	0.0698
SPCOR3Y_1	0.00791714	0.163	0.8709	0.0004	0.05236	1.69	0.0958	0.0421
H_index_1	0.606612	1.08	0.2846	0.0182	-1.38478	-4.20	0.0001**	0.2137
H_com_1	56.6228	1.04	0.3027	0.0169	-45.5294	-1.33	0.1869	0.0266
CITindpct_1	-0.573913	-1.22	0.2274	0.0230	0.76426	2.56	0.0128*	0.0916
AR 1-7:	F(5,58) = 3.0409 [0.0166]*				F(5,60) = 0.54634 [0.7404]			
ARCH 1-7:	F(5,53) = 1.5415 [0.1929]				F(5,55) = 0.96812 [0.4454]			
Normality:	Chi^2(2) = 4.7575 [0.0927]				Chi^2(2) = 1.3143 [0.5183]			
Hetero:	F(36,26) = 1.0727 [0.4321]				F(32,32) = 0.75185 [0.7879]			
RESET23:	F(1,62) = 1.0144 [0.3178]				F(1,64) = 0.039976 [0.8422]			

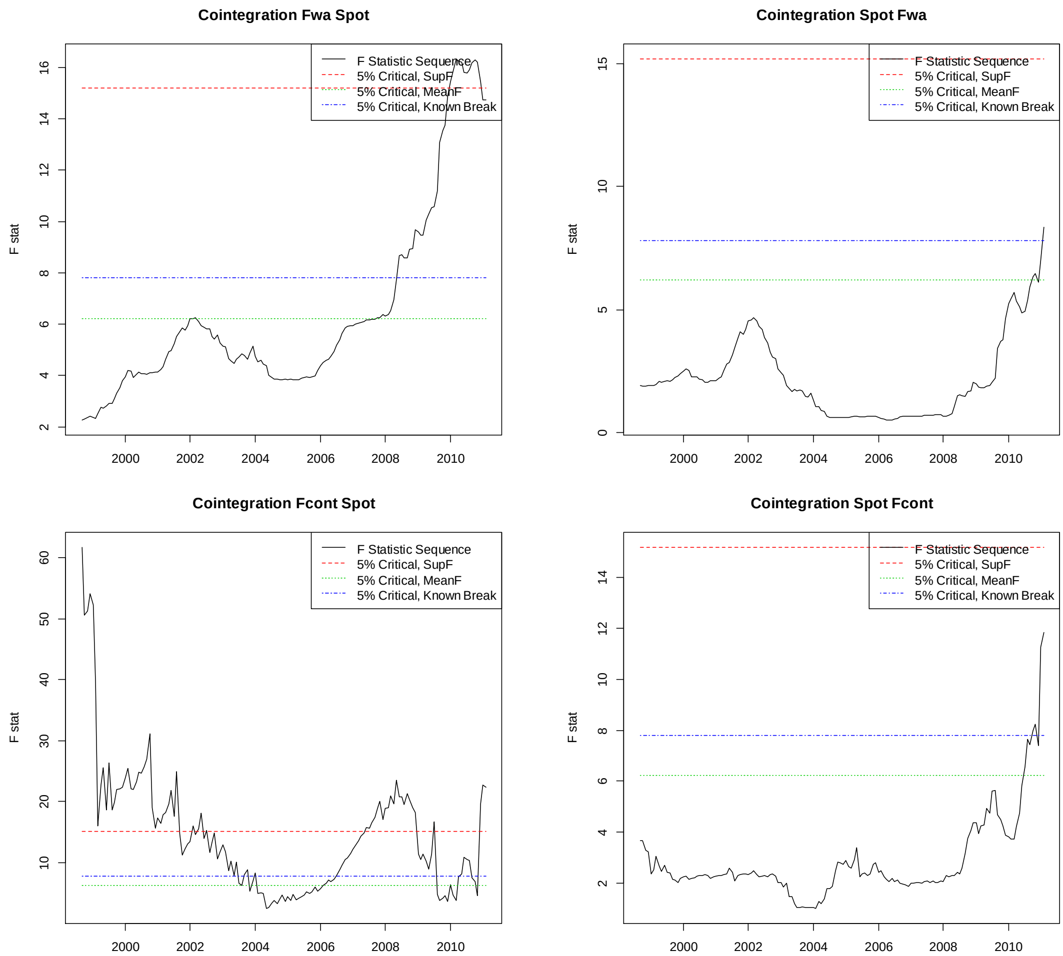
Notes: ** indicates significance at the 1% level, * indicates significance at the 5% level.
D12 indicates annual differences, D indicates first difference, _1 indicates lagged one period; SLIBOR is the cash price times interest rate, Inventory is level of inventories; SPCOR3Y is systematic risk; com_H is hedging pressure using the COT data; H_com is hedging pressure using CIT data; H_index denotes index pressure using CIT data.

Appendix 4.9 Hansen Parameter Instability Tests Restricted Model

Figure 4.9.1: Hansen Parameter Instability Test Wheat



Fiure 4.9.2: Hansen Parameter Instability Test Cocoa



Notes: Graphics created by R with Hansen program.

Appendix 4.10 Recursive Coefficient Estimation Wheat

Recursive estimates of the coefficient are surrounded by the approximately 95 per cent confidence interval formed by two lines, indicating plus-minus two standard deviations around the recursive estimates. If the estimate lies outside the band of the previous time period this is interpreted as a sign of parameter instability. The second graphic shows one-step recursive residuals, framed by the 95 per cent confidence interval. Points outside the interval are either outliers or parameter changes.

Figure 4.10.1: April 1995 – December 2013, Fcont Unrestricted Forward ECM (Y=S)

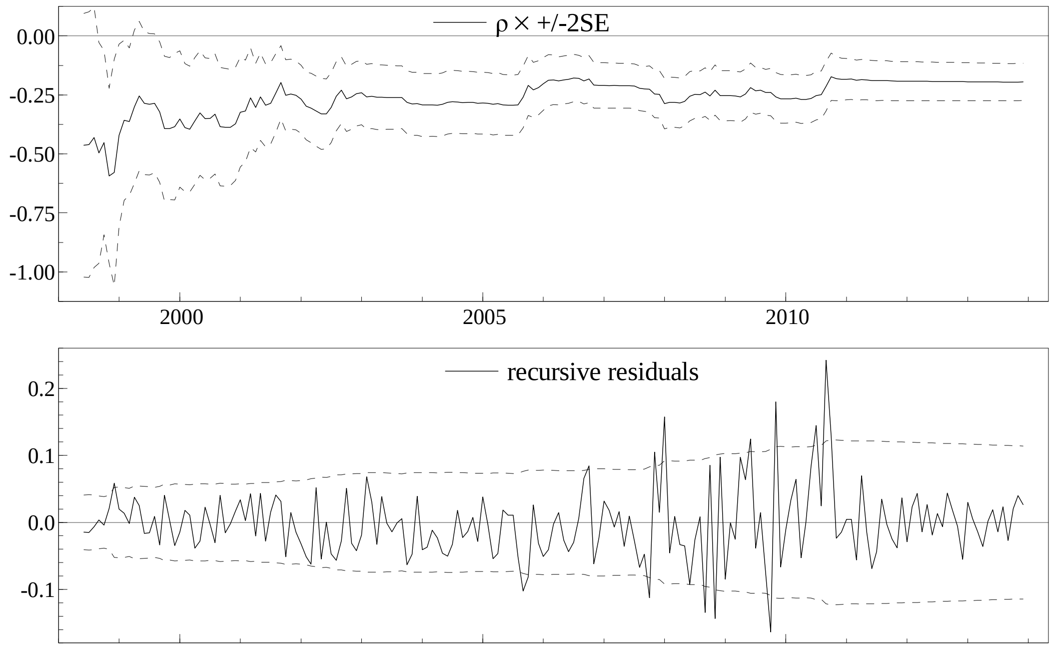
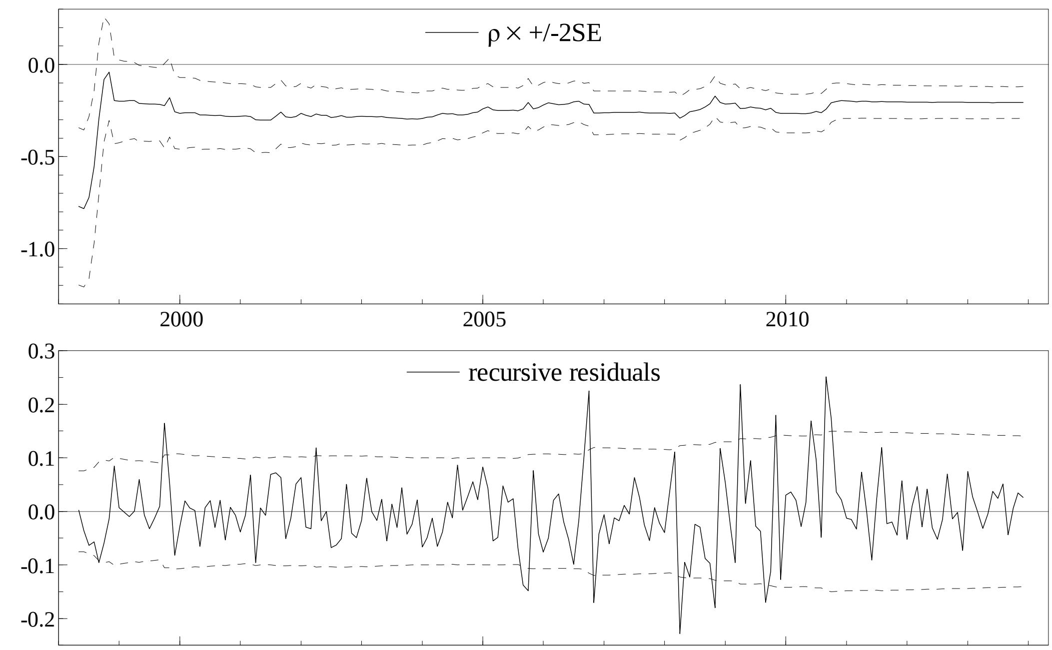


Figure 4.10.2: April 1995 – December 2013, Fcont Restricted Forward ECM (Y=S)



Note: Recurisve Estimation created by PcGive.

Figure 4.10.3: April 1995 – December 2013, Fcont Unrestricted Backward ECM (Y=F)

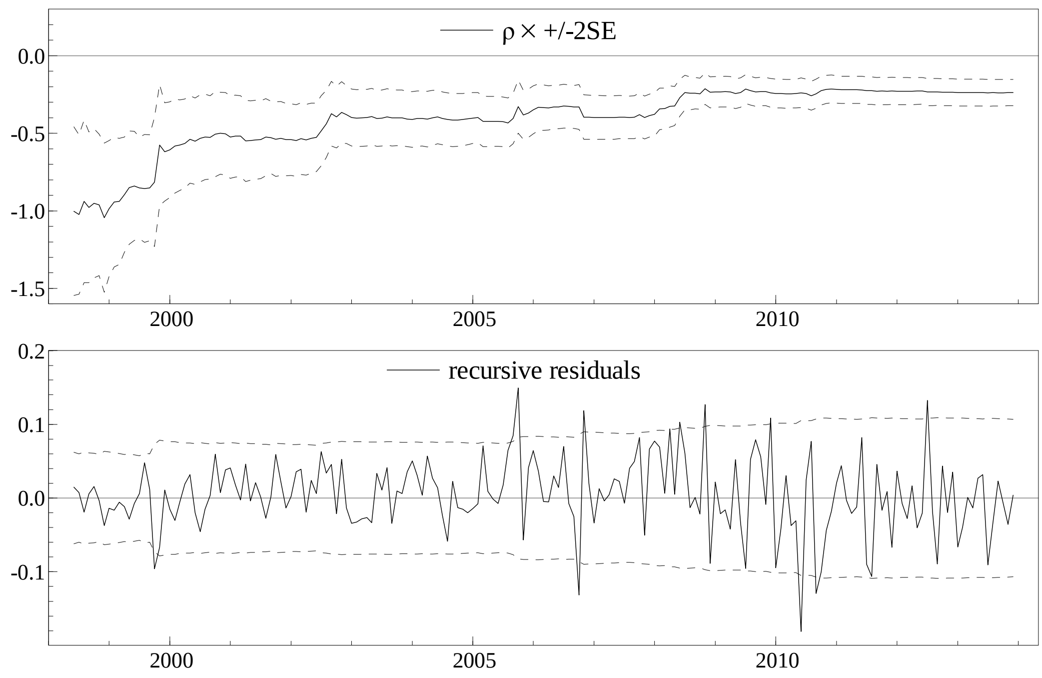
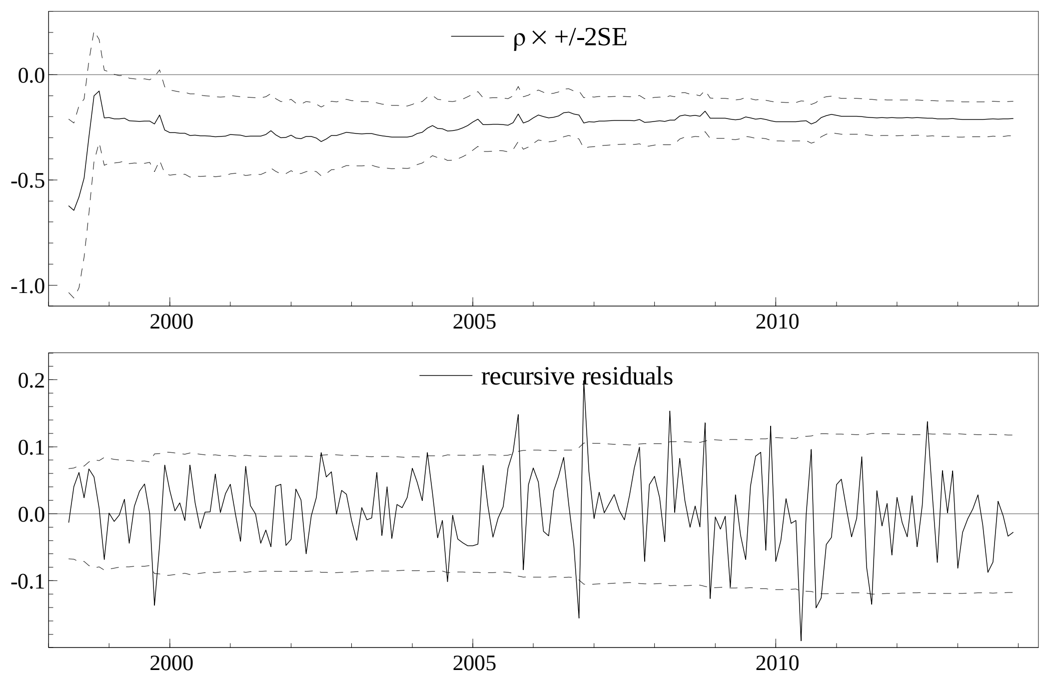


Figure 4.10.4: April 1995 – December 2013, Fcont Restricted Backward ECM (Y=F)



Note: Recurisve Estimation created by PcGive.

Figure 4.10.5: April 1995 – December 2013, Fwa Unrestricted Forward ECM (Y=S)

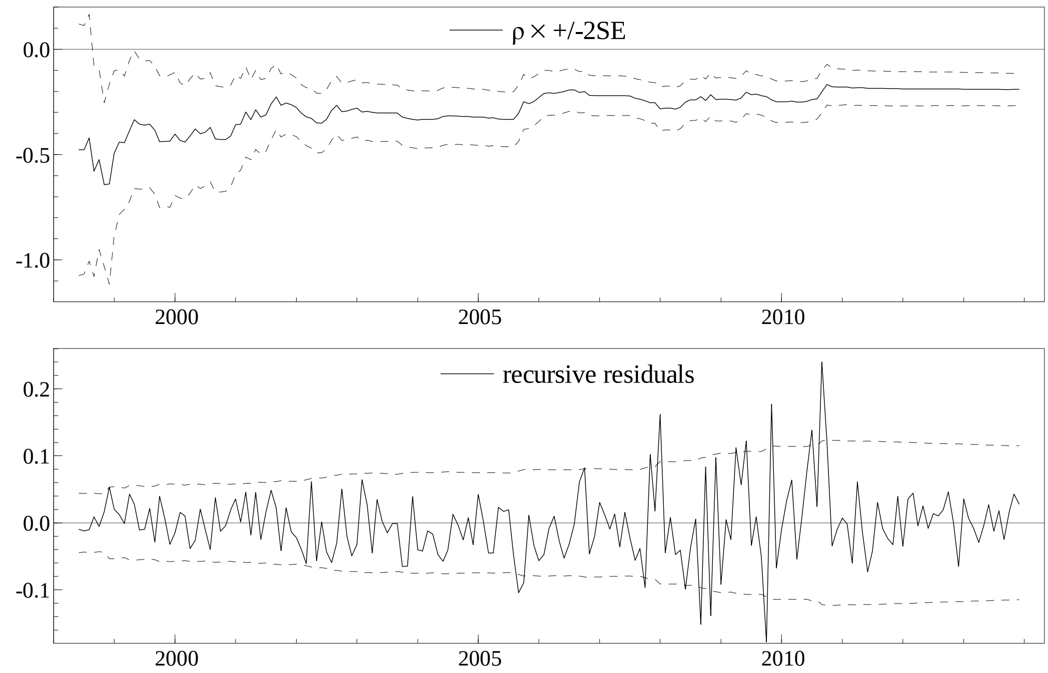
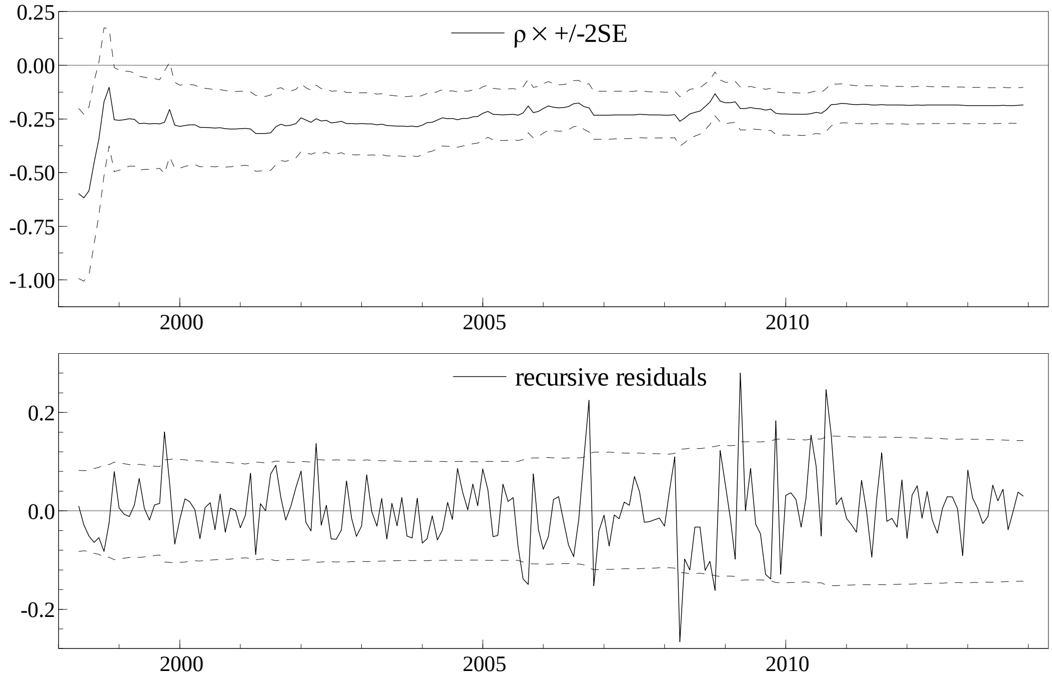


Figure 4.10.6: April 1995 – December 2013, Fwa Restricted Forward ECM (Y=S)



Note: Recurisve Estimation created by PcGive.

Figure 4.10.7: April 1995 – December 2013, Fwa Unrestricted Backward ECM (Y=F)

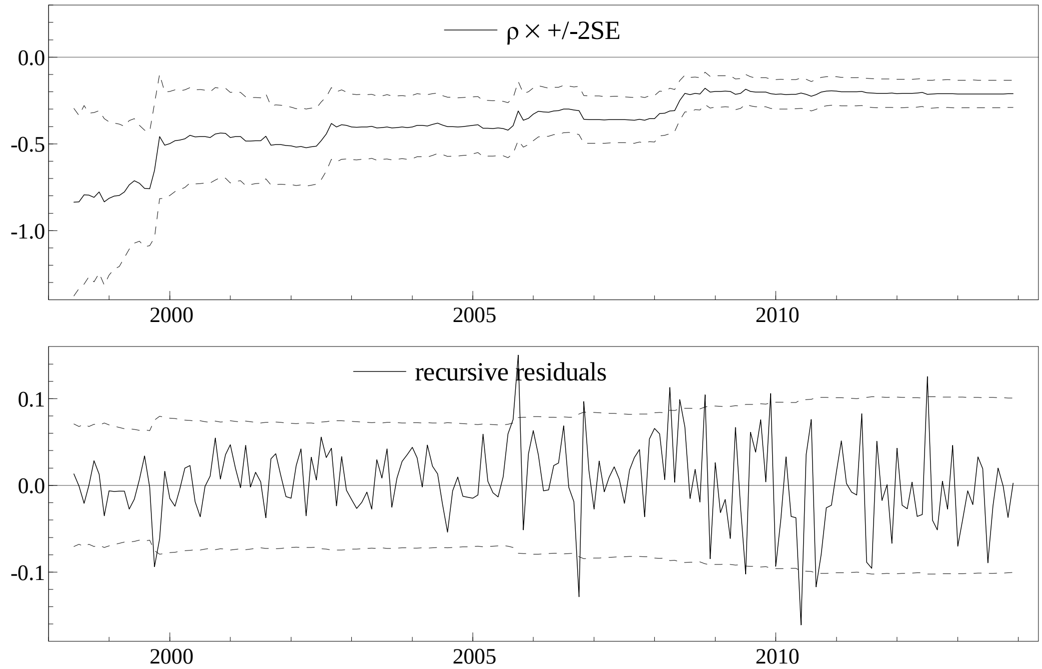
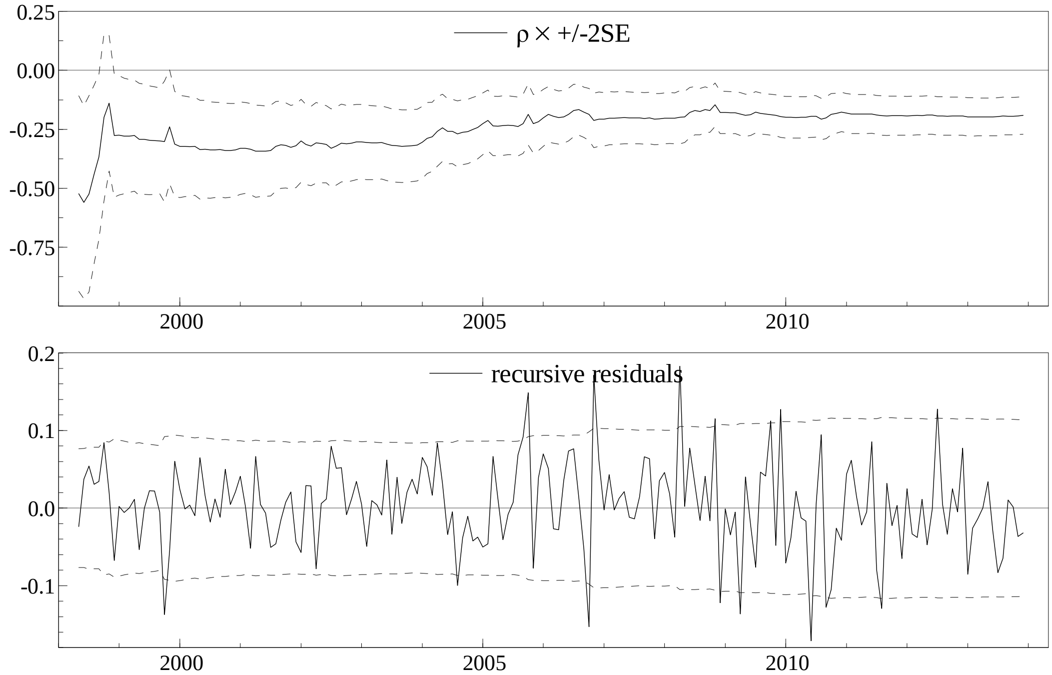


Figure 4.10.8: April 1995 – December 2013, Fwa Restricted Nackward ECM (Y=F)



Note: Recurisve Estimation created by PcGive.

Figure 4.10.9: January 2006 – December 2013, Fcont Unrestricted Forward ECM (Y=S)

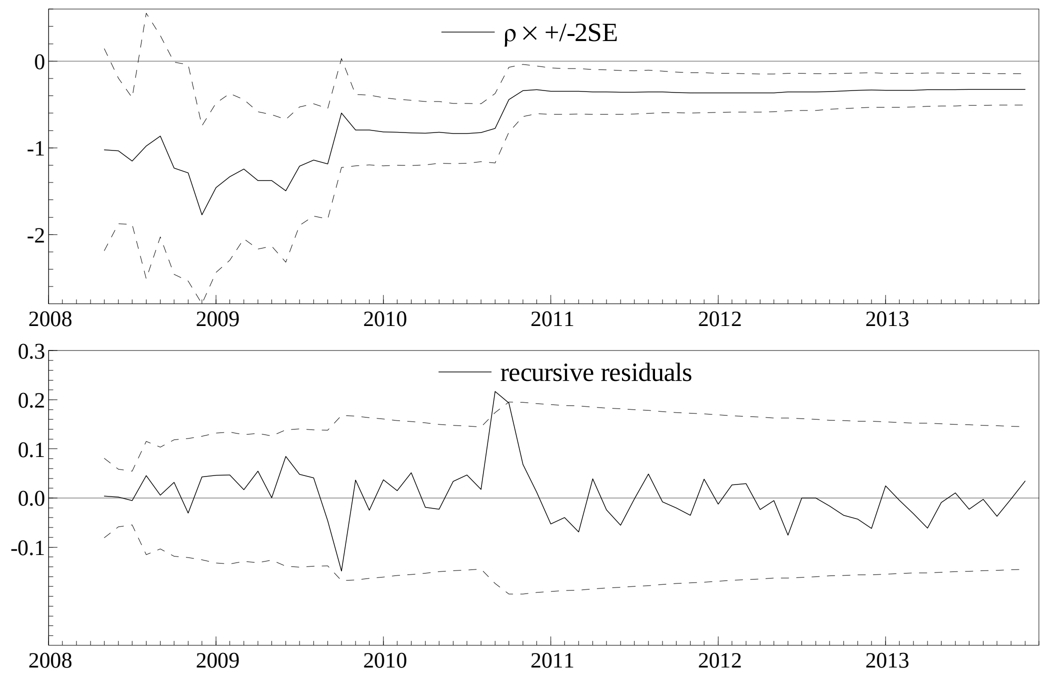
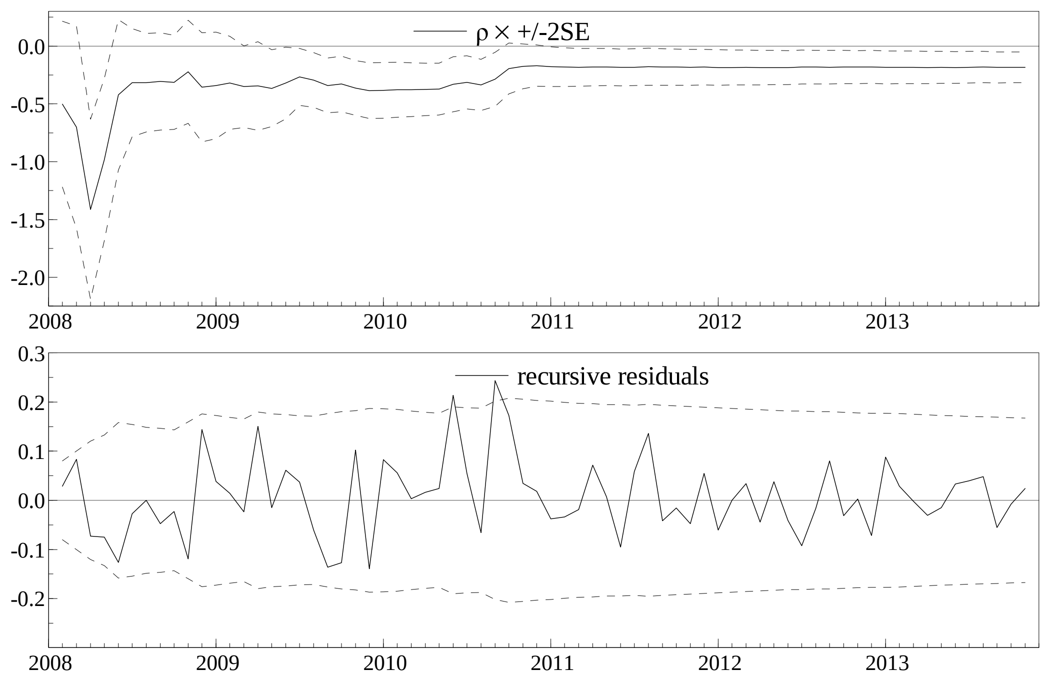


Figure 4.10.10: January 2006 – December 2013, Fcont Restricted Forward ECM (Y=S)



Note: Recurisve Estimation created by PcGive.

Figure 4.10.11: January 2006 – December 2013, Fcont Unrestricted Backward ECM (Y=F)

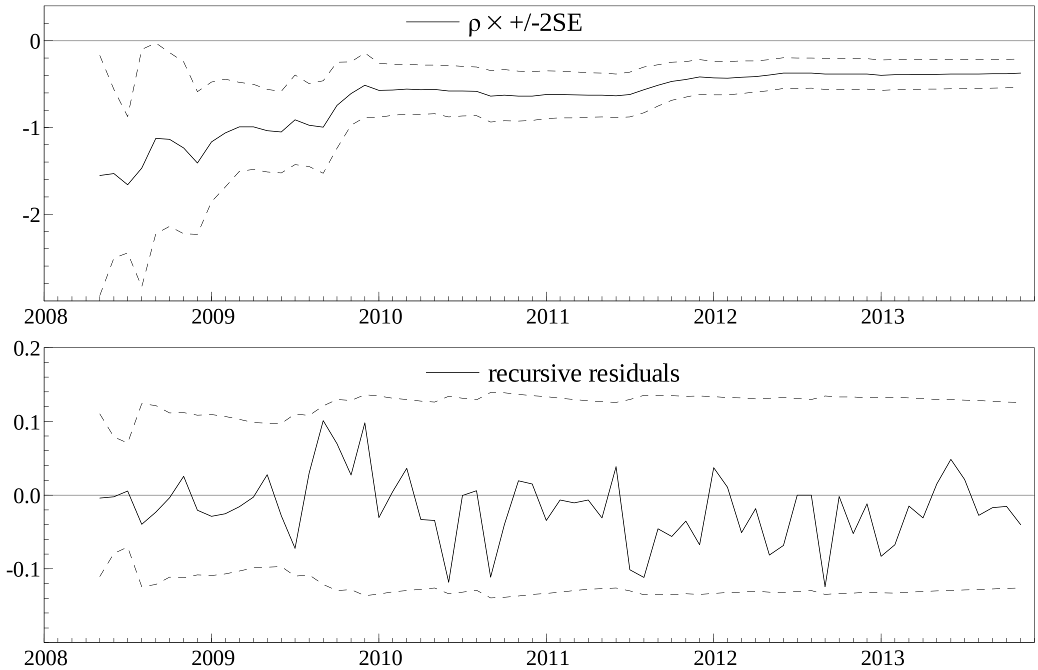
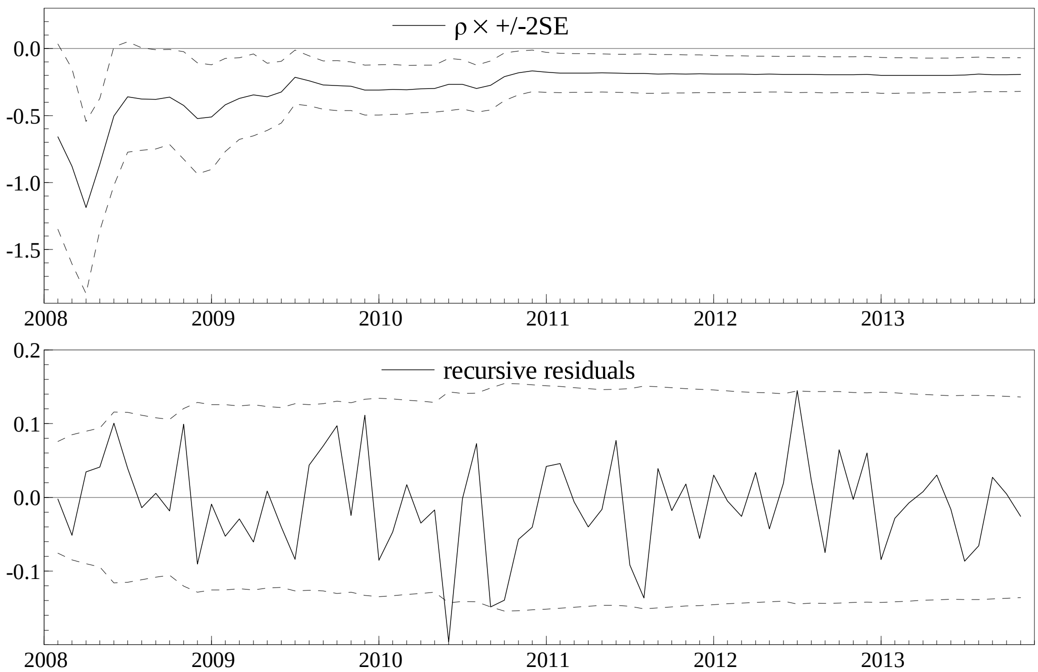


Figure 4.10.12: January 2006 – December 2013, Fcont Restricted Backward ECM (Y=F)



Note: Recurisve Estimation created by PcGive.

Figure 4.10.13: January 2006 – December 2013, Fwa Unrestricted Backward ECM (Y=F)

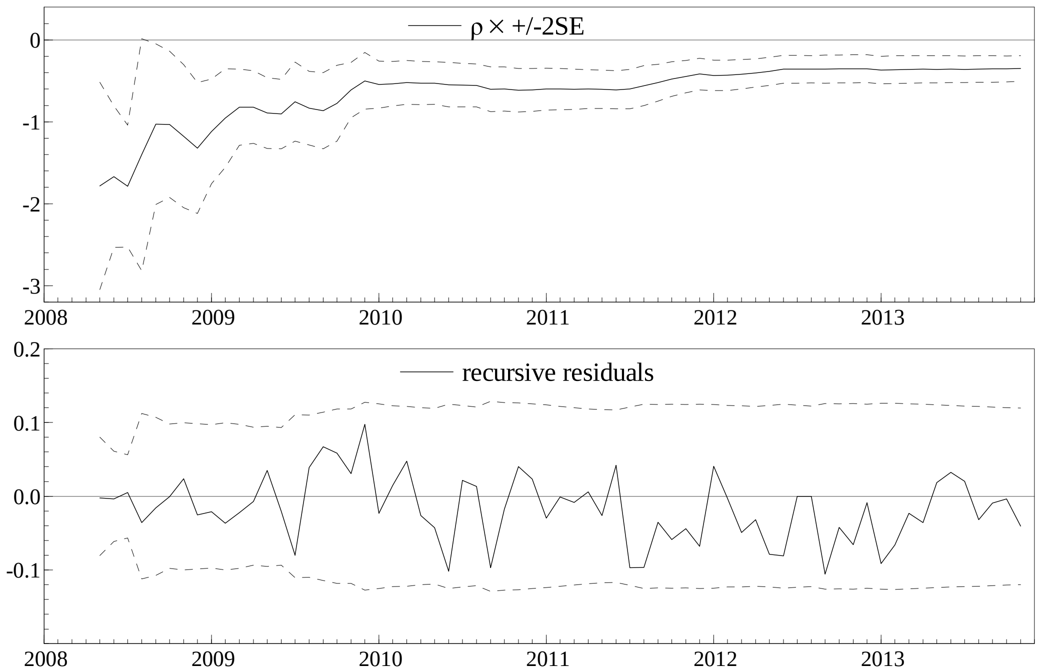
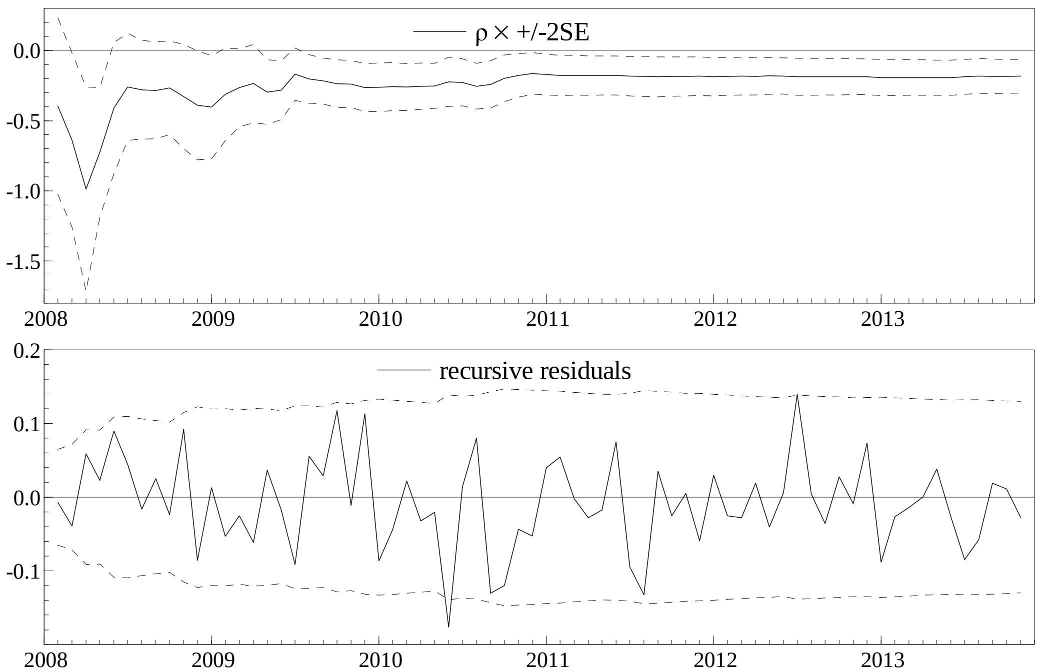


Figure 4.10.14: January 2006 – December 2013, Fwa Restricted Backward ECM (Y=F)



Note: Recurisve Estimation created by PcGive.

Figure 4.10.15: January 2006 – December 2013, Fwa Unrestricted Forward ECM (Y=S)

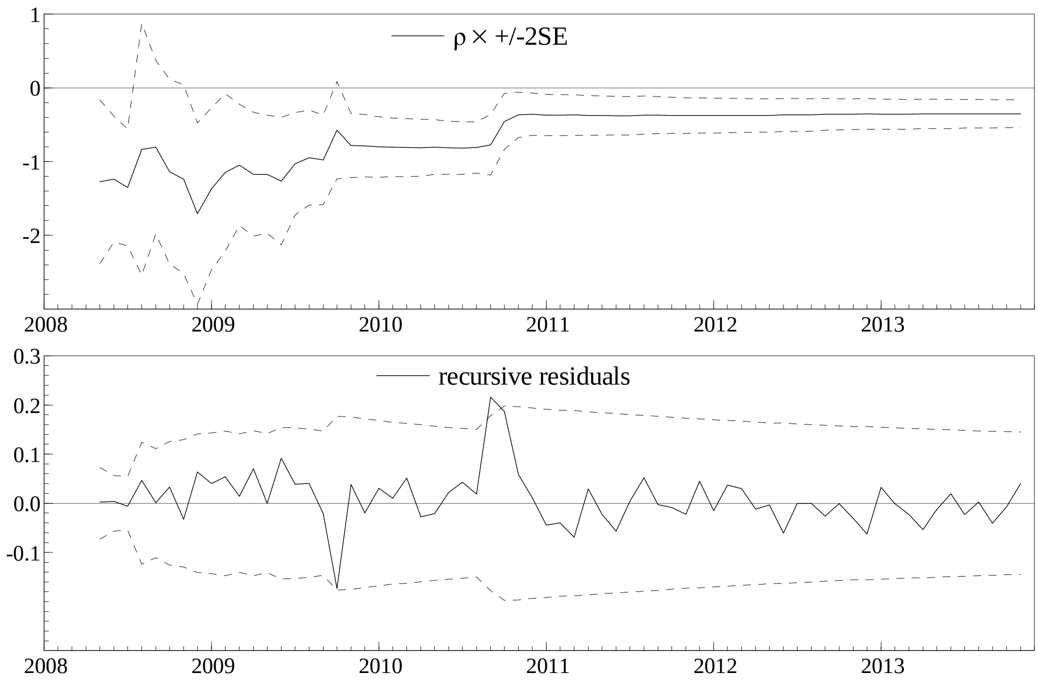
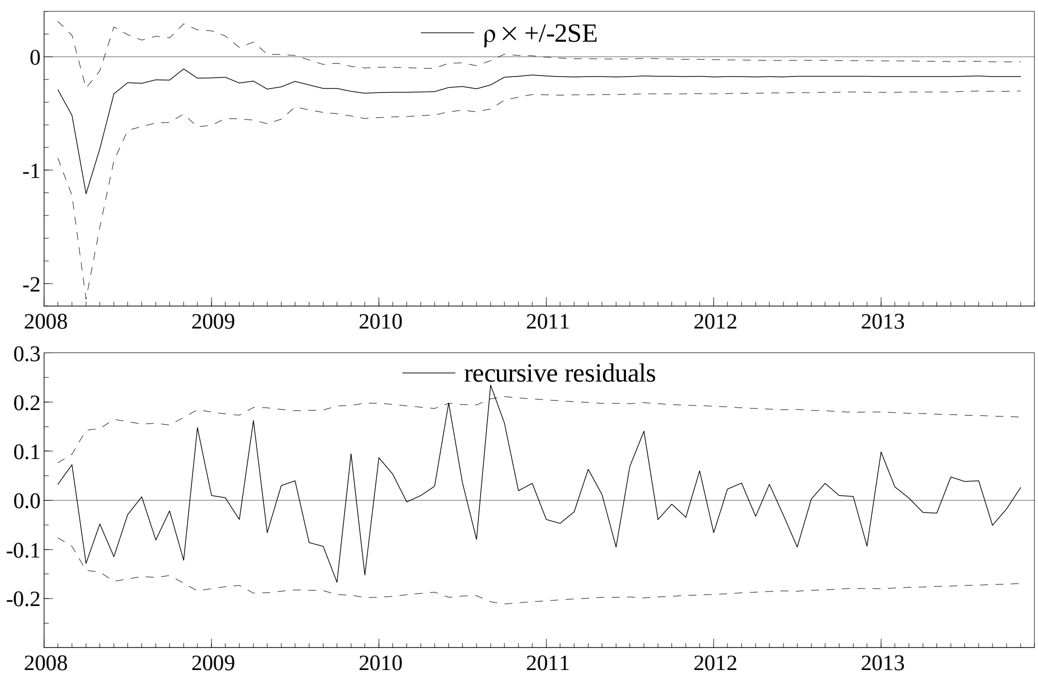


Figure 4.10.16: January 2006 – December 2013, Fwa Restricted Forward ECM (Y=S)



Note: Recurisve Estimation created by PcGive.

Appendix 4.11 Recursive Coefficient Estimation Cocoa

Recursive estimates of the coefficient are surrounded by the approximately 95 per cent confidence interval formed by two lines, indicating plus-minus two standard deviations around the recursive estimates. If the estimate lies outside the band of the previous time period this is interpreted as a sign of parameter instability. The second graphic shows one-step recursive residuals, framed by the 95 per cent confidence interval. Points outside the interval are either outliers or parameter changes.

Figure 4.11.1: April 1995 – December 2013, Fcont Unrestricted Backward ECM (Y=F)

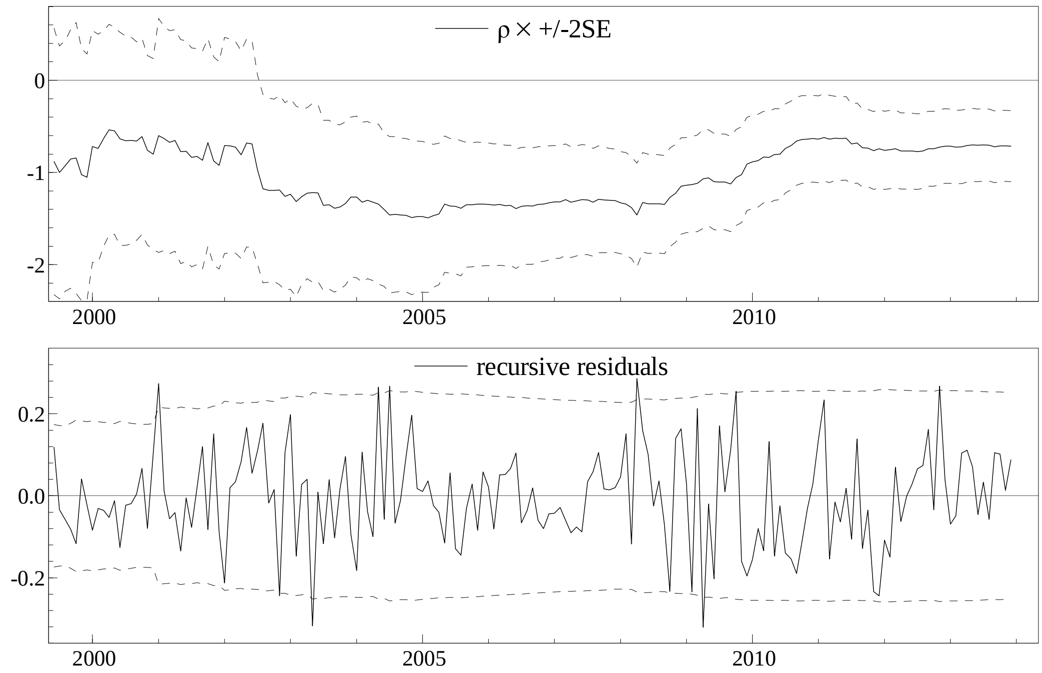
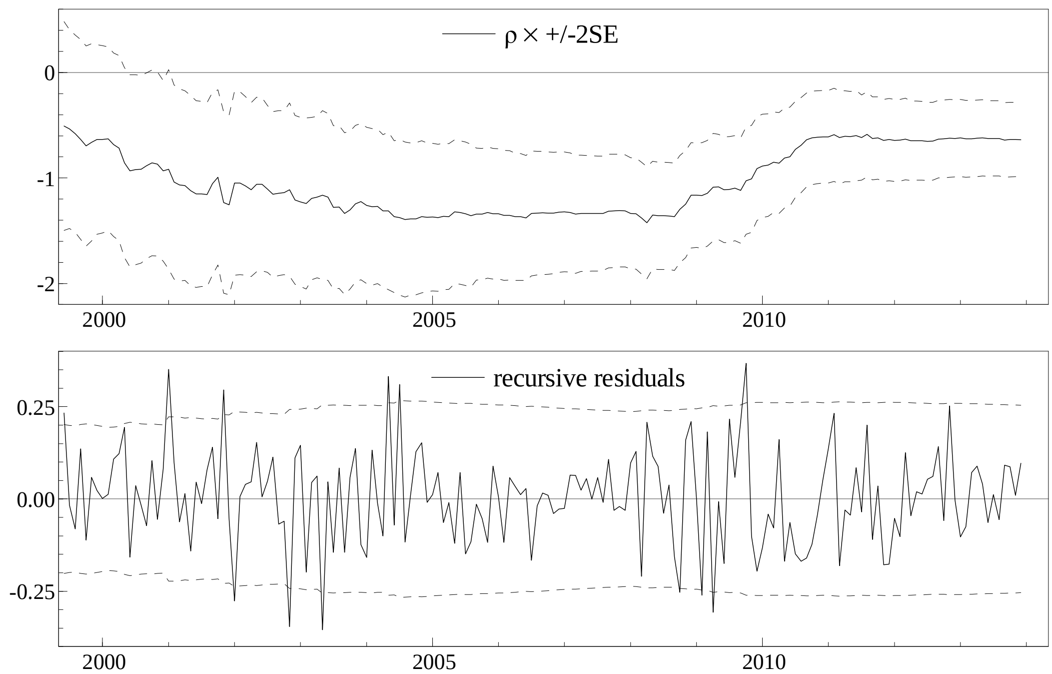


Figure 4.11.2: April 1995 – December 2013, Fcont Restricted Backward ECM (Y=F)



Note: Recurisve Estimation created by PcGive.

Figure 4.11.3: April 1995 – December 2013, Fcont Unrestricted Forward ECM (Y=S)

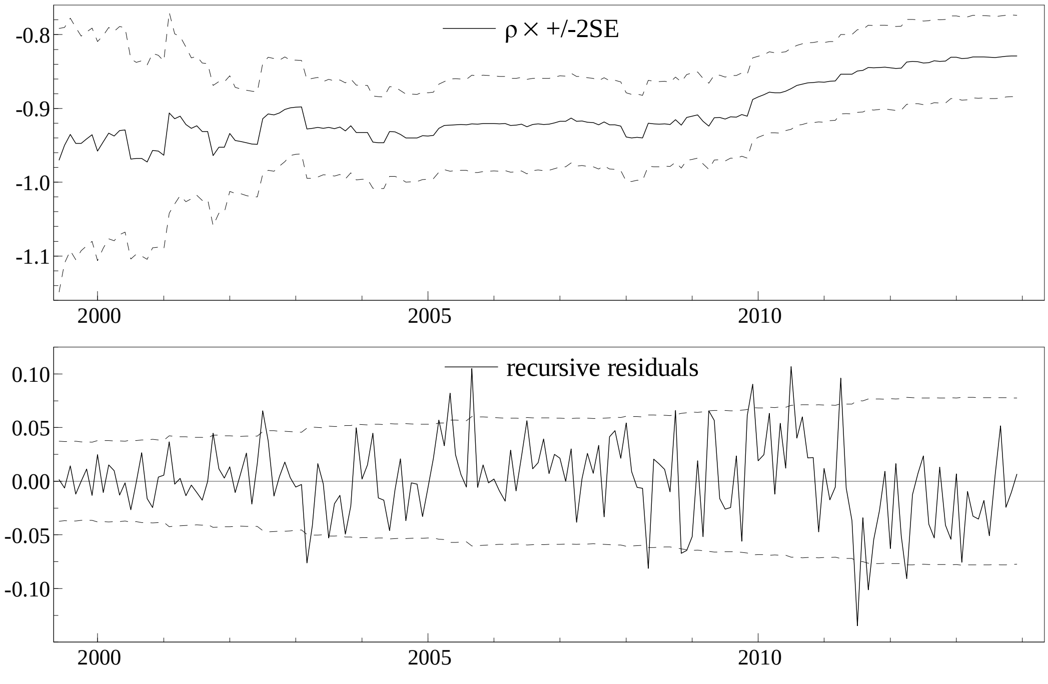
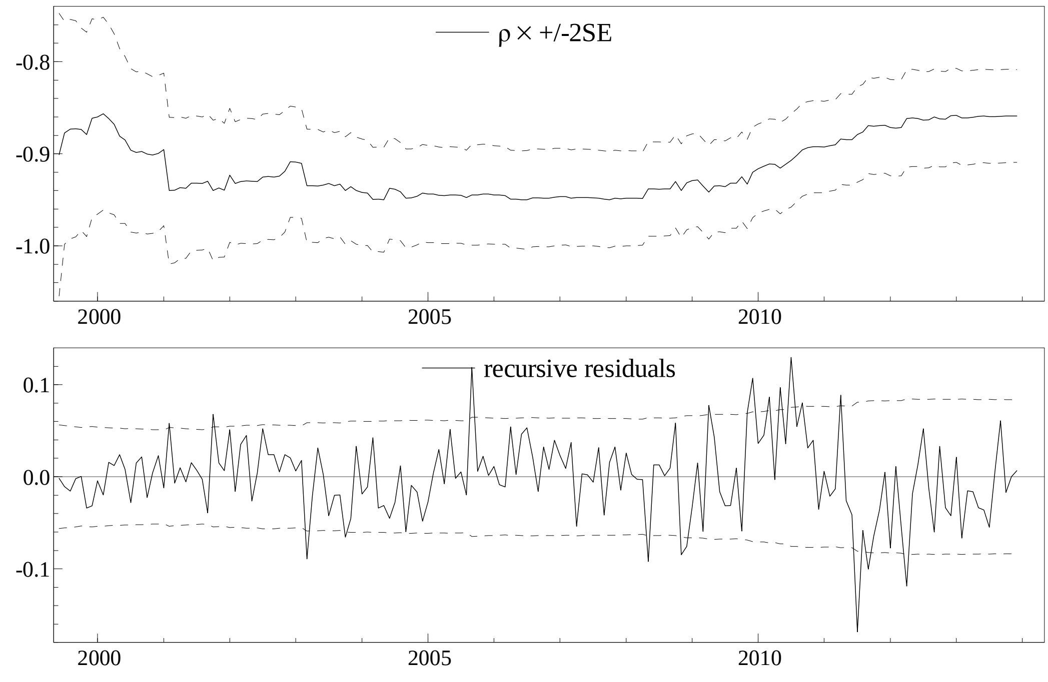


Figure 4.11.4: April 1995 – December 2013, Fcont Restricted Forward ECM (Y=S)



Note: Recurisve Estimation created by PcGive.

Figure 4.11.5: April 1995 – December 2013, Fwa Unrestricted Backward ECM (Y=F)

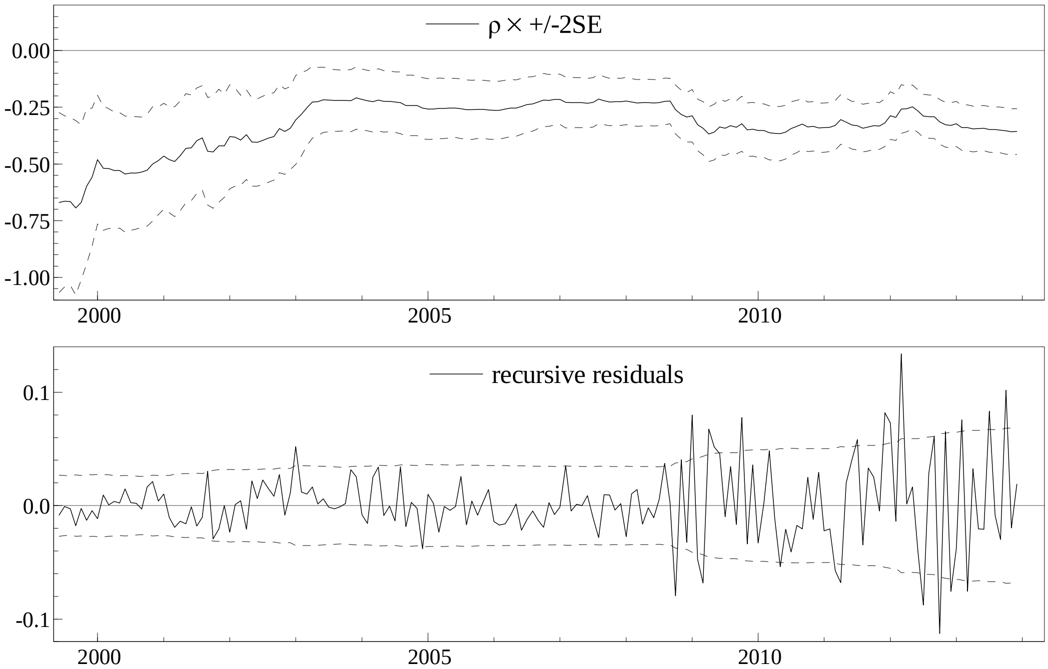
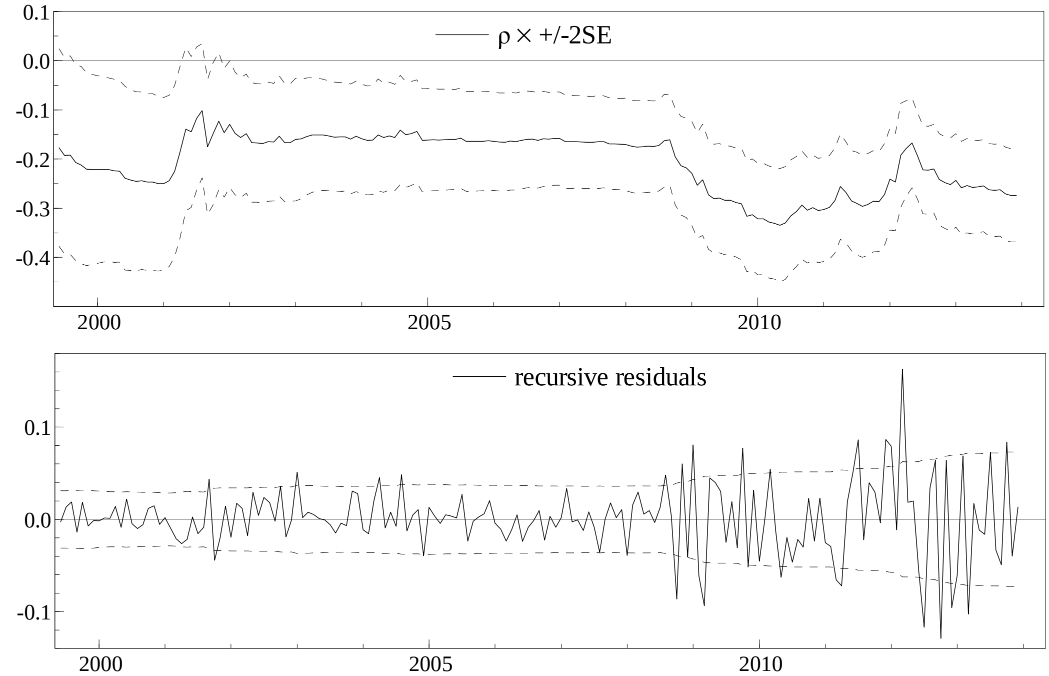


Figure 4.11.6: April 1995 – December 2013, Fwa Restricted Backward ECM (Y=F)



Note: Recurisve Estimation created by PcGive.

Figure 4.11.7: April 1995 – December 2013, Fwa Unrestricted Forward ECM (Y=S)

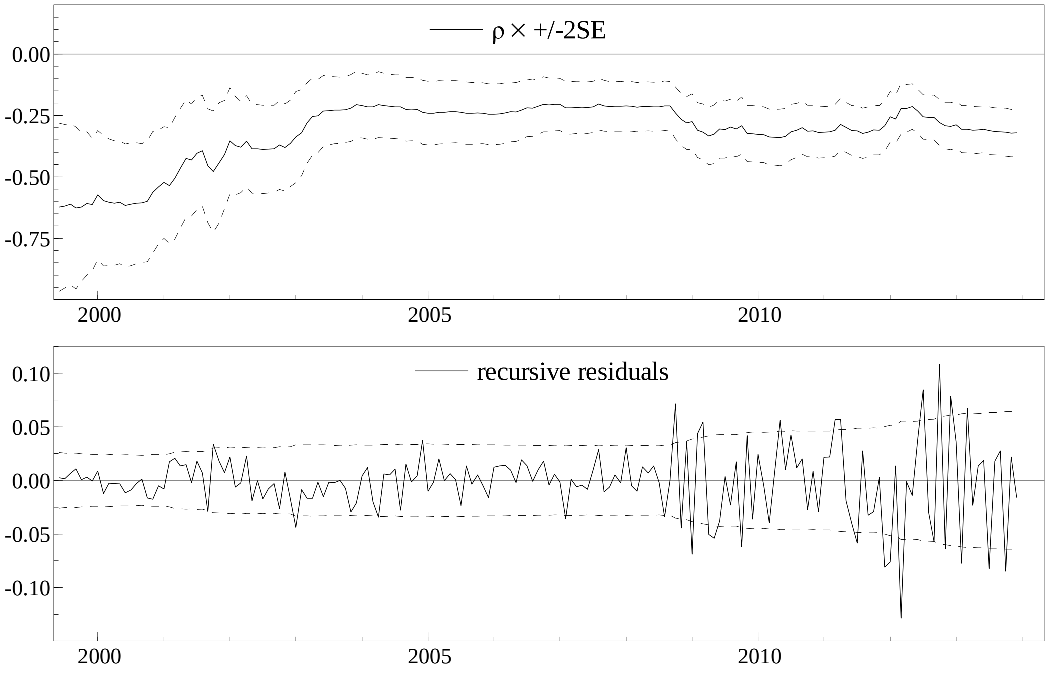
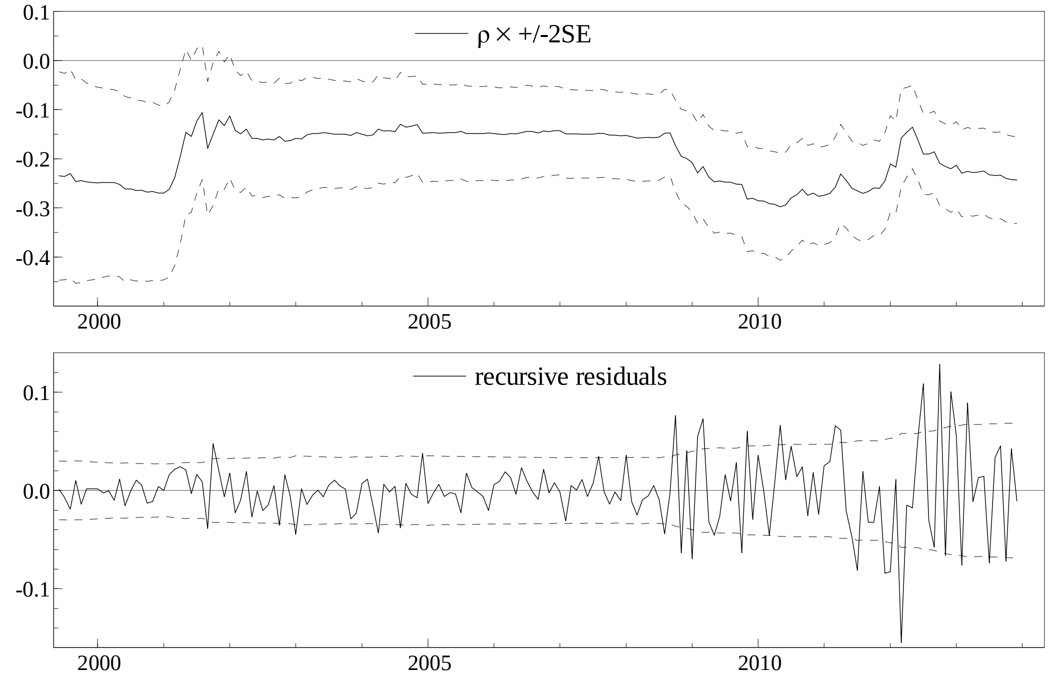


Figure 4.11.8: April 1995 – December 2013, Fwa Restricted Forward ECM (Y=S)



Note: Recurisve Estimation created by PcGive.

Figure 4.11.9: January 2006 – December 2013, Fcont Unrestricted Forward ECM (Y=S)

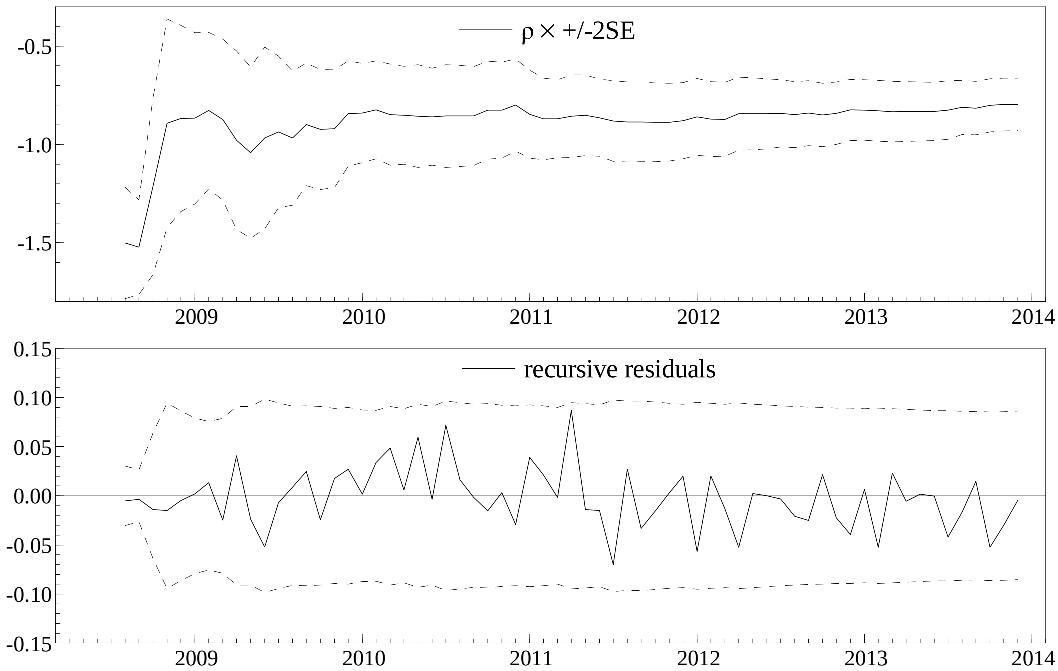
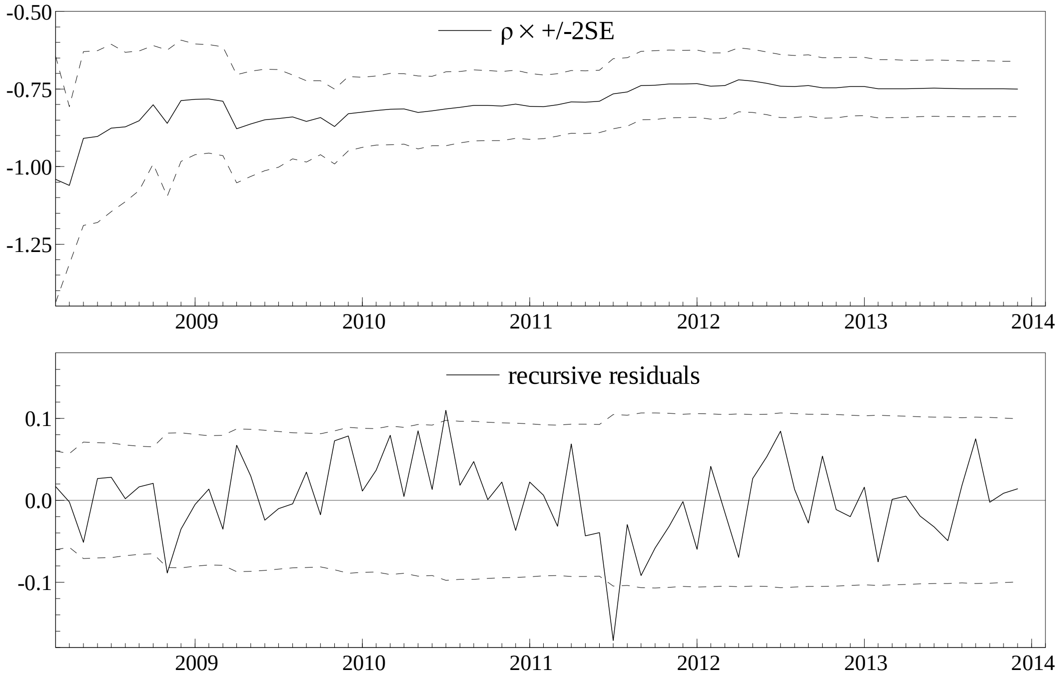


Figure 4.11.10: January 2006 – December 2013, Fcont Restricted Forward ECM (Y=S)



Note: Recurisve Estimation created by PcGive.

Figure 4.11.11: January 2006 – December 2013, Fcont Unrestricted Backward ECM (Y=F)

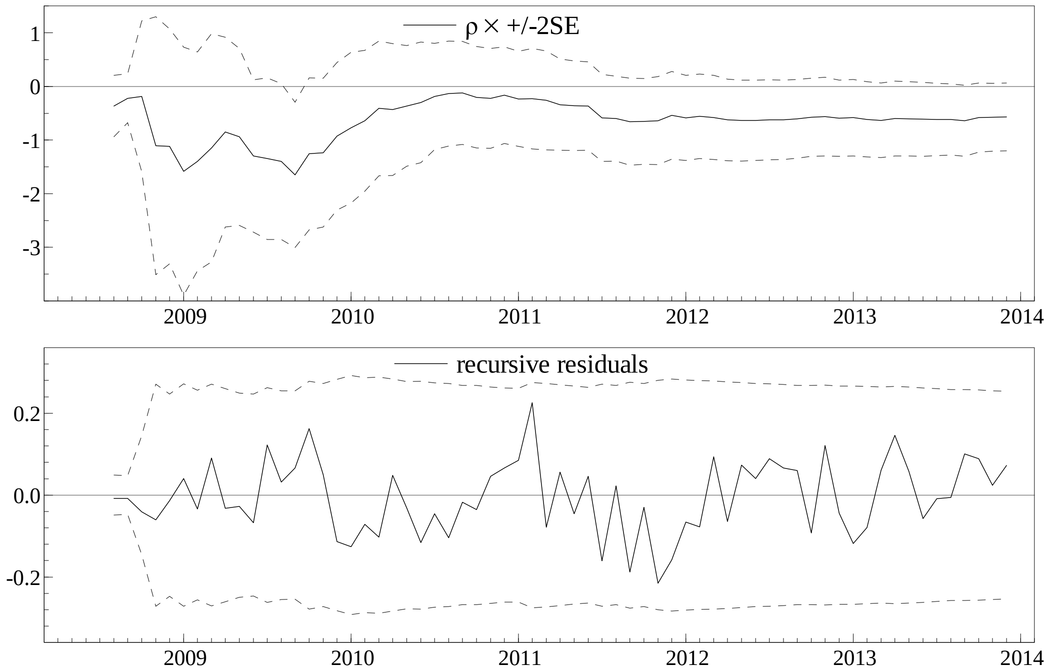
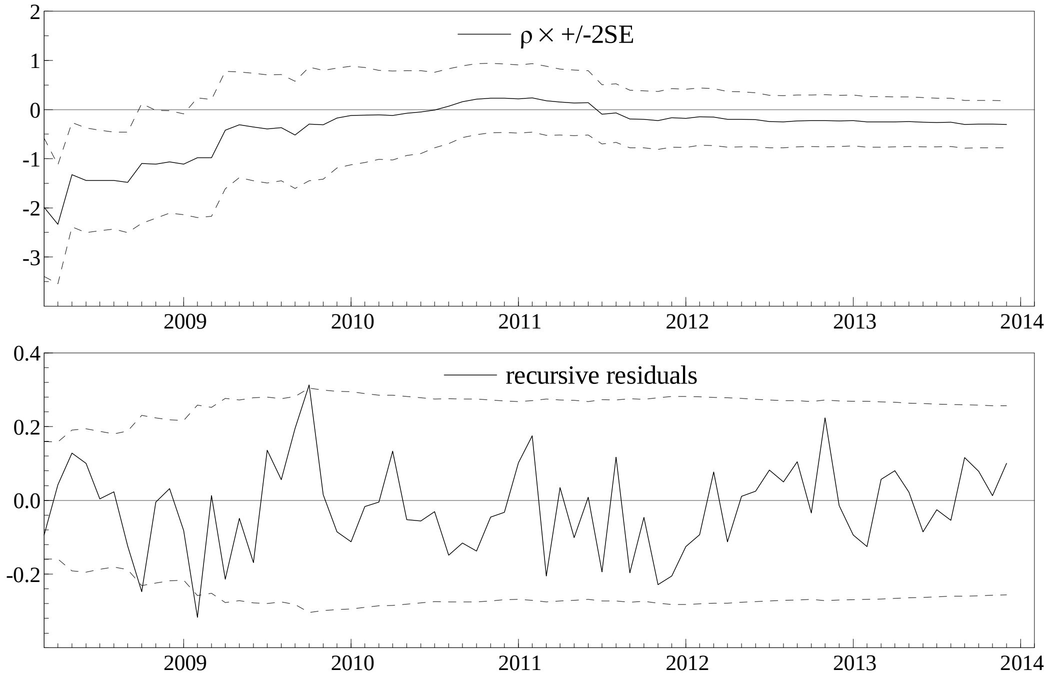


Figure 4.11.12: January 2006 – December 2013, Fcont Restricted Backward ECM (Y=F)



Note: Recurisve Estimation created by PcGive.

Figure 4.11.13: January 2006 – December 2013, Fwa Unrestricted Backward ECM (Y=F)

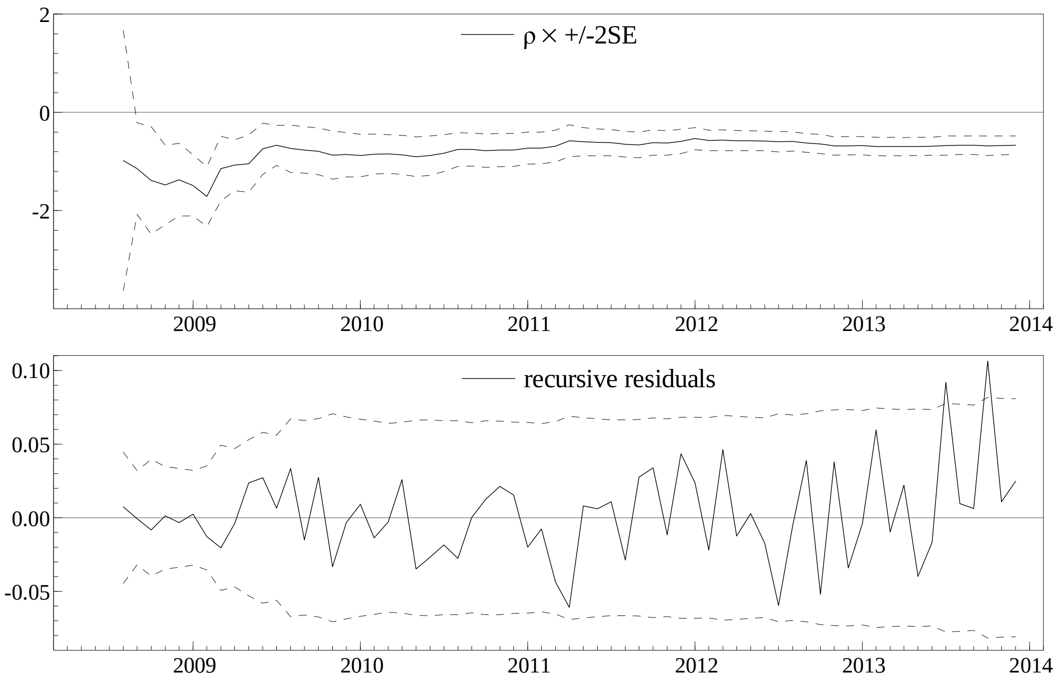
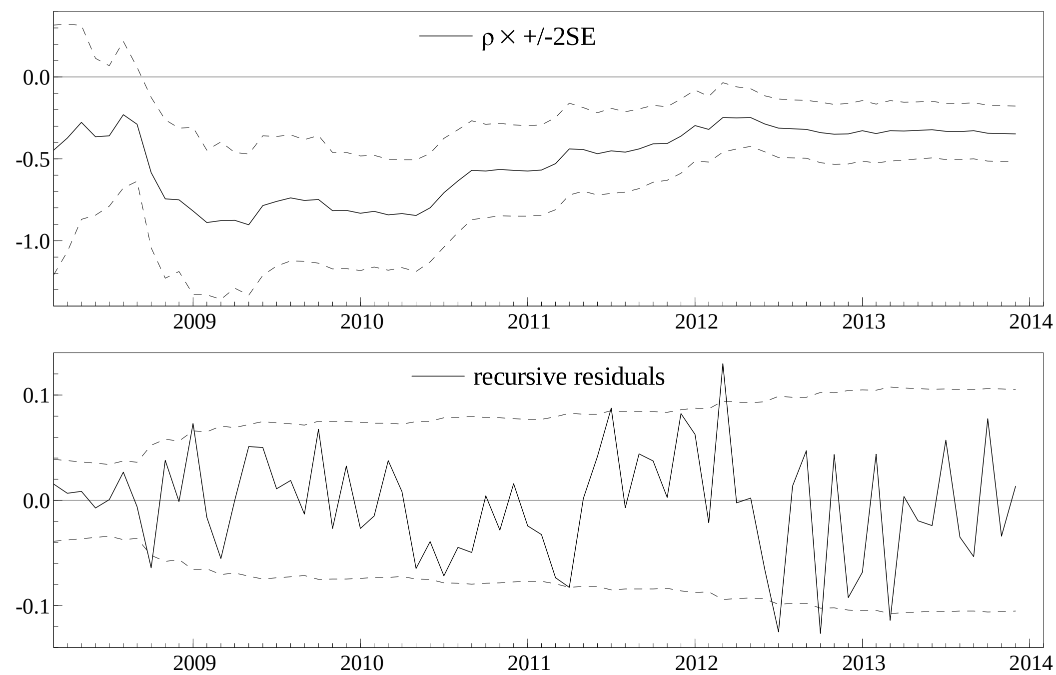


Figure 4.11.14: January 2006 – December 2013, Fwa Restricted Backward ECM (Y=F)



Note: Recurisve Estimation created by PcGive.

Figure 4.11.15: January 2006 – December 2013, Fwa Unrestricted Forward ECM (Y=S)

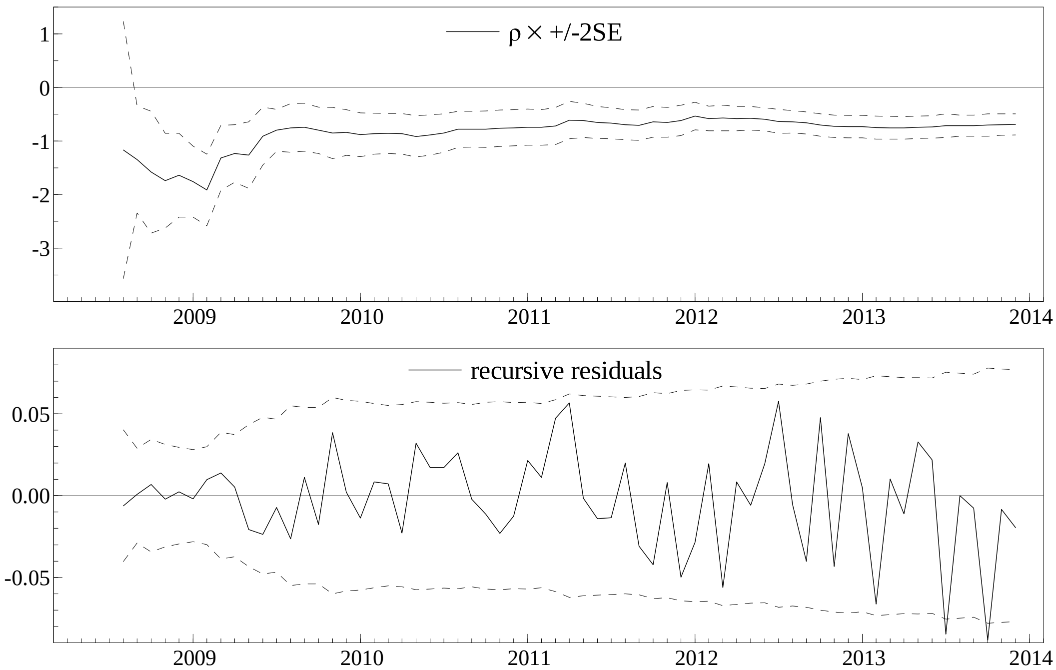
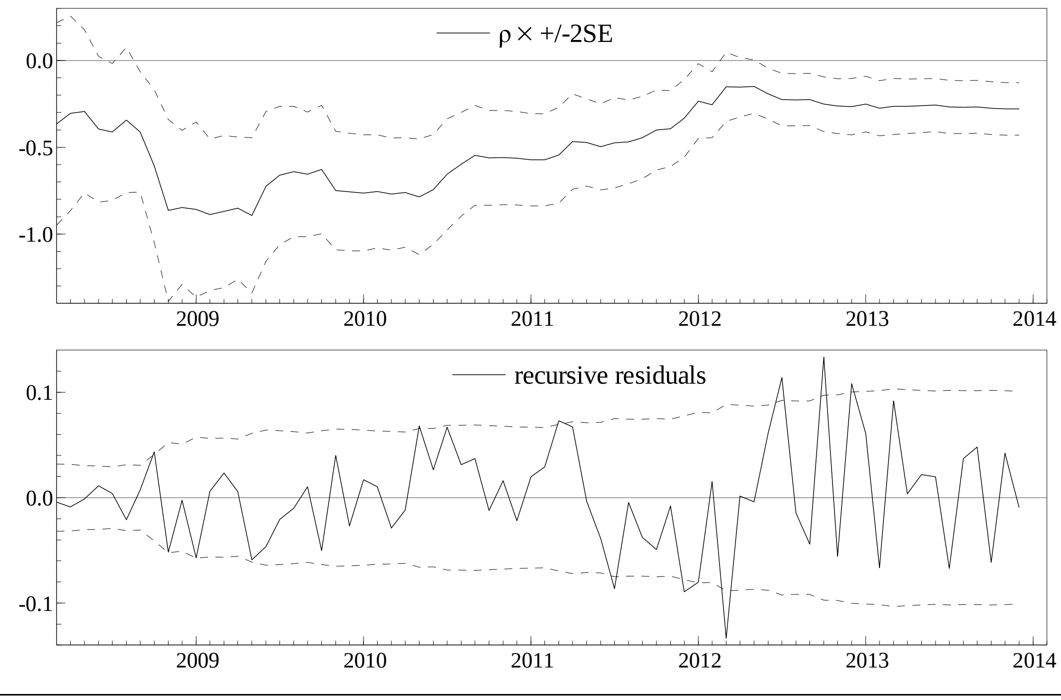


Figure 4.11.16: January 2006 – December 2013, Fwa Restricted Forward ECM (Y=S)

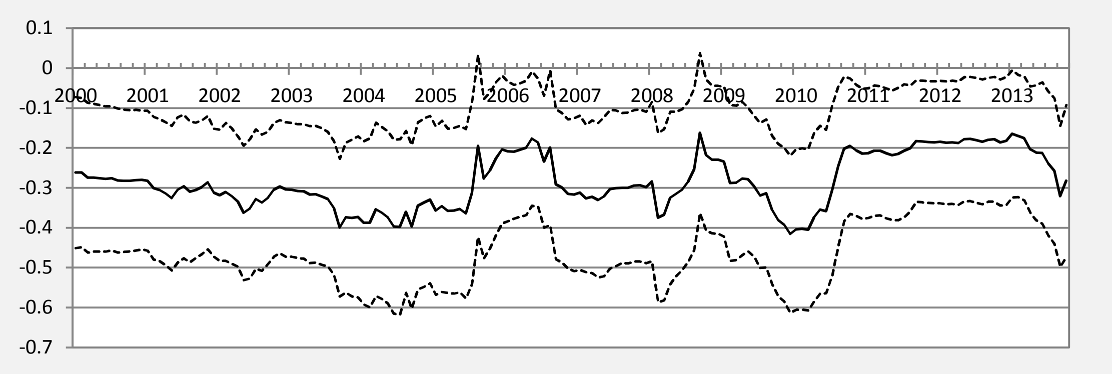


Note: Recurisve Estimation created by PcGive.

Appendix 4.12 Rolling Coefficient Estimation Cocoa and Wheat

Figure 4.12.1: Wheat Rolling Window Estimation ϱ Restricted ECM Fcont - Spot

Forward (Y=S)



Backward (Y=F)

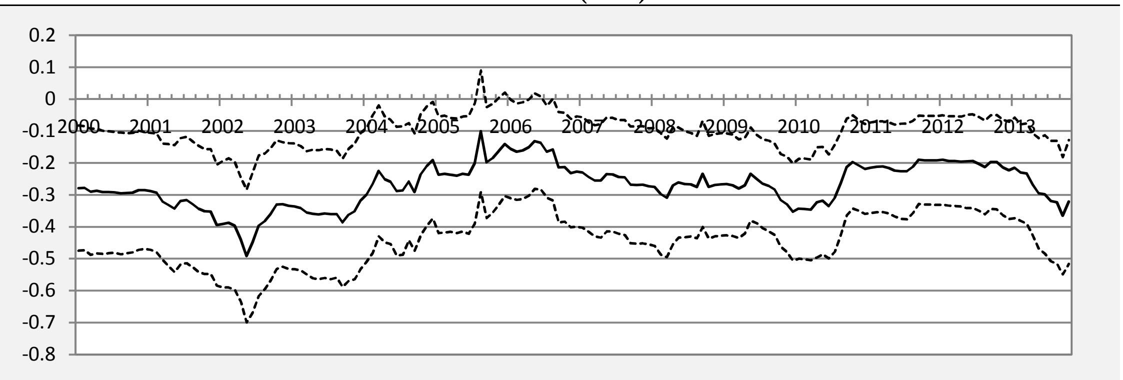
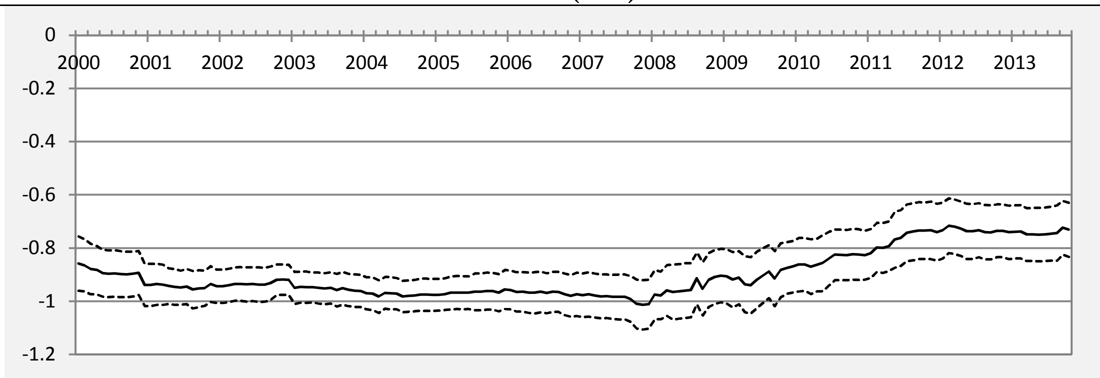
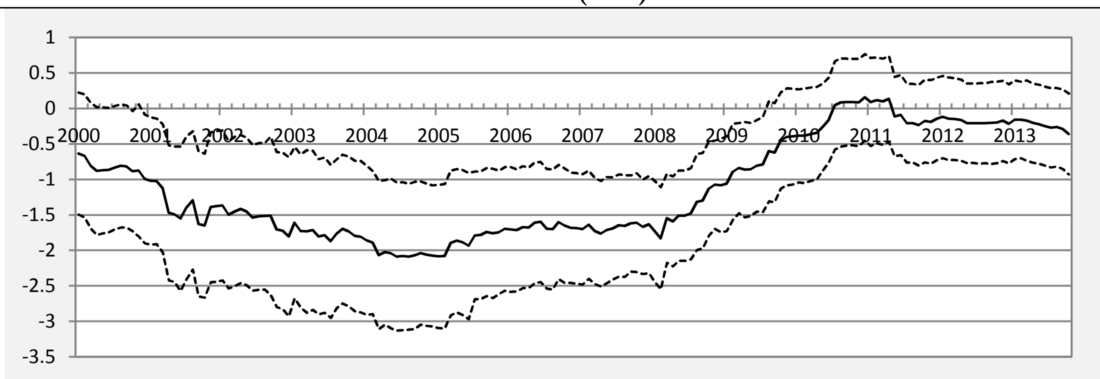


Figure 4.12.2: Cocoa Rolling Window Estimation ϱ Restricted ECM Fcont - Spot

Forward (Y=S)



Backward (Y=F)



Source: author's calculation

Appendix Chapter 5

Appendix 5.1 Unit Root Tests Annual Differences

ADF tests (T=83, Constant; 5%=-2.90 1%=-3.51) – lag length decided by AIC information criteria with a maximum lag length of 6.

Table 5.1.1: Unit Root Tests Annual Differences Cocoa

	Variable	D-lag	t-adf	D1_lag	D1_t-adf	D2_lag	D2_t-adf	Integration
Calendar Spreads	2-1	0	-6.715**	-	-	-	-	I(0)
	3-2	2	-3.736**	-	-	-	-	I(0)
	4-3	0	-5.204**	-	-	-	-	I(0)
	5-4	2	-3.307*	-	-	-	-	I(0)
	6-5	0	-3.669**	-	-	-	-	I(0)
	7-6	2	-4.843**	-	-	-	-	I(0)
	8-7	5	-3.059*	-	-	-	-	I(0)
Explanatory Variables	I	4	-3.109*	-	-	-	-	I(0)
	SLIBOR	1	-1.953	0	-12.76**	-	-	I(1)
	VAR^							I(1)
	COR^							I(0)
	WEIGHT^							I(1)
	D_COM	0	-2.189	0	-8.509**	-	-	I(1)
	D_INDX	2	-2.948*	-	-	-	-	I(0)
	NCOM_EX	0	-7.789**	-	-	-	-	I(0)

^ Seven variables, one for each spread, fall under this category. Since the order of integration does not vary for different spreads, the dominant order of integration is reported here.

Table 5.1.2: Unit Root Tests Annual Differences Coffee

	Variable	D-lag	t-adf	D1_lag	D1_t-adf	D2_lag	D2_t-adf	Integration
Calendar Spreads	2-1	1	-4.450**	-	-	-	-	I(0)
	3-2	0	-2.937*	-	-	-	-	I(0)
	4-3	0	-2.389	0	-10.77**	-	-	I(1)
	5-4	4	-2.429	4	-4.217**	-	-	I(1)
	6-5	1	-1.942	0	-11.13**	-	-	I(1)
	7-6	0	-2.099	0	-10.11**	-	-	I(1)
	8-7	0	-2.394	0	-10.94**	-	-	I(1)
	9-8	6	-3.330*	-	-	-	-	I(0)
Explanatory Variables	I	2	-1.938	0	-4.102**	-	-	I(1)
	SLIBOR	0	-2.064	3	-4.178**	-	-	I(1)
	VAR^							I(1)
	COR^							I(0)
	WEIGHT^							I(1)
	D_COM	0	-2.964*	-	-	-	-	I(0)
	D_INDX	1	-1.536	0	-12.38**	-	-	I(1)
	NCOM_EX	4	-1.700	2	-5.499**	-	-	I(1)

^ Seven variables, one for each spread, fall under this category. Since the order of integration does not vary for different spreads, the dominant order of integration is reported here.

Appendix 5.2 Calendar Spread Regression Results Annual Differences Cocoa

Table 5.2.1: SPREAD_21 - Annual differences, constant, AR(5)					
	Coefficient	Std.Error	t-value	t-prob	Part.R^2
I	***2.093	0.769	2.72	0.0082	0.0932
DI	2.934	1.870	1.57	0.1210	0.0331
DI_1	0.190	1.746	0.11	0.9135	0.0002
SLIBOR	*-0.005	0.003	-1.82	0.0726	0.0441
VAR_21	*-196.5	99.92	-1.97	0.0530	0.0510
COR_21	4.885	6.068	0.81	0.4234	0.0089
WEIGHT_21	69.20	165.7	0.42	0.6775	0.0024
D_COM	-0.034	0.023	-1.47	0.1461	0.0291
D_INDX	**0.150	0.059	2.54	0.0134	0.0820
NCOM_EX	-1.084	1.243	-0.87	0.3861	0.0104
AR 1-6 test:	1.4711 [0.2110]				
ARCH 1-6 test:	0.8971 [0.4877]		Joint F-test:	3.431 [0.001]**	
Normality test:	16.339 [0.0003]**		R^2 :	0.343907	
Hetero test:	0.6371 [0.8792]				
RESET23 test:	0.2816 [0.7554]				
Notes: Inventory data in 10.000 tonnes, trader-position data in 100 contracts.					

Table 5.2.2: SPREAD_32 - Annual differences, constant, AR(5)					
	Coefficient	Std.Error	t-value	t-prob	Part.R^2
I	***1.920	0.402	4.78	0.0000	0.2461
DI	-0.917	0.820	-1.12	0.2674	0.0175
DI_1	-1.107	0.718	-1.54	0.1277	0.0328
SLIBOR	***-0.006	0.001	-5.05	0.0000	0.2674
VAR_32	***-291.3	81.06	-3.59	0.0006	0.1558
COR_32	-4.453	9.950	-0.45	0.6559	0.0029
WEIGHT_23	**-41.66	19.14	-2.18	0.0329	0.0634
D_COM	-0.008	0.010	-0.79	0.4324	0.0088
D_INDX	***0.074	0.022	3.42	0.0011	0.1430
NCOM_EX	-0.087	0.494	-0.18	0.8603	0.0004
AR 1-6 test:	1.0571 [0.3923]				
ARCH 1-6 test:	0.4604 [0.8044]		Joint F-test:	7.319 [0.000]**	
Normality test:	25.646 [0.0000]**		R^2 :	0.576151	
Hetero test:	0.6929 [0.8463]				
RESET23 test:	3.1238 [0.0504]				
Notes: Inventory data in 10.000 tonnes, trader-position data in 100 contracts.					

Table 5.2.3: SPREAD_43 - Annual differences, constant, AR(3)

	Coefficient	Std.Error	t-value	t-prob	Part.R^2
I	***9.738	3.367	2.89	0.0050	0.1016
DI	7.054	7.835	0.90	0.3709	0.0108
DI_1	-7.328	7.558	-0.97	0.3354	0.0125
SLIBOR	**-0.003	0.001	-2.30	0.0240	0.0669
VAR_43	***-379.3	95.26	-3.98	0.0002	0.1764
COR_43	-4.990	5.040	-0.99	0.3253	0.0131
WEIGHT_43	-28.54	17.94	-1.59	0.1158	0.0331
D_COM	0.013	0.010	1.39	0.1688	0.0254
D_INDX	0.039	0.025	1.57	0.1199	0.0324
NCOM_EX	-0.390	0.538	-0.73	0.4709	0.0070

AR 1-6 test:	1.9131 [0.0911]		
ARCH 1-6 test:	1.0892 [0.3769]	Joint F-test:	4.341 [0.000]**
Normality test:	41.819 [0.0000]**	R^2 :	0.392189
Hetero test:	0.8696 [0.6313]		
RESET23 test:	0.1220 [0.8854]		

Notes: Inventory data in 10.000 tonnes, trader-position data in 100 contracts.

Table 5.2.4: SPREAD_54 - Annual differences, constant, AR(3)

	Coefficient	Std.Error	t-value	t-prob	Part.R^2
I	***1.389	0.264	5.26	0.0000	0.2695
DI	-0.606	0.669	-0.91	0.3681	0.0108
DI_1	**-1.509	0.725	-2.08	0.0409	0.0545
SLIBOR	-0.002	0.001	-1.66	0.1016	0.0353
VAR_54	***-332.7	88.81	-3.75	0.0004	0.1576
COR_54	-0.003	0.349	-0.01	0.9929	0.0000
WEIGHT_54	18.64	18.34	1.02	0.3127	0.0136
D_COM	**0.020	0.008	2.38	0.0200	0.0701
D_INDX	0.001	0.021	0.04	0.9722	0.0000
NCOM_EX	-0.076	0.481	-0.16	0.8735	0.0003

AR 1-6 test:	1.8423 [0.1036]		
ARCH 1-6 test:	1.0008 [0.4313]	Joint F-test:	4.693 [0.000]**
Normality test:	47.052 [0.0000]**	R^2 :	0.407686
Hetero test:	0.6646 [0.8564]		
RESET23 test:	1.1227 [0.3310]		

Notes: Inventory data in 10.000 tonnes, trader-position data in 100 contracts.

Table 5.2.5: SPREAD_65 - Annual differences, constant, AR(3)

	Coefficient	Std.Error	t-value	t-prob	Part.R^2
I	***7.788	2.159	3.61	0.0006	0.1512
DI	-4.276	5.924	-0.72	0.4728	0.0071
DI_1	**-1.113	0.549	-2.03	0.0465	0.0532
SLIBOR	-0.001	0.001	-0.88	0.3809	0.0105
VAR_65	***-195.2	70.33	-2.78	0.0070	0.0955
COR_65	-2.191	4.681	-0.47	0.6411	0.0030
WEIGHT_65	-0.285	14.32	-0.02	0.9842	0.0000
D_COM	*0.014	0.008	1.82	0.0732	0.0433
D_INDX	-0.015	0.016	-0.90	0.3717	0.0109
NCOM_EX	-0.422	0.382	-1.10	0.2738	0.0164

AR 1-6 test:	1.7714 [0.1184]		
ARCH 1-6 test:	0.8884 [0.5079]		
Normality test:	57.102 [0.0000]**	Joint F-test:	10.34 [0.000]**
Hetero test:	0.9348 [0.5581]	R^2 :	0.62964
RESET23 test:	1.7319 [0.1843]		

Notes: Inventory data in 10.000 tonnes, trader-position data in 100 contracts.

Table 5.2.6: SPREAD_76 - Annual differences, constant, AR(1)

	Coefficient	Std.Error[1]	t-value[1]	t-prob	Part.R^2
I	0.270	1.770	1.53	0.1310	0.0310
DI	**-1.075	0.495	-2.17	0.0332	0.0606
DI_1	-0.004	0.050	-0.07	0.9434	0.0001
SLIBOR	-0.001	0.001	-1.57	0.1212	0.0326
VAR_76	**-168.0	82.04	-2.05	0.0442	0.0543
COR_76	***-3.296	1.214	-2.71	0.0083	0.0917
WEIGHT_76	**-26.39	12.65	-2.09	0.0405	0.0563
D_COM	0.001	0.005	0.18	0.8604	0.0004
D_INDX	**0.061	0.024	2.51	0.0141	0.0797
NCOM_EX	***-0.956	0.303	-3.16	0.0023	0.1201

AR 1-6 test:	1.1825 [0.3263]		
ARCH 1-6 test:	2.5013 [0.0294]*		
Normality test:	14.234 [0.0008]**	Joint F-test:	8.041 [0.000]**
Hetero test:	1.7951 [0.0344]*	R^2 :	0.56931
RESET23 test:	7.7410 [0.0009]**		

Notes: Inventory data in 10.000 tonnes, trader-position data in 100 contracts.

Table 5.2.7: SPREAD_87 - Annual differences, constant, AR(6)

	Coefficient	Std.Error	t-value	t-prob	Part.R^2
I	**0.587	0.258	2.28	0.0259	0.0730
DI	*-1.064	0.622	-1.71	0.0920	0.0424
DI_1	***-1.654	0.615	-2.69	0.0091	0.0986
SLIBOR	**-0.002	0.001	-2.12	0.0375	0.0640
VAR_87	***-268.6	76.22	-3.52	0.0008	0.1583
COR_87	5.896	10.48	0.56	0.5755	0.0048
WEIGHT_87	-4.115	10.29	-0.40	0.6905	0.0024
D_COM	-0.009	0.008	-1.09	0.2807	0.0176
D_INDX	***0.058	0.020	2.89	0.0052	0.1122
NCOM_EX	-0.576	0.459	-1.25	0.2140	0.0233
AR 1-6 test:	0.6475 [0.6644]				
ARCH 1-6 test:	1.4351 [0.2219]				
Normality test:	5.7435 [0.0566]		Joint F-test:	4.607 [0.000]**	
Hetero test:	1.1144 [0.3590]		R^2 :	0.527592	
RESET23 test:	3.1031 [0.0517]				

Notes: Inventory data in 10.000 tonnes, trader-position data in 100 contracts.

Appendix 5.3 Calendar Spread Regression Results Annual Differences Coffee

Table 5.3.1: SPREAD_21 - Annual differences, constant, AR(5)

	Coefficient	Std.Error	t-value	t-prob	Part.R^2
I^	***6.804	1.611	4.22	0.0001	0.2009
DI^	-0.195	0.127	-1.54	0.1271	0.0325
DI_1^	***0.358	0.133	2.68	0.0091	0.0920
SLIBOR^^	3.115	0.129	0.24	0.8096	0.0008
VAR_21	*-0.172	0.087	-1.97	0.0528	0.0518
COR_21	0.015	0.015	1.00	0.3212	0.0139
WEIGHT_21	-0.012	0.035	-0.34	0.7375	0.0016
D_COM^^	-0.023	0.090	-0.26	0.7979	0.0009
D_INDX^^	0.187	0.210	0.89	0.3767	0.0110
NCOM_EX	0.002	0.005	0.46	0.6484	0.0029
AR 1-6 test:	0.9884 [0.4316]				
ARCH 1-6 test:	2.2062 [0.0626]		Joint F-test:	4.623 [0.000]**	
Normality test:	39.051 [0.0000]**		R^2 :	0.438603	
Hetero test:	1.4719 [0.1155]				
RESET23 test:	11.986 [0.0000]**				

^In 1,000,000,000, ^^ in 1,000,000.

Table 5.3.2: SPREAD_32 - Annual differences, constant, AR(1)

	Coefficient	Std.Error	t-value	t-prob	Part.R^2
I^	***3.602	1.314	2.74	0.0076	0.0900
DI^	-1.491	5.830	-0.26	0.7988	0.0009
DI_1^	4.583	6.257	0.73	0.4662	0.0070
SLIBOR^^	**12.15	5.419	2.24	0.0279	0.0620
VAR_32	-0.003	0.026	-0.13	0.8978	0.0002
COR_32	-0.000	0.004	-0.10	0.9171	0.0001
WEIGHT_32	**-0.011	0.005	-2.09	0.0396	0.0545
D_COM^^	**0.090	0.034	2.61	0.0110	0.0821
D_INDX^^	0.041	0.097	0.42	0.6754	0.0023
NCOM_EX	-0.002	0.002	-0.82	0.4140	0.0088
AR 1-6 test:	2.1010 [0.0639]				
ARCH 1-6 test:	0.4521 [0.8413]		Joint F-test:	17.88 [0.000]**	
Normality test:	16.794 [0.0002]**		R^2 :	0.721315	
Hetero test:	1.1347 [0.3368]				
RESET23 test:	0.2219 [0.8015]				

^In 1,000,000,000, ^^ in 1,000,000, [1] HACSE standard errors

Table 5.3.3: SPREAD_43 - Annual differences, constant, AR(1)

	Coefficient	Std.Error	t-value	t-prob	Part.R^2
I^	*1.395	0.792	1.76	0.0821	0.0392
DI^	5.435	5.857	0.93	0.3563	0.0112
DI_1^	-2.355	6.379	-0.37	0.7130	0.0018
SLIBOR^^	-2.246	4.755	-0.47	0.6380	0.0029
VAR_43	***-0.090	0.024	-3.80	0.0003	0.1598
COR_43	0.000	0.001	0.10	0.9183	0.0001
WEIGHT_43	0.010	0.007	1.50	0.1378	0.0287
D_COM^^	*0.059	0.032	1.85	0.0678	0.0432
D_INDX^^	0.098	0.089	1.11	0.2722	0.0158
NCOM_EX	0.002	0.002	0.79	0.4350	0.0080
AR 1-6 test:	1.2676 [0.2835]				
ARCH 1-6 test:	0.9641 [0.4553]		Joint F-test:	29.59 [0.000]**	
Normality test:	3.6354 [0.1624]		R^2 :	0.810719	
Hetero test:	0.9253 [0.5644]		Res. ADF (0)[3]	-8.017**	
RESET23 test:	0.9936 [0.3751]				

^In 1,000,000,000, ^^ in 1,000,000

Table 5.3.4: SPREAD_54 - Annual differences, constant, AR(1)

	Coefficient	Std.Error[2]	t-value[2]	t-prob	Part.R^2
I^	**1.796	0.825	2.18	0.0325	0.0587
DI^	3.358	6.464	0.52	0.6049	0.0035
DI_1^	0.634	8.285	0.08	0.9392	0.0001
SLIBOR^^	-11.68	8.622	-1.35	0.1795	0.0236
VAR_54	***-0.125	0.045	-2.79	0.0066	0.0930
COR_54	-0.005	0.003	-1.54	0.1269	0.0304
WEIGHT_54	0.006	0.006	1.03	0.3076	0.0137
D_COM^^	***0.145	0.035	4.18	0.0001	0.1870
D_INDX^^	0.021	0.107	0.19	0.8467	0.0005
NCOM_EX	0.003	0.003	1.25	0.2158	0.0201
AR 1-6 test:	2.1220 [0.0614]				
ARCH 1-6 test:	1.4038 [0.2242]		Joint F-test:	37.03 [0.000]**	
Normality test:	0.9279 [0.6288]		R^2 :	0.842766	
Hetero test:	2.3351 [0.0044]**		Res. PP (0)[3]	-8.196**	
RESET23 test:	0.0270 [0.9734]				

^In 1,000,000,000, ^^ in 1,000,000, [2] HCSE standard errors, [3] PP test for residuals, lags selected by AIC and reported in (.).

Table 5.3.5: SPREAD_65 - Annual differences, constant, AR(1)

	Coefficient	Std.Error	t-value	t-prob	Part.R^2
I^	**2.847	1.216	2.34	0.0218	0.0673
DI^	8.745	6.787	1.29	0.2015	0.0214
DI_1^	3.826	7.299	0.52	0.6016	0.0036
SLIBOR^^	**-11.56	5.727	-2.02	0.0472	0.0508
VAR_65	***-0.142	0.029	-4.90	0.0000	0.2401
COR_65	***-0.012	0.004	-2.80	0.0065	0.0935
WEIGHT_65	0.002	0.004	0.46	0.6495	0.0027
D_COM^^	***0.141	0.041	3.45	0.0009	0.1355
D_INDX^^	0.114	0.118	0.97	0.3361	0.0122
NCOM_EX	0.002	0.003	0.58	0.5621	0.0044
AR 1-6 test:	1.2079 [0.3126]		Joint F-test:	43.91 [0.000]**	
ARCH 1-6 test:	1.3095 [0.2633]		R^2 :	0.864047	
Normality test:	1.4777 [0.4777]		Res. ADF (0)[3]	-7.686**	
Hetero test:	0.7686 [0.7502]				
RESET23 test:	0.4023 [0.6702]				

^In 1,000,000,000, ^^ in 1,000,000, [2] HCSE standard errors, [3] ADF test without constant for residuals, lags selected by AIC and reported in (.).

Table 5.3.6: SPREAD_76 - Annual differences, constant, AR(5)

	Coefficient	Std.Error	t-value	t-prob	Part.R^2
I^	0.417	1.694	0.25	0.8064	0.0009
DI^	4.611	8.837	0.52	0.6035	0.0038
DI_1^	8.470	8.880	0.95	0.3434	0.0127
SLIBOR^^	2.624	6.171	0.43	0.6720	0.0025
VAR_76	-0.046	0.028	-1.61	0.1118	0.0352
COR_76	-0.002	0.001	-1.61	0.1120	0.0352
WEIGHT_76	-0.005	0.003	-1.67	0.1002	0.0376
D_COM^^	***0.136	0.046	2.95	0.0043	0.1094
D_INDX^^	0.191	0.126	1.51	0.1345	0.0313
NCOM_EX	0.000	0.003	-0.10	0.9245	0.0001
AR 1-6 test:	2.2887 [0.0558]		Joint F-test:	34.55 [0.000]**	
ARCH 1-6 test:	0.4652 [0.8009]		R^2 :	0.853777	
Normality test:	2.4307 [0.2966]		Res. ADF (0)[3]	-8.276**	
Hetero test:	0.7435 [0.7861]				
RESET23 test:	0.1154 [0.8912]				

^In 1,000,000,000, ^^ in 1,000,000, [2] HCSE standard errors, [3] ADF test without constant for residuals, lags selected by AIC and reported in (.).

Table 5.3.7: SPREAD_87 - Annual differences, constant, AR(1)

	Coefficient	Std.Error	t-value	t-prob	Part.R^2
I^	2.328	1.503	1.55	0.1256	0.0306
DI^	-1.975	8.802	-0.22	0.8231	0.0007
DI_1^	8.402	9.233	0.91	0.3657	0.0108
SLIBOR^^	0.276	6.875	0.04	0.9680	0.0000
VAR_87	*-0.043	0.025	-1.76	0.0820	0.0393
COR_87	0.003	0.004	0.82	0.4136	0.0088
WEIGHT_87	0.004	0.003	1.44	0.1527	0.0267
D_COM^^	*0.081	0.048	1.69	0.0945	0.0364
D_INDX^^	0.220	0.139	1.59	0.1165	0.0321
NCOM_EX	-0.004	0.003	-1.15	0.2531	0.0171
AR 1-6 test:	1.9112 [0.0910]		Joint F-test:	25.47 [0.000]**	
ARCH 1-6 test:	1.2775 [0.2778]		R^2 :	0.786625	
Normality test:	1.5096 [0.4701]		Res. ADF (4)[3]	-4.412**	
Hetero test:	0.8389 [0.6683]				
RESET23 test:	0.1460 [0.8644]				

^In 1,000,000,000, ^^ in 1,000,000, [2] HCSE standard errors, [3] ADF test without constant for residuals, lags selected by AIC and reported in (.).

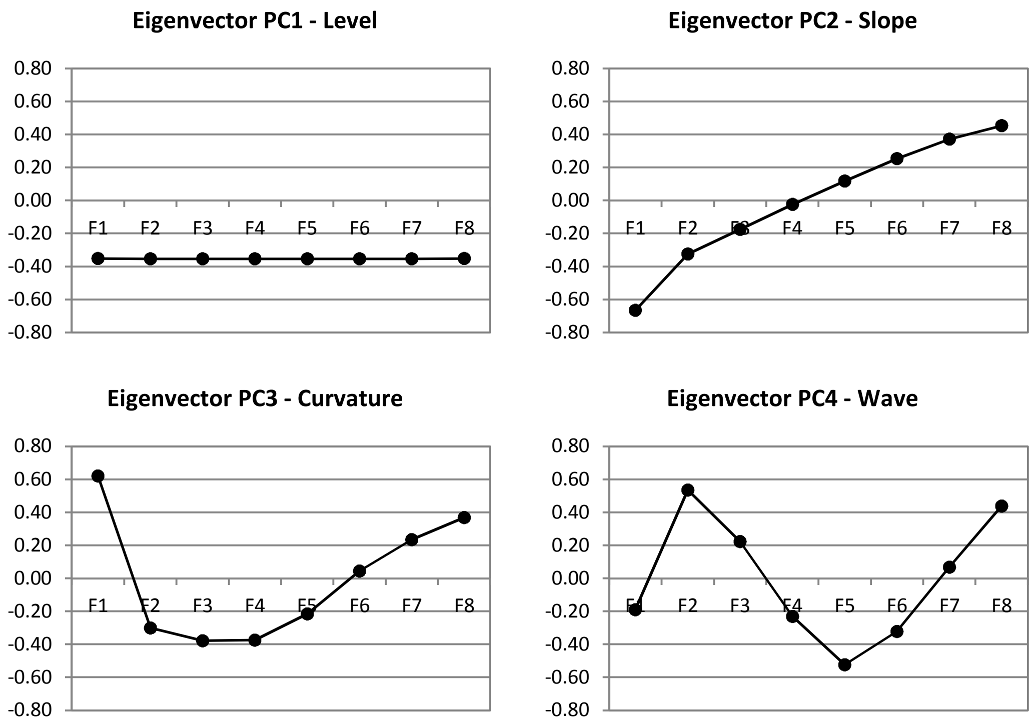
Table 5.3.8: SPREAD_98 - Annual differences, constant, AR(0)

	Coefficient	Std.Error[2]	t-value[2]	t-prob	Part.R^2
I^	6.032	5.236	1.15	0.2529	0.0169
DI^	-21.53	16.370	-1.31	0.1925	0.0220
DI_1^	-1.621	18.100	-0.09	0.9289	0.0001
SLIBOR^^	30.38	19.040	1.60	0.1147	0.0320
VAR_98	***-0.181	0.025	-7.26	0.0000	0.4061
COR_98	*-0.003	0.001	-1.87	0.0650	0.0435
WEIGHT_98	0.014	0.005	2.81	0.0063	0.0929
D_COM^^	-0.045	0.114	-0.40	0.6927	0.0020
D_INDX^^	**0.996	0.443	2.25	0.0276	0.0615
NCOM_EX	**-0.019	0.009	-2.27	0.0262	0.0626
AR 1-6 test:	9.5390 [0.0000]**		Joint F-test:	9.107 [0.000]**	
ARCH 1-6 test:	6.3966 [0.0000]**		R^2 :	0.54187	
Normality test:	16.374 [0.0003]**		Res. ADF (2)[3]	-4.278**	
Hetero test:	1.2791 [0.2241]				
RESET23 test:	0.38888 [0.6792]				

^In 1,000,000,000, ^^ in 1,000,000, [2] HCSE standard errors, [3] ADF test without constant for residuals, lags selected by AIC and reported in (.).

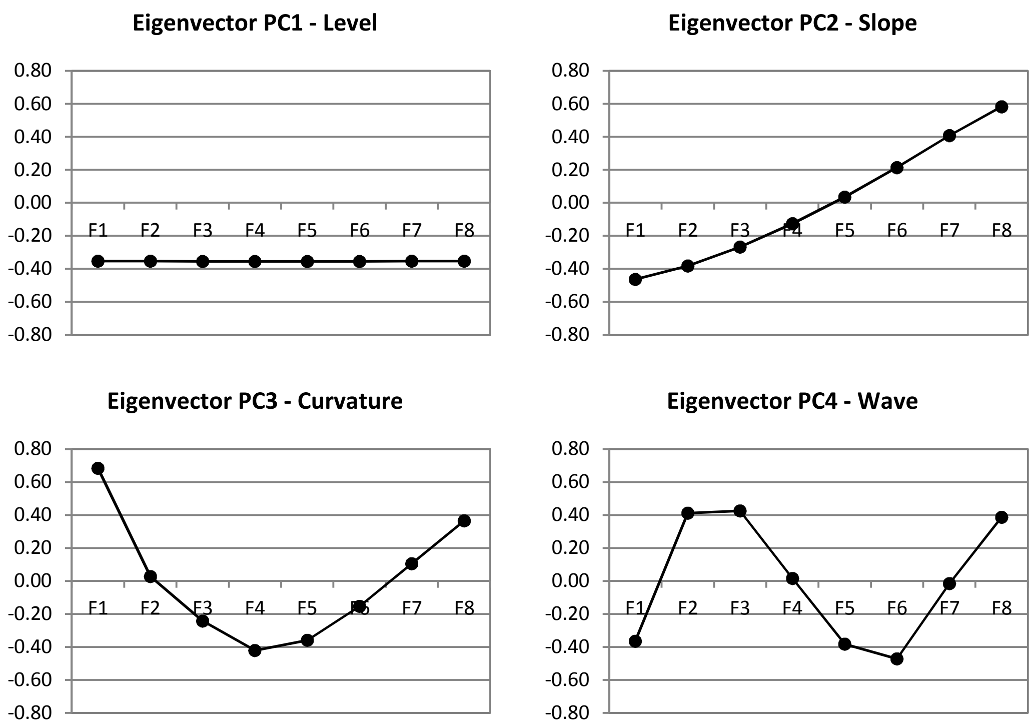
Appendix 5.4 Eigenvectors Principal Component Analysis

Table 5.4.1: Eigenvectors Cocoa



Source: author's calculation

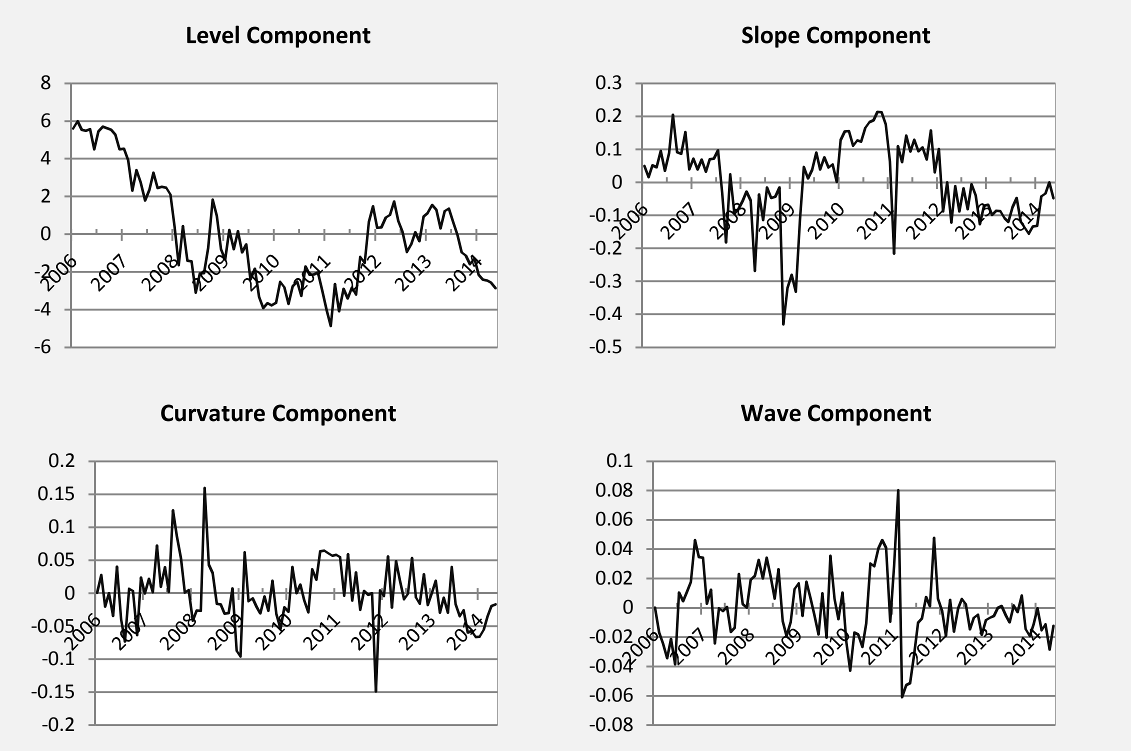
Table 5.4.2: Eigenvectors Coffee



Source: author's calculation

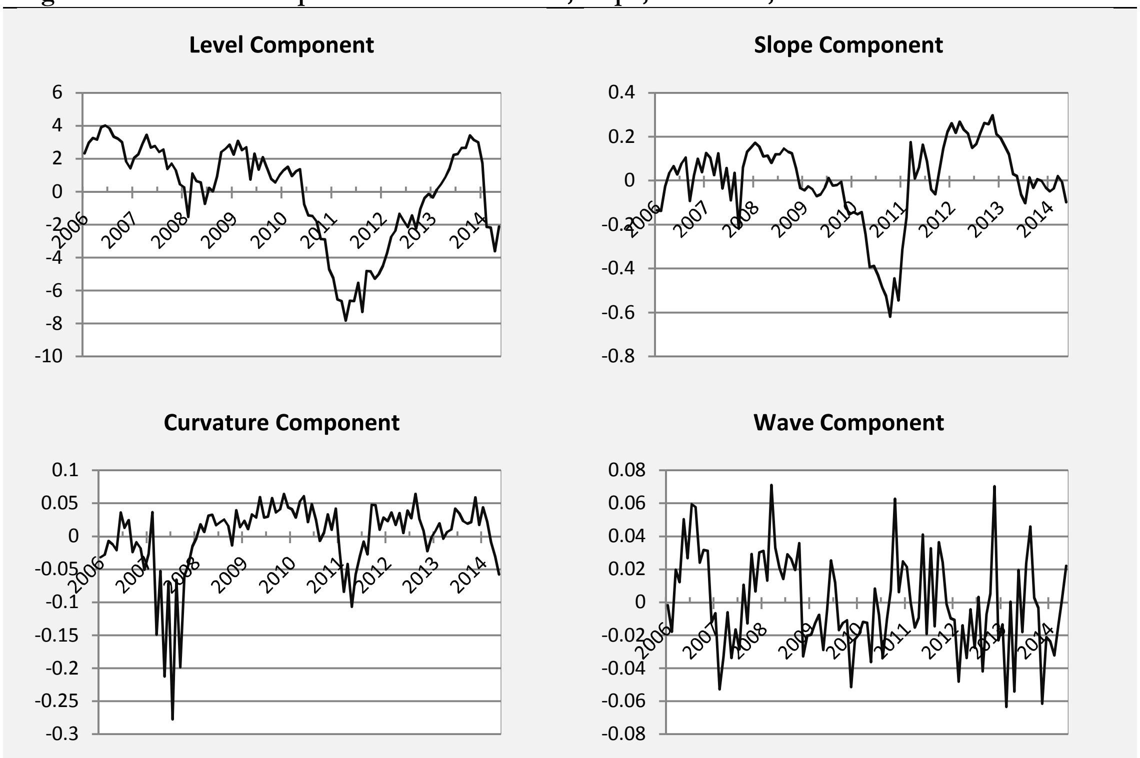
Appendix 5.5 Component Indicators Level, Slope, Curvature, and Wave

Figure 5.5.1: Cocoa Component Indicators Level, Slope, Curvature, and Wave



Source: author's calculation

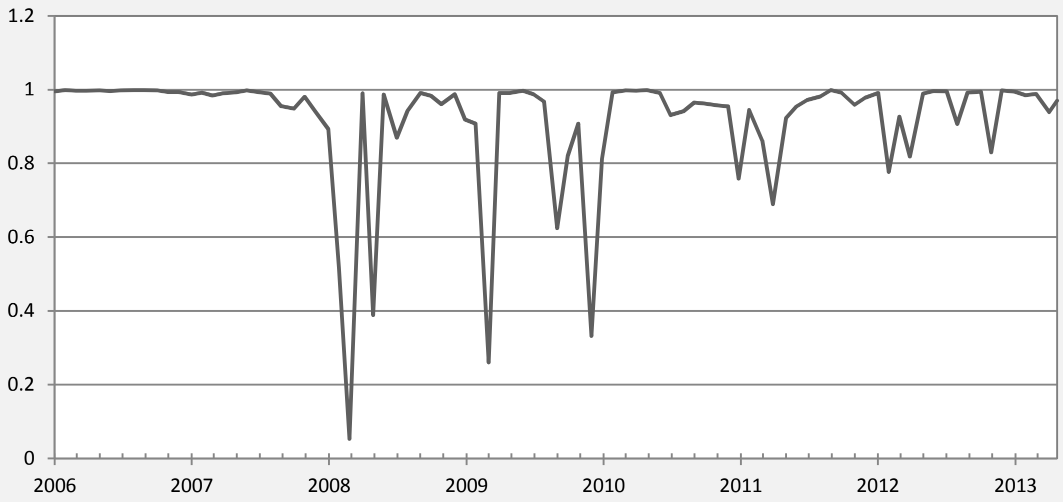
Figure 5.5.2: Coffee Component Indicators Level, Slope, Curvature, and Wave



Source: author's calculation

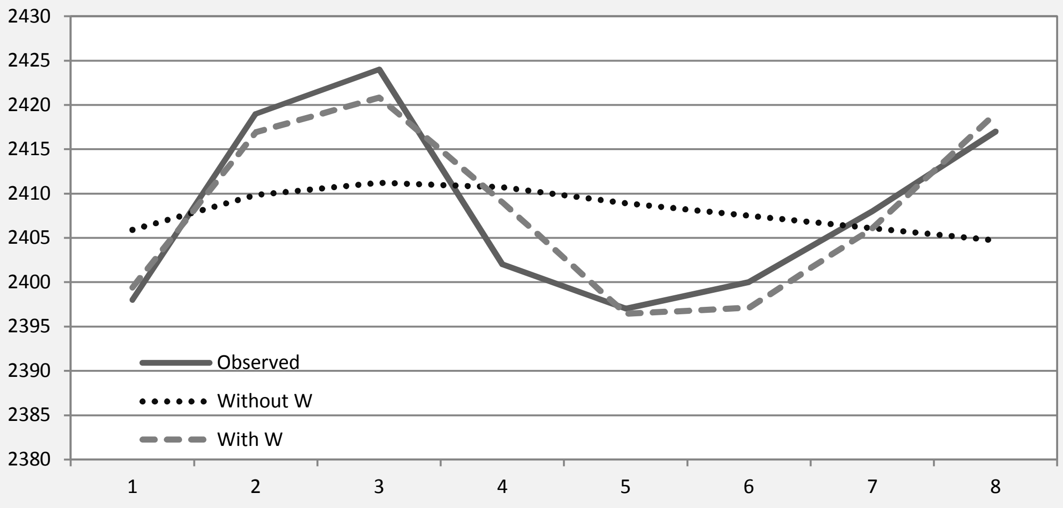
Appendix 5.6 Three-factor Nelson-Siegel Model Fit

Figure 5.6.1: R-Square Nelson-Siegel Three Factor Model for Cocoa



Source: author's calculation

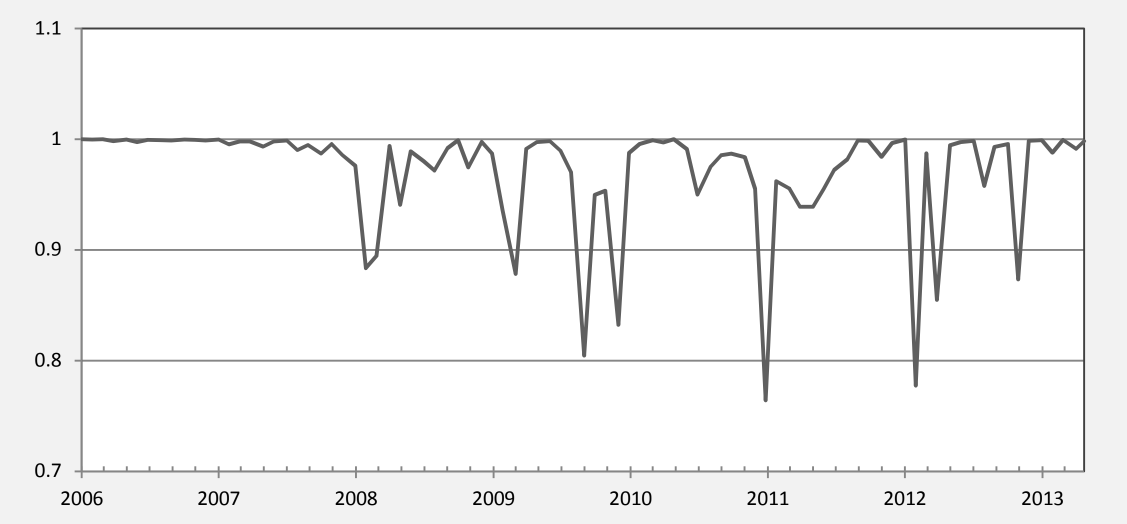
Figure 5.6.2: Fitted and Observed Future Curve 25 March 2008 Cocoa Market



Note: For the example chosen, the first observation reflects the May 2008 contract. The second observation is the July 2008 contract when most confectionery companies start buying for the Christmas season and hence the price is high. The September 2008 contract goes at a lower price as the harvest is about to begin and for the December 2008 contract, the harvest time, the price is low as a short-term supply flood is expected during this season. However, in the long-run traders seem to expect that the harvest falls short of demand and later contracts trade at a higher price level. While the three factor model cannot replicate the wave form and instead suggests a hump-shaped fitted line, the four factor model almost perfectly replicates the observed futures curve.
Source: Author's calculation.

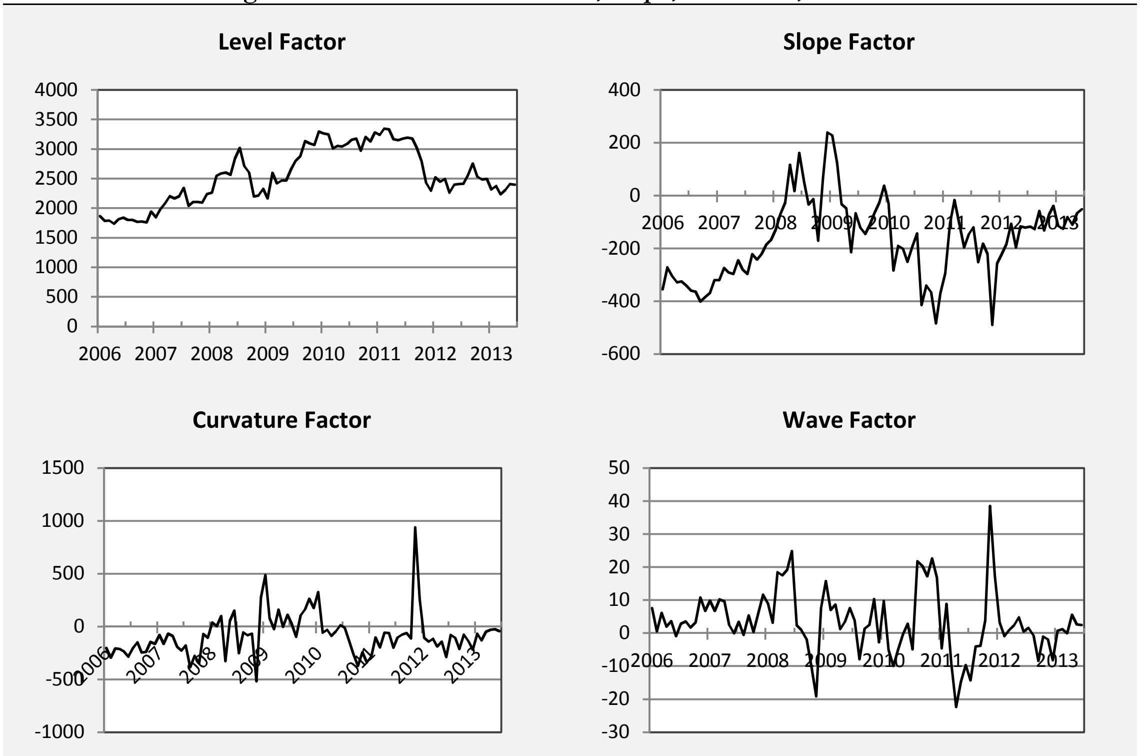
Appendix 5.7 Factors Level, Slope, Curvature, and Wave and Model Fit

Figure 5.7.1: R-square Nelson-Siegel Four Factor Model for Cocoa



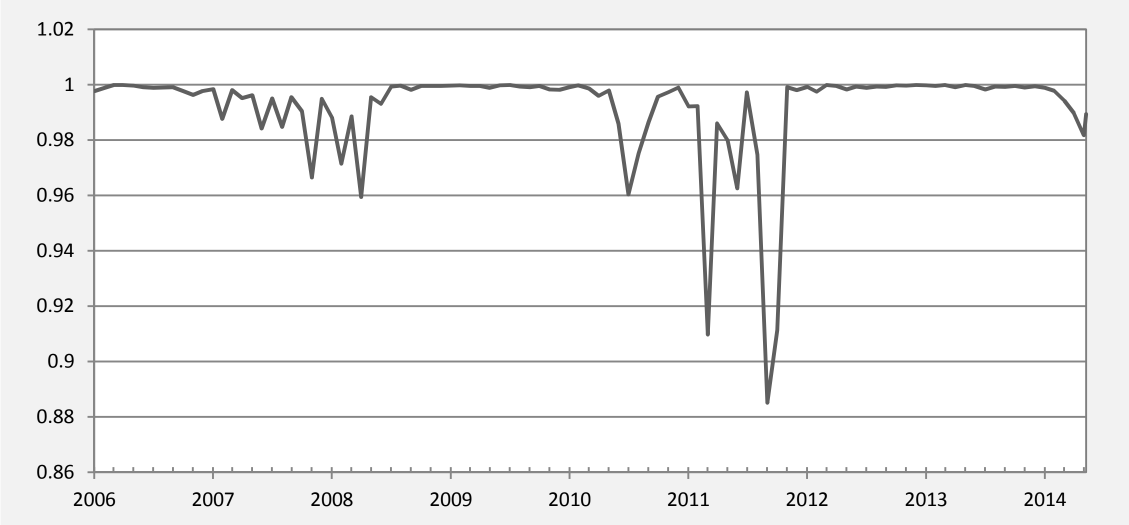
Source: author's calculation

Figure 5.7.2: Cocoa Factors Level, Slope, Curvature, and Wave



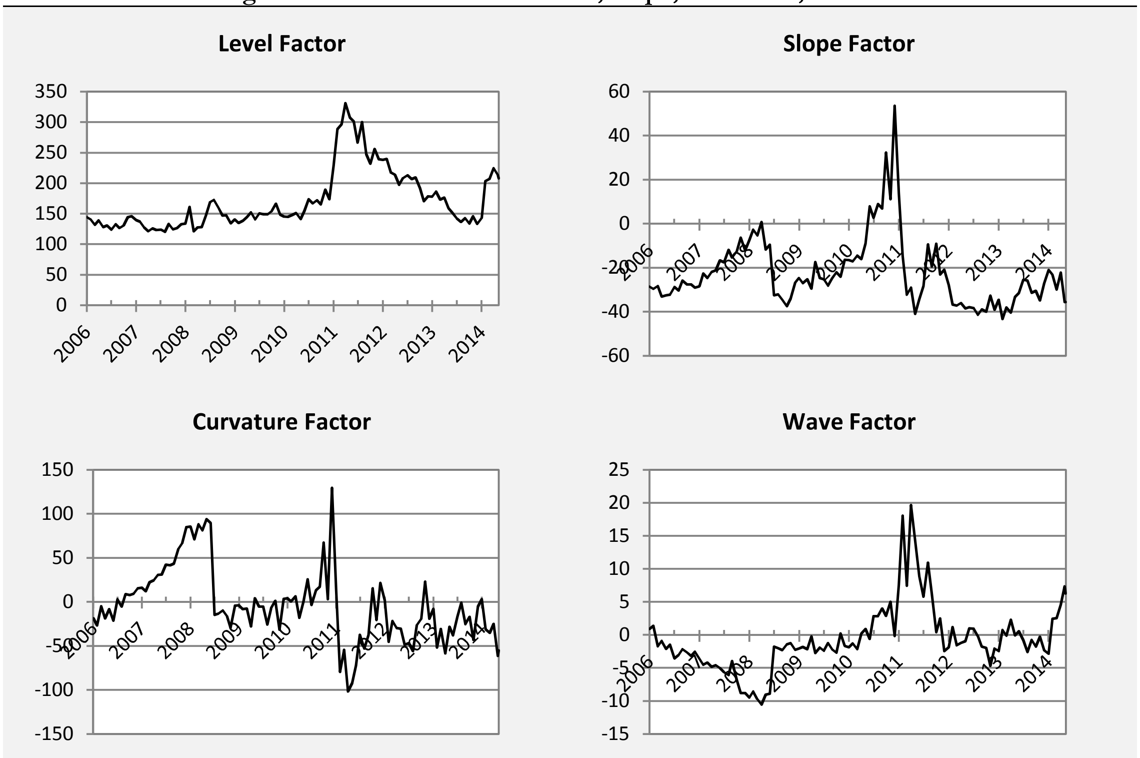
Source: author's calculation

Figure 5.7.3: R-square Nelson-Siegel Four Factor Model for Coffee



Source: author's calculation

Figure 5.7.4: Coffee Factors Level, Slope, Curvature, and Wave



Source: author's calculation

Appendix 5.8 Autocorrelation Functions Components and Factors

Figure 5.8.1: Autocorrelation Function Cocoa Factors

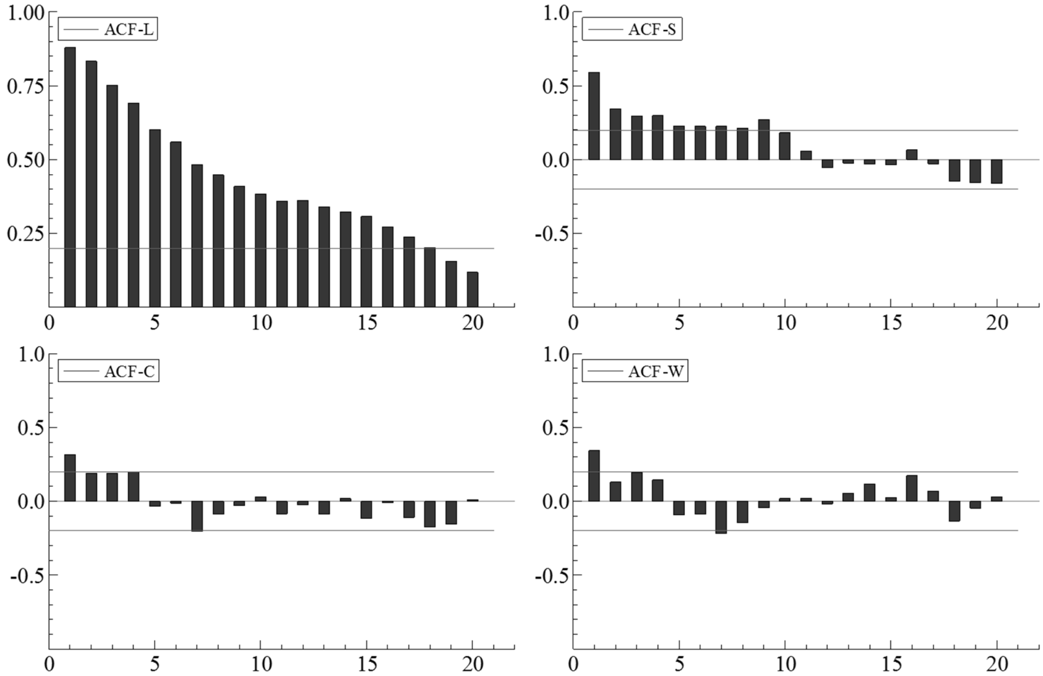
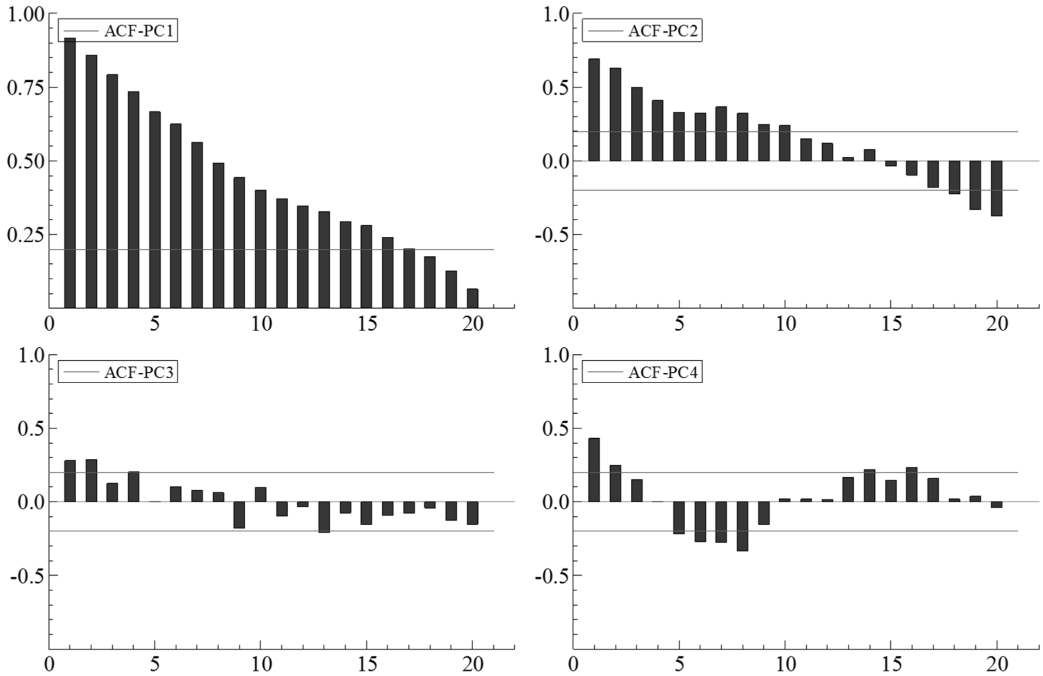


Figure 5.8.2: Autocorrelation Functions Cocoa Components



Source: author's calculation (graphics are created with PcGive)

Figure 5.8.3: Autocorrelation Function Coffee Factors

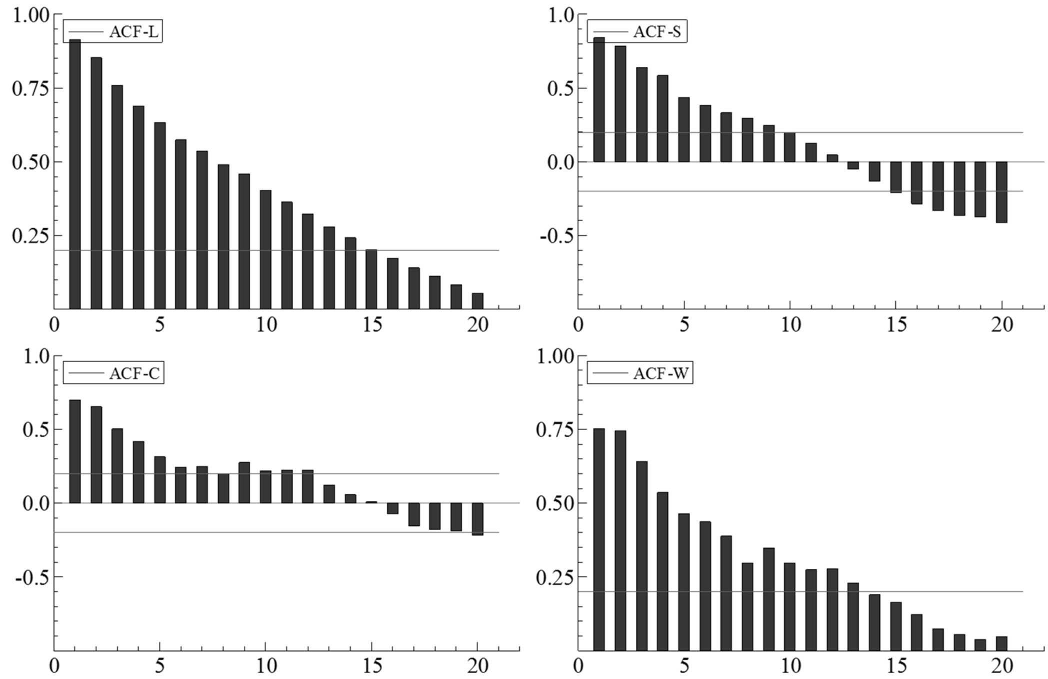
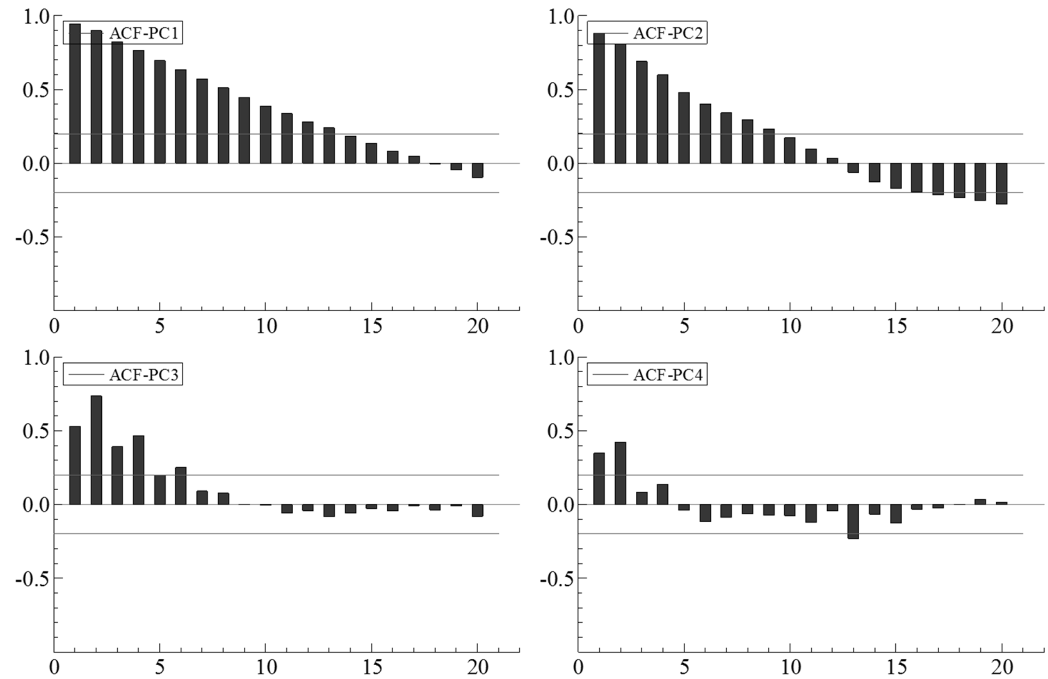


Figure 5.8.4: Autocorrelation Function Coffee Components



Source: author's calculation (graphics are created with PcGive)

Appendix 5.9 Unit Root Test Factors

Table 5.9.1: ADF Test Cocoa

Variable	D-lag	t-adf	D1_lag	D1_t-adf	Integration
Level					
L	0	-2.240	0	-9.498**	I(1)
S	0	-3.355*	-	-	I(0)
C	0	-5.946**	-	-	I(0)
W	6	-4.971**	-	-	I(0)
Table 5.9.2: ADF Test Coffee					
L	2	-1.965	1	-5.586**	I(1)
S	2	-3.041*	-	-	I(0)
C	1	-2.558	0	-13.37**	I(1)
W	3	-1.992	2	-5.031**	I(1)

Notes: ADF tests (T=77, Constant; 5%=-2.90 1%=-3.51) – lag length decided by Akaike information criteria with a maximum lag length of 12.

Appendix 5.10 Cocoa Full Results Individual AR

Table 5.10.1: Future Curve Factor Regression Results Cocoa First Differences			
Level			
AR(0)	**Coefficient**	**Standard Error**	**p-value**
I	64.5076	64.64	0.3214
DI	-22.3948	62.46	0.7209
DI_1	7.5730	57.49	0.8955
SLIBOR	-0.4729	2.01	0.8148
VAR	-3.7496	3.59	0.9170
COR	688.0390	802.40	0.3939
WEIGHT	0.1004	4.14	0.9807
COM_H	-4.8995	1.67	0.0043
IND_H	-4.3257	3.58	0.2303
NCOM_EX	2.4008	4.20	0.5688
DIAGNOSTICS	Adj.R^2	0.0575	
	AR	0.86142	[0.5276]
	ARCH	1.9325	[0.0863]
	Normality	2.259	[0.3232]
	Hetero	0.87788	[0.6139]
Slope			
AR(1)	**Coefficient**	**Standard Error^**	**p-value**
I	26.9909	37.78	0.4771
DI	35.0119	36.56	0.3413
DI_1	0.8547	33.77	0.9799
SLIBOR	-0.4209	1.18	0.7221
VAR	6.3740	2.10	0.0033
COR	217.2030	470.50	0.6457
WEIGHT	-0.1944	2.42	0.9363
COM_H	-2.3387	0.97	0.0188
IND_H	-3.3145	2.09	0.1172
NCOM_EX	7.1951	2.46	0.0045
DIAGNOSTICS	Adj.R^2	0.1960	
	AR	2.959	[0.0124]*
	ARCH	1.4998	[0.1897]
	Normality	2.357	[0.3077]
	Hetero	2.1343	[0.0097]**
Curvature			
AR(2)	**Coefficient**	**Standard Error^**	**p-value**
I	-32.9180	78.92	0.6778
DI	111.6610	77.10	0.1517
DI_1	20.3376	72.02	0.7784
SLIBOR	-0.1179	2.48	0.9621
VAR	5.1448	4.41	0.2474
COR	-2013.8600	992.20	0.0459
WEIGHT	9.4624	5.06	0.0653
COM_H	-1.5003	2.04	0.4653
IND_H	2.1368	4.45	0.6321
NCOM_EX	-18.1408	5.12	0.0007
DIAGNOSTICS	Adj.R^2	0.3603	
	AR	1.9432	[0.0860]
	ARCH	2.7196	[0.0190]*
	Normality	15.28	[0.0005]**
	Hetero	4.3309	[0.0000]**
Wave			
AR(1)	**Coefficient**	**Standard Error^**	**p-value**
I	-2.9970	4.00	0.4560
DI	2.4036	3.94	0.5431
DI_1	0.4551	3.56	0.8986
SLIBOR	-0.0231	0.12	0.8535
VAR	0.2498	0.22	0.2651
COR	-81.9375	49.80	0.1041
WEIGHT	0.3953	0.26	0.1277
COM_H	-0.0784	0.10	0.4503
IND_H	0.3297	0.22	0.1417
NCOM_EX	-0.5028	0.26	0.0565
DIAGNOSTICS	Adj.R^2	0.0975	
	AR	1.0337	[0.4110]
	ARCH	1.4884	[0.1935]
	Normality	3.7553	[0.1530]
	Hetero	2.4905	[0.0024]**
Note: ^White robust standard errors.			

Table 5.10.2: Future Curve Factor Regression Results Cocoa Levels			
Level			
AR(2)	**Coefficient**	**Standard Error**	**p-value**
I	-13.4999	26.63	0.6136
DI	6.9085	52.85	0.8963
DI_1	41.5070	57.07	0.4693
SLIBOR	-2.1547	0.85	0.0133
VAR	-0.1346	0.74	0.8571
COR	-249.9490	178.50	0.1654
WEIGHT	11.2552	4.66	0.0182
COM_H	-3.5378	1.26	0.0063
IND_H	-1.7767	2.36	0.4534
NCOM_EX	-7.5960	5.29	0.1554
DIAGNOSTICS	Adj.R^2	0.92104	
	AR	1.0931	[0.3752]
	ARCH	0.082209	[0.9978]
	Normality	2.1515	[0.3410]
	Hetero	1.0927	[0.3770]
Unit Root (ADF)	-4.858**	Lag Length	8
Slope			
AR(1)	**Coefficient**	**Standard Error^**	**p-value**
I	-4.6860	13.87	0.7364
DI	71.4406	30.98	0.0238
DI_1	8.2717	33.35	0.8048
SLIBOR	0.5476	0.49	0.2656
VAR	1.7027	0.52	0.0015
COR	417.8920	112.40	0.0004
WEIGHT	0.9881	2.72	0.7170
COM_H	-0.6688	0.73	0.3650
IND_H	-1.6087	1.40	0.2546
NCOM_EX	2.5688	3.14	0.4160
DIAGNOSTICS	Adj.R^2	0.7258	
	AR	1.9585	[0.0832]
	ARCH	1.2334	[0.2986]
	Normality	7.831	[0.0199]*
	Hetero	1.5844	[0.0780]
Curvature			
AR(0)	**Coefficient**	**Standard Error^**	**p-value**
I	-36.8450	29.68	0.2181
DI	96.4738	66.27	0.1495
DI_1	-21.2352	70.13	0.7629
SLIBOR	-3.8402	1.04	0.0004
VAR	2.7014	0.87	0.0026
COR	-526.4810	210.50	0.0145
WEIGHT	11.6689	5.80	0.0477
COM_H	-4.5407	1.57	0.0050
IND_H	5.1323	2.93	0.0842
NCOM_EX	-4.0461	6.63	0.5432
DIAGNOSTICS	Adj.R^2	0.2938	
	AR	1.0383	[0.4079]
	ARCH	0.041175	[0.9997]
	Normality	46.631	[0.0000]**
	Hetero	0.96056	[0.5180]
Wave			
AR(0)	**Coefficient**	**Standard Error^**	**p-value**
I	-1.6914	1.42	0.2378
DI	-1.1666	3.19	0.7155
DI_1	-0.4908	3.34	0.8836
SLIBOR	-0.0594	0.05	0.2354
VAR	-0.0119	0.04	0.7755
COR	-19.0574	10.03	0.0613
WEIGHT	0.4954	0.28	0.0773
COM_H	-0.1363	0.08	0.0744
IND_H	0.3599	0.15	0.0162
NCOM_EX	-0.1698	0.32	0.5963
DIAGNOSTICS	Adj.R^2	0.3150	
	AR	0.50294	[0.8041]
	ARCH	0.5806	[0.7447]
	Normality	7.5692	[0.0227]*
	Hetero	1.2927	[0.2101]
Note: ^White robust standard errors. Lag length of ADF test decided by Akaike Information Criteria.			

Appendix 5.11 Coffee Full Results Individual AR

Table 5.11.1: Future Curve Factor Regression Results Coffee First Differences			
Level			
AR(0)	**Coefficient**	**Standard Error^**	**p-value**
I	-0.0101	0.01	0.4044
DI	0.0405	0.02	0.0753
DI_1	-0.0077	0.02	0.7226
SLIBOR	14.6545	3.53	0.0001
VAR	0.0623	0.09	0.4688
COR	99.5802	133.00	0.4562
WEIGHT	-0.3869	0.18	0.0346
COM_H	0.0495	0.15	0.7486
IND_H	-0.3650	0.35	0.2972
NCOM_EX	1.3817	5.81	0.8128
DIAGNOSTICS	Adj.R^2	0.4223	
	AR	0.87072	[0.5208]
	ARCH	6.3734	[0.0000]**
	Normality	27.624	[0.0000]**
	Hetero	7.3133	[0.0000]**
Slope			
AR(1)	**Coefficient**	**Standard Error^**	**p-value**
I	-0.0120	0.01	0.0825
DI	-0.0073	0.02	0.6574
DI_1	0.0111	0.02	0.5920
SLIBOR	-2.7225	1.83	0.1404
VAR	0.0392	0.09	0.6573
COR	-120.8280	106.70	0.2611
WEIGHT	-0.0084	0.16	0.9591
COM_H	-0.3455	0.10	0.0006
IND_H	-0.2919	0.30	0.3347
NCOM_EX	2.4652	4.07	0.5466
DIAGNOSTICS	Adj.R^2	0.1652	
	AR	1.9194	[0.0894]
	ARCH	9.6718	[0.0000]**
	Normality	81.581	[0.0000]**
	Hetero	16.97	[0.0000]**
Curvature			
AR(0)	**Coefficient**	**Standard Error^**	**p-value**
I	-0.0058	0.03	0.8556
DI	-0.0462	0.06	0.4117
DI_1	0.0741	0.06	0.2066
SLIBOR	-10.2570	4.88	0.0390
VAR	-0.0269	0.23	0.9084
COR	-45.1602	314.50	0.8862
WEIGHT	1.4824	0.44	0.0013
COM_H	-0.7940	0.26	0.0032
IND_H	-0.2389	0.79	0.7635
NCOM_EX	4.1653	16.84	0.8053
DIAGNOSTICS	Adj.R^2	0.2162	
	AR	2.035	[0.0719]
	ARCH	3.6523	[0.0030]**
	Normality	83.598	[0.0000]**
	Hetero	6.0761	[0.0000]**
Wave			
AR(0)	**Coefficient**	**Standard Error^**	**p-value**
I	0.0079	0.03	0.7642
DI	0.0667	0.04	0.1396
DI_1	-0.0900	0.05	0.0662
SLIBOR	0.8698	0.76	0.2549
VAR	0.0285	0.02	0.1172
COR	-19.3944	28.39	0.4965
WEIGHT	-0.1307	0.05	0.0070
COM_H	0.0196	0.04	0.5970
IND_H	-0.0094	0.08	0.9053
NCOM_EX	0.1714	1.45	0.9064
DIAGNOSTICS	Adj.R^2	0.2578	
	AR	0.99323	[0.4365]
	ARCH	6.4264	[0.0000]**
	Normality	22.304	[0.0000]**
	Hetero	5.0105	[0.0000]**
Note: ^White robust standard errors.			

Table 5.11.2: Future Curve Factor Regression Results Coffee Levels			
Level			
AR(1)	**Coefficient**	**Standard Error^**	**p-value**
I	-0.0057	0.003	0.0767
DI	0.0181	0.027	0.5016
DI_1	0.0007	0.026	0.7848
SLIBOR	-1.0358	1.358	0.4481
VAR	0.0385	0.023	0.0980
COR	68.9598	43.930	0.1205
WEIGHT	-0.1619	0.231	0.4862
COM_H	-0.4867	0.218	0.0284
IND_H	-0.5040	0.359	0.1644
NCOM_EX	0.9043	8.270	0.9132
DIAGNOSTICS	Adj.R^2	0.9168	
	AR	1.5947	[0.1611]
	ARCH	2.1437	[0.0576]
	Normality	11.8620	[0.0027]**
	Hetero	3.7308	[0.0000]**
Unit Root (ADF)	-4.582**	Lag Length	1
Slope			
AR(1)	**Coefficient**	**Standard Error^**	**p-value**
I	-0.0020	0.002	0.2066
DI	-0.0259	0.014	0.0599
DI_1	0.0012	0.016	0.9401
SLIBOR	0.7701	0.659	0.2461
VAR	-0.0010	0.007	0.8888
COR	-59.5308	28.440	0.0396
WEIGHT	0.0130	0.140	0.9267
COM_H	-0.1348	0.091	0.1445
IND_H	-0.1330	0.234	0.5717
NCOM_EX	-1.5898	3.854	0.6811
DIAGNOSTICS	Adj.R^2	0.7040	
	AR	3.0422	[0.0104]*
	ARCH	1.7629	[0.1177]
	Normality	34.3480	[0.0000]**
	Hetero	2.2840	[0.0052]**
Curvature			
AR(1)	**Coefficient**	**Standard Error^**	**p-value**
I	0.0026	0.005	0.6144
DI	-0.0345	0.053	0.5200
DI_1	0.0539	0.058	0.3589
SLIBOR	1.6549	2.675	0.5380
VAR	-0.0167	0.021	0.4341
COR	-75.7106	90.520	0.4055
WEIGHT	0.5382	0.514	0.2984
COM_H	-0.3608	0.385	0.3512
IND_H	-0.2803	0.637	0.6610
NCOM_EX	1.9655	16.820	0.9073
DIAGNOSTICS	Adj.R^2	0.5452	
	AR	1.2170	[0.3077]
	ARCH	2.6031	[0.0237]*
	Normality	46.0050	[0.0000]**
	Hetero	2.6849	[0.0010]**
Unit Root (ADF)	-8.692**	Lag Length	0
Wave			
AR(2)	**Coefficient**	**Standard Error^**	**p-value**
I	-0.0001	0.001	0.8049
DI	0.0063	0.007	0.3631
DI_1	-0.0087	0.001	0.1704
SLIBOR	-0.1639	0.315	0.6040
VAR	0.0029	0.003	0.3225
COR	-2.8467	8.208	0.7297
WEIGHT	-0.0296	0.065	0.6492
COM_H	-0.0215	0.057	0.7078
IND_H	-0.0583	0.079	0.4652
NCOM_EX	0.8270	1.819	0.6507
DIAGNOSTICS	Adj.R^2	0.715214	
	AR	2.6752	[0.0214]*
	ARCH	6.7453	[0.0000]**
	Normality	22.4790	[0.0000]**
	Hetero	3.7645	[0.0000]**
Unit Root (ADF)	-3.710**	Lag Length	2
Note: ^White robust standard errors. Lag length of ADF test decided by Akaike Information Criteria.			

Appendix Chapter 7

Appendix 7.1: List of Interviewees

Cat.	Nr.	Company – Interviewee Name (position)	Location	Date
A	Chocolate Producers			
	1	August Storck – Markus Bohnemeier (Abteilungsleiter Einkauf)	Halle Westfahlen, DE	19 August 2013
B	First-tier supplier, Trader			
	1	Olam Internatioal Ltd. – Chris Thompson (senior vice president macro & strategic trading)	London, UK	20 August 2013
	2	Olam – Peter Peterson (pod counting)	Accra, GH	7 November 2013
C	First-tier supplier, Processor			
	1	Real Products – Richmond Boaitey (admin, general management)	Takoradi, GH	12 November 2013
	2	Barry Callebaut – Kofi Addo (logistics manager)	Tema Free Zone, GH	15 November 2013
	3	Cargill Ghana Ltd. – Samuel Nobel (sustainability head)	Tema Free Zone, GH	29 November 2013
D	Traders, Predominantly Exchange Related			
	1	Jenkins Sugar – Ken Lorenz	Norwalk, CT, US	16 September 2013
	2	Commodity Risk Analysis LLC – Steven Haws	Pennsylvania, US	30 September 2013
	3	Sucden – Whit Miller	New York, US	04 October 2013
E	Certification			
	1	Touton – Charles Tellier (Ghana coordinator for sustainable sourcing)	Accra, GH	28 November 2013
	2	Akuafo Adamfo, Finatrade Distribution - Hamid El-Kareh (certification manager)	Accra, GH	28 November 2013
	3	UTZ Certified - Siriki Diakité (regional representative for West Africa)	Accra, GH	28 November 2013
	4	Cocoa Abrabopa – Mirjam van Leeuwen (certification manager)	Dunkwa-On Offin, GH	27 November 2013
F	Farmer			
	1	Fair Trade Farmer Representative	Accra, GH	28 November 2013
	2	PPRC Farmer Representative	Accra, GH	28 November 2013
G	Government Organisation Ghana, Division or Subsidiary			
	1	CMC – Moussa Lenboni (manager CMC UK)	London, UK	29 August 2013
	2	COCOBOD – Fuad Abubakar (M&E and research analyst)	Accra, GH	28 October 2013
	3	CMC – Samuel Takyi (trader)	Accra, GH	28 October 2013

	4	QCD-COCOBOD – Thomas Kwame Osei (managing director)	Accra, GH	30 October 2013
	5	CMC – Paul Isaac Kwofie (shipping manager)	Accra, GH	30 October 2013
	6	CMC – Edem Amegashie (commodity trader)	Accra, GH	30 October 2013
	7	Ministry of Finance & Economic Planning – Michael Owusu-Manu (technical advisor, cocoa affairs)	Accra, GH	3 November 2013
	8	COCOBOD – Ambrose Awity (research manager)	Accra, GH	4 November 2013
H	Hauliers			
	1	Global Haulage Company Lid. – E A. Kwakye (director of transport)	Tema industrial area, GH	19 November 2013
I	Input and Extension Services			
	1	Ignitia Ghana Ltd. – Liisa Petrykowska (CEO)	Accra, GH	26. November 2013
	2	Wienco Ghana Ltd. – Marc Kok (managing director)	Accra, GH	12 December 2013
J	Warehousing			
	1	Continental Terminals (ICE) – Bob Forcillo (managing director)	Port Jersey Blvd, Jersey City, US	19 August 2013
	2	CWT Commodities Ghana Ltd. – Dirk de Bruin (operations manager)	Tema Free Zone, GH	29. November 2013
	3	Unicontrol Commodity Ghana Ltd. – Kor Ritsema (country manager)	Takoradi Harbour, GH	4 December 2013
K	International Organisation			
	1	ICCO – Michele Nardella (econometrician)	London, UK	20 August 2013
L	LBCs			
	1	Cocoa Merchants Ltd. – Lawrence Ayisi Botwe (director of operations)	Kumasi, GH	12 November 2013
	2	Akuafo Adamfo, Finatrade Distribution – Theophilus Agyare Asare (general manager of operations)	Kumasi, GH	13 November 2013
	3	Adwumapa Buyers Limited – Ali Issaka (general manager)	Kumasi, GH	13 November 2013
	4	Olam Ghana Ltd.– Gurinder Goindi (business head cocoa)	Accra, GH	15 November 2013

Appendix 7.2: Fieldwork Plan and Implementation

	Price Formation	Risk Management	Financial Markets	Regional/Global Chain	INTERVIEWED
LBCs					
Produce Buying Co. Ltd		X		X	
Akuafo Adamfo Mktg Co. Ltd.		X		X	X
Olam Ghana Ltd.		X		X	X
Adwumapa Buyers Ltd.		X		X	X
Armajaro Ghana ltd.		X		X	X
Kuapa Kokoo Ltd.		X		X	X
Federated Commodities Ltd.		X		X	
Cashpro Company Ltd.		X		X	
Transroyal Ghana Ltd.		X		X	
Cocoa Merchants Ghana Ltd.		X		X	X
Diaby Company Ltd.		X		X	
Premus Trading Co. Ltd.		X		X	
Royal Commodities Ltd.		X		X	
Others below 5% share		X		X	
International Buyers					
Olam	X	X	X	X	X
Armajaro	X	X	X	X	
ADM	X	X	X	X	
Barry Callebaut	X	X	X	X	
Cargill	X	X	X	X	
Touton	X	X	X	X	
… (?)	X	X	X	X	
Traders					
Jenkins Sugar	X	X	X		X
Commodity Risk Analysis	X	X	X		X
Sucden	X	X	X		X
…?	X	X	X		
Cocobod (divisions and subsidiaries)					
CMC London	X	X	X	X	X
CMC Accra	X	X	X	X	X
Warehousing and Port Operations Manager		X		X	
Shipping Manger		X		X	X
Marketing Manager	X	X	X	X	X
Managing Director QCD		X		X	X
Director of Research CRIG		X		X	X
Head of CSSVD		X		X	

PPRC Members					
Farmers’ Representative	X				X
LBCs’ Representative	X				X
Hauliers’ Representative	X				X
Representative from Academia	X				
Cocobod Representative	X				
Other government bodies					
Ghana Ports and Harbours Authority		X		X	
Ministry of Finance and Economic Planning	X	X	X		X
Haulers					
Global Haulage Co. Ltd.	X	X		X	X
... (?)	X	X		X	
Processors					
Cocoa Processing Company	X	X	X	X	
Cargill Ghana Limited	X	X	X	X	X
Archer Daniels Midland	X	X	X	X	
Barry Callebaut Ghana Limited	X	X	X	X	X
Real Products	X	X	X	X	X
Wamco Ltd	X	X	X	X	
Commodities (now Niche Cocoa Industry Ltd)	X	X	X	X	
Plot	X	X	X	X	
B.D. Assoc	X	X	X	X	
Calf Cocoa	X	X	X	X	
Afrotropics	X	X	X	X	
Warehousing and Extension Services					
Unicontrol Commodity Ghana Ltd		X			X
Sitos Ghana Ltd		X			X
Wienco		X		X	X
Certification					
UTZ	X	X		X	X
Rainforest Alliance	X	X		X	
Fair Trade	X	X		X	
Inetrnational & National Organsiation & Federations					
International Cocoa Organisation	X	X	X	X	X
Alliance of Cocoa Producing Countries	X	X	X	X	
International Cocoa Initiative	X	X	X	X	
The Federation of Cocoa Commerce	X	X	X		
Cocoa Merchants' Association of America	X	X	X		
Farmers Co-operatives					
Kuapa Kokoo Ltd	X	X	X	X	X

Appendix 7.3: Interview Agreement

Sophie van Huellen
School of Oriental and African Studies
University of London
Email: sv8@soas.ac.uk
Mobile: +44 (0)741 1144 400

Interview Agreement

Please specify, which of the following details can be used for my PhD and related publications:

◯ Personal name

◯ Position within company or organisation

◯ Affiliation (company's or organisation's name)

◯ Sector (e.g. export sector, government organisation)

◯ None (completely anonymous)

I hereby confirm, that all information gained from this interview will solely be used for my PhD and related publications. No commercial gain will be made from it.

I further guarantee, that I will not mention any personal name, position, affiliation, or sector detail if not explicitly specified above.

All statements and information, which I wish to use in my PhD or related publications, will be sent to you for approval. Information or phrases, which do not find approval, will be deleted or rephrased until approval is given.

Many thanks for taking the time to participate in my PhD project!

Sincerely,

…………………………………… ………………………………….
Sophie van Huellen Date

Appendix 7.4: Letter of Introduction Cocobod

SOAS
University of London

Chief Executive of Ghana Cocoa Board.
Ghana Cocoa Board
Cocoa House
PO Box 3197
Accra, Ghana.

SOAS, University of London
Thornhaugh Street
Russell Square
London WC1H 0XG
+44 (0) 20 7637 2388

www.soas.ac.uk

02 October 2013

Dear Mr Chief Executive of Ghana Cocoa Board

LETTER OF INTRODUCTION – Ms Sophie van Huellen

Sophie van Huellen is a 3rd year PhD student in the Department of Economics, School of Oriental and African Studies (SOAS), University of London. The objective of her PhD is to examine commodity price formation in general as well as applied to cocoa and coffee, and value formation in Global Value Chains (GVCs) in cocoa. The second part of this project will cover trade practices, risk management and transfer, the role of the state, value addition, and regional integration.

As part of her fieldwork in Ghana, we would like her to conduct interview-based studies with stakeholder in the Ghanaian cocoa value chain. This includes the Ghana Cocoa Board, its divisions and subsidiaries, other government agencies (e.g. Ministry of Finance and Economic Planning), licensed buying companies (e.g. Cocoa Merchants Co. Ltd., Kuapa Koko, Produce Buying Company), haulers (e.g. Global Haulage Co. Ltd.), international buyers (e.g. Barry Callebaut, Cargill, Olam), national and international organisations (e.g. International Cocoa Organisation, Ghana Cocoa, Coffee and Shea Nut Farmers Association), local processors (e.g. Cocoa Processing Company, Afrotropics), and farmer cooperatives.

In this context, we would be particularly thankful if you could facilitate her interviews with people in charge of the following positions.

- Warehousing and Port Operation Manager
- Shipping Manager
- Marketing Manager
- Managing Director of Quality Control Operations
- Director of Research
- Management Director of CSSVD

Participation in the fieldwork will be highly confidential. Results will be published on a 'no-name basis' and as aggregate and average findings as part of her PhD thesis and related papers. The thesis and its fieldwork are being supervised by Professor Nissanke, a specialist in global trade and commodities and are subject to the research guidelines and ethical standards of the University of London.

The Queen's Anniversary Prizes
2009

During her fieldwork, Ms Sophie van Huellen can be contacted via email sv8@soas.ac.uk. We are happy to provide a set of broad questions we would like to raise in the interviews.

We would be grateful if you could provide her with the necessary assistance to conduct her fieldwork.

Thank you.

Yours sincerely,

Prof. Machiko Nissanke

(Supervisor)

Appendix 7.5 Email to Interview Partners

Dear [NAME]

I hope this email finds you well.

[NAME] kindly provided your email contact. [*if applicable*]

I am Sophie, a second year PhD student at SOAS, University of London. My research is on cocoa chains and covers everything that is related to price discovery, price setting and price-related risk mitigation practices throughout the chain. This includes trade practices and chain structure as well.

Against this background, I am looking for interview partner, who are working in cocoa trade or associated areas and would be able to spend 30 to 40 minutes for an informal interview in person or over the phone.

I am fully aware that some of this information is highly sensitive and cannot be shared with the general public. I am not seeking detailed information about company specific trade strategies and akin but rather a broad introduction in the functioning and peculiarities of cocoa trade in general.

All information will be used for my PhD and related publications only (no commercial gain will be made from it). Interviews will be entirely anonymous, if it is not explicitly agreed upon mentioning name, profession, and/or affiliation. All information incorporated in my PhD and related publications will be sent for review by the interviewee before publication. Information or phrases which do not find approval will be deleted or rephrased until approval is given.

For further information, I attached an outline of potential interview questions as well as an interview agreement. Questions are open and semi-structured and should only serve as a general guideline.

I am very much looking forward to your reply.

With sincere regards,

Sophie

****
Sophie van Huellen
PhD Candidate, Economic Department
School of Oriental and African Studies
University of London
****

Appendix 7.6: Key Points for Interviews

Introductory Text

My research project covers four main areas regarding cocoa chains: (1) trade, (2) price discovery, and (3) price risk management, (4) value addition. Within these areas I focus particularly on beans originating from Ghana and Cote d'Ivoire. The following sub-question could be relevant under the above headlines:

Multinational/International Intermediaries and End-Producers

1. **Trade and logistics:**
   - From **whom** and from **where** are beans **bought** (Government Agency, farmer co-operative, local traders at ports, farm-gate, dedicated trading places)?
   - **How** are beans **bought** (by cash, by forward contracts, domestic or foreign currency)?
   - **How** are beans **transported** (own or third party vessels, bulk trade or other forms of transportation)?
   - **How** are beans **stored** (own or third party warehouses, exchange registered warehouses)?
   - **How** beans are **sold** (long-term contracts, one-period contracts, open market, in domestic or foreign currency)?

2. **Price discovery and price setting:**
   - How are cocoa **prices set/discovered** (public or private available benchmark indicators for price setting, open markets, individual bargaining, futures or cash market prices)?
   - Have there been any **significant changes** in the way prices were specified over the last decades?
   - How on your opinion do **financial investors influence** commodity futures markets?
   - How do you assess the **importance** of **the futures market** relative to the physical market in **price discovery**? Which price does drive which?
   - How **transparent** is the physical market relative to the derivative market (transactions, trading partners, price settlement)?

3. **Price risk management (exchange rate risk and commodity price risk):**
   - Which **instruments** are used for mitigating **short-term and long-term** price risk (hedging via derivatives, forward contracts, long-term contracts, diversification/vertical integration)?
   - Have there been any **significant changes in the degree of price-related risk** over the last decades?
   - Have there been any **significant changes in the way such price-related risk is managed** over the last decades?

4. **Value addition and regional/global chains:**
   - **Where** are cocoa beans **processed**?
   - What **proportion** is processed **at origin** and what proportion is processed after export?
   - Do **beans** processed and exported regionally **differ** from those exported and processed globally?
   - Who **owns** processing capacities at origin (privately owned, state owned)?
   - Which of the West African cocoa producing countries do engage in **regional trade** for cocoa beans and/or cocoa/chocolate products?

5. **Institutional questions**
   - Who has the agenda setting power i.e. who defines the terms of trade and the way the trade is executed?
     - Who is setting the standards and organisational form of exchange – **legislative**
     - Who is monitoring the performance of these standards and forms of exchange; if there is any dispute, how do you settle it? – **judicial**
     - Who helps people to meet standards; who is enforcing these rules? – **executive**
   - Who decides about the prices for farmers? How is the **farm-gate price** calculated; what variables are considered? Who has a saying in the level of the farm-gate price? (**legislative, judicial, executive**)
   - How is the **margin** for the **LBCs** calculated? (**legislative, judicial, executive**)
   - The **people** you are **trading with**, do you know them in person? Are they the same people every year?
   - How do the **contracts** look like? What are the terms agreed upon? Are these contracts **individually defined** or **standardised**? If yes, who sets the standards for these contracts?
   - **Demand** and **supply uncertainty**? How unpredictable are they? How do you predict them? Do you know the demand of the multinational buyers ex ante?
   - Are **contract** terms sometimes **renegotiated** after the trade took place? Who is mediating such disputes? What is the subject of such renegotiations?
   - **Who are the multinationals** you are dealing with? How many trading partners do you have? What do you know about them? How often do new ones come along?
   - What is the **salvage value of unsold cocoa**? What are you doing with the cocoa you cannot sell do multinationals? Do you get less of more?
   - How does the Cocobod acquire its resources for its services? **Trade margin, taxation**, …?
   - Which **international trade agreements** do affect cocoa trade?

6. **Question about economic rents**
   - Endogenous and/or constructed rents:

    - Innovation rents; Technology or institutional rents, having command over scarce technologies
    - Human resource rents, having access to better skills than competitors
    - Organisational rents, possessing superior forms of internal organisation
    - Marketing rents, possessing better marketing capabilities and/or valuable brand names
    - Relational rents, having superior quality relationships with suppliers and customers
- Exogenous:
    - Resource rents, access to scarce natural resources
- What kind of **barriers to entry** exists for new trading firms/LBCs to enter the business in Ghana?
- What is the **information** you would like to get about your trading partners? What kind of information gathering do you involve in? Does this give you an advantage over your trading partner?

Local Processors

1. **Firm characteristcs**
    - How many beans do you process annually?
    - How many people are employed in the factory?
    - When did this factory open?
    - What products are produced here?

2. **Incentives and processing economy**
    - Why did you decide to process your beans at origin?
    - You are operating in a free zone. What are the benefits?
    - What are the main obstacles you face in processing at origin?
    - What are the main advantages in processing at origin?

3. **Inputs and costs**
    - Beans
        - What kind of beans is bought for processing?
        - How are beans bought?
        - How are prices set for beans?
        - How many beans do you buy at origin and how many are imported?
    - Sugar, milk and other ingredients
        - Do you have to import other ingredients?
        - From where do you import these ingredients?
        - Would you welcome a development where you could source these inputs locally?
    - Infrastructure: Is the infrastructure sufficient?
        - Energy
        - Water

    - Roads
    - Finance
- Labour
    - What is the percent of foreign labour hired?
    - Which positions are filled with foreign labour?

4. **<u>Trade and export/import duties</u>**
    - Trade
        - Who receives the intermediate products sold?
            - If they are shipped to the mother company for further processing, how is the value of the products defined in the books? (cost approach)
            - If they are sold to an external party, how are prices set for these goods? (financial market)
        - What is the price differential (value addition) of the product?
        - How are contracts for intermediate products specified? (forward sale, long-term agreements, personal relationship)
        - What determines your decision in the amount and type of cocoa processed?
        - Can processed cocoa been stored for a longer duration? Do you own warehouses?
    - Trade duties
        - Are there any export duties you have to pay on the intermediate products?
        - Are there any import duties you have to pay if
            - Selling to the mother company?
            - Selling to another company?
    - International standards
        - Which in international standards do you have to follow?
        - Is it difficult to achieve these standards?
        - Can Barry Callebaut influence the definition of such standards?

5. **<u>Competition</u>**
    - How stringent is competition in processed cocoa products?
    - What are barriers to entry into the sector for other companies?
    - Do you prefer Ghana as a sourcing country over others? Why?
    - Why does it make economic sense to source the beans yourself?
    - Are there attempts for specialty beans (organic, traceable, etc.). How is this achieved?

6. **<u>Bean sourcing purely for export</u>**
    1. How are beans sourced for export? (different countries)
    2. How easy is bean sourcing in Ghana compared to other producing countries?
    3. How do you agree upon prices for the beans? (different countries)
    4. How does the process of sourcing differ?

Licenced Buying Companies

1. **<u>Firm information</u>**
    - Your position in the firm?
    - What does your firm do?
    - How many districts do you cover?
    - How many farms do approximately deliver their cocoa to you?

2. **<u>Profits, costs and competition</u>**
    - Profits and costs
        - How do you earn revenue if the margins per cocoa bag are fixed?
        - How are these margins fixed? Do you have a saying in this process?
        - Were these margins relatively stable over the last decade? Do they vary with the price of cocoa or only with industry costs?
        - What are your operational costs? Do you think the price committee accounts for them sufficiently?
    - Competition and ease of business
        - How did you start with your business? How did you establish the necessary relationships?
        - What was your motivation in starting to operate an LBC?
        - Did these expectations materialize? If not, why did you stay in business?
        - Are there any barriers to entry for competing firms?
        - How do you defend your sourcing grounds? How do you insure purchasing clerks and farmers are selling to you?
    - Wider business
        - Are you only operating as a cocoa LBC? If your company is involved in other business areas, what are those and how does this support you operations as a cocoa LBC?
        - Are you only operating in Ghana? If not, how does the system in Ghana compare to other countries and why might doing business there be more or less profitable?
        - Do you also buy specialty cocoa (organic, traceability, fair trade, …)? How do you ensure the required standards? Why does it make economic sense to purchase such beans?

3. **<u>Personal relationships, supervision and information</u>**
    - Purchasing clerks
        - How important is your relationship to purchasing clerks in the cocoa villages?
        - How do you select purchasing clerks?
        - How do you pay purchasing clerks? How is the pay rate decided upon?
        - How do you supervise them, regarding handling cash and delivering high quality beans?
    - Hauliers

    - How important is your relationship to hauliers?
    - How do you select hauliers?
    - How do you pay hauliers? How is the pay rate decided upon?
    - Do you outsource the transportation of beans (own vehicle or third party vehicles, vertical integration to hauliers or separate)?
    - Why is it/is it not advisable to outsource the transportation?
- District officers
    - How important is your relationship with district officers?
    - How do you select district officers?
    - What falls under their responsibility?
- On whom do you rely for/whom do you feed with information in order to tailor your business operations?

4. **<u>Ownership and risk</u>**
    - When do you attain ownership of the crop (when the purchasing clerk buys the beans, when he delivers the beans, when they reach the sheds)?
    - Who is held responsible for the loss or damage of beans during transportation between society and district, district and port?
    - How is this responsibility dealt with? How do you insure yourself against bean loss and damage?
    - When do you start buying? How do you decide when to take ownership of the beans?

5. **<u>Finance</u>**
    - How do you finance your operations? Is the funding by Cocobod sufficient?
    - Can availability of cash give you an edge over other LBCs?
    - How do you manage your cash exposure and credit turnaround?
    - Why is your market share large/small compared to other LBCs?

Hauliers

1. **<u>Firm information</u>**
    a. How **many beans** do you transport annually on average (last three years)?
    b. How **many districts** do you cover?
    c. How **many LBCs** use your service?

2. **<u>Profits, costs and competition</u>**
    a. Profits and costs
        i. How do you **earn revenue** if the margins per cocoa bag are fixed?
        ii. How are these margins fixed? Do you **feel** that you **have an influence** on the process in which these margins are fixed?
        iii. Were these **margins relatively stable** over the last decade? Do they **vary with** the **price of cocoa** and/or only with **industry costs**?
        iv. What are your **main operational costs**?

v. Do you think the price committee accounts for them **sufficiently**?

b. Competition and ease of business
   i. How did you **start** with your business **(company history)**?
   ii. How did your **business change** since you entered?
   iii. How many **other haulage businesses** exist in Ghana?
   iv. Is it relatively **easy** for other competing firms to **enter into the business**?
   v. How do you **defend** your business against competitors? How do you ensure clients hire you and not others?

c. Wider business
   i. Do you transport from farm-gate to **district?**
   ii. Do you transport from district to **port**?
   iii. Are you **only operating as a hauler**? If your company is involved in other business areas, what are those and **how does this support you operations** as a hauler?
   iv. Do you **associate with** any **LBCs**? If yes with which?

3. **<u>Personal relationships, supervision and information</u>**
   a. Who **hires your services** (LBCs or CMC)?
   b. **Who pays** for your services?
   c. LBCs
      i. Do you maintain personal relationships to the LBC district officers?
      ii. How do the LBCs select you?
      iii. How do they pay for your services (advance, once you delivered)?

   d. CMC
      i. Do you maintain personal relationships to the CMC officers?
      ii. How does CMC hire you?
      iii. How do the pay for your service (advance, once you delivered)?
      iv. How do you pay hauliers? How is the pay rate decided upon?

4. **<u>Ownership and risk</u>**
   a. Do you **own** your **trucks**?
   b. Do you have **warehouses** which belong to you?
   c. If during **transportation** beans are **damaged** (rain, road accident, etc.), who is held **responsible**?
   d. If there is any damage incurred, do you get paid for the damaged bags as well?

5. **<u>Finance</u>**
   a. How do you **finance** your operations?

General Questions for other Interview Partners

1. **<u>Trade and logistics:</u>**

- From **whom** and from **where** are beans **bought** (Government Agency, farmer co-operative, local traders at ports, farm-gate, dedicated trading places)?
- **How** are beans **bought** (by cash, by forward contracts, domestic or foreign currency)?
- **How** are beans **transported** (own or third party vessels, bulk trade or other forms of transportation)?
- **How** are beans **stored** (own or third party warehouses, exchange registered warehouses)?
- **How** are beans **sold** (long-term contracts, one-period contracts, open market, in domestic or foreign currency)?

2. **<u>Price discovery and price setting:</u>**
   - How are cocoa **prices set/discovered** (public or private available benchmark indicators for price setting, open markets, individual bargaining, futures or cash market prices)?
   - Have there been any **significant changes** in the way prices were specified over the last decades?
   - How on your opinion do **financial investors influence** commodity futures markets?
   - How do you assess the **importance** of **the futures market** relative to the physical market in **price discovery**? Which price does drive which?
   - How **transparent** is the physical market relative to the derivative market (transactions, trading partners, price settlement)?

3. **<u>Price risk management (exchange rate risk and commodity price risk):</u>**
   - Which **instruments** are used for mitigating **short-term and long-term** price risk (hedging via derivatives, forward contracts, long-term contracts, diversification/vertical integration)?
   - Have there been any **significant changes in the degree of price-related risk** over the last decades?
   - Have there been any **significant changes in the way such price-related risk is managed** over the last decades?

4. **<u>Value addition and regional/global chains:</u>**
   - **Where** are cocoa beans **processed**?
   - What **proportion** is processed **at origin** and what proportion is processed after export?
   - Do **beans** processed and exported regionally **differ** from those exported and processed globally?
   - Who **owns** processing capacities at origin (privately owned, state owned)?
   - Which of the West African cocoa producing countries do engage in **regional trade** for cocoa beans and/or cocoa/chocolate products?

5. **Institutional questions**

- Who has the agenda setting power i.e. who defines the terms of trade and the way the trade is executed?
    - Who is setting the standards and organisational form of exchange – **legislative**
    - Who is monitoring the performance of these standards and forms of exchange; if there is any dispute, how do you settle it? – **judicial**
    - Who helps people to meet standards; who is enforcing these rules? – **executive**
- Who decides about the prices for farmers? How is the **farm-gate price** calculated; what variables are considered? Who has a saying in the level of the farm-gate price? (**legislative, judicial, executive**)
- How is the **margin** for the **LBCs** calculated? (**legislative, judicial, executive**)
- The **people** you are **trading with**, do you know them in person? Are they the same people every year?
- How do the **contracts** look like? What are the terms agreed upon? Are these contracts **individually defined** or **standardised**? If yes, who sets the standards for these contracts?
- **Demand** and **supply uncertainty**? How unpredictable are they? How do you predict them? Do you know the demand of the multinational buyers ex ante?
- Are **contract** terms sometimes **renegotiated** after the trade took place? Who is mediating such disputes? What is the subject of such renegotiations?
- **Who are the multinationals** you are dealing with? How many trading partners do you have? What do you know about them? How often do new ones come along?
- What is the **salvage value of unsold cocoa**? What are you doing with the cocoa you cannot sell do multinationals? Do you get less of more?
- How does the Cocobod acquire its resources for its services? **Trade margin, taxation**, …?
- Which **international trade agreements** do affect cocoa trade?

6. **Question about economic rents**

- Endogenous and/or constructed rents:
    - Innovation rents; Technology or institutional rents, having command over scarce technologies
    - Human resource rents, having access to better skills than competitors
    - Organisational rents, possessing superior forms of internal organisation
    - Marketing rents, possessing better marketing capabilities and/or valuable brand names
    - Relational rents, having superior quality relationships with suppliers and customers
- Exogenous:
    - Resource rents, access to scarce natural resources
- What kind of **barriers to entry** exists for new trading firms/LBCs to enter the business in Ghana?

- What is the **information** you would like to get about your trading partners? What kind of information gathering do you involve in? Does this give you an advantage over your trading partner?

Cocobod Research Manager

1. <u>**Value Addition**</u>

- **How much** cocoa is processed at origin?
- What are the **obstacles and difficulties** in processing at origin?
- Who **owns processing capacities** at origin (privately owned, state owned)?
- How are **intermediate products taxed** in comparison to cocoa beans? How are cocoa beans taxed?
- How many local **workers** are employed in the processing sector?
- What is the **percentage share** of **people directly or indirectly employed** in the cocoa sector in total population?
- **Ghana Free Zones** and who is benefitting from these zones? Only foreign or also domestic?
- How much of the **inputs are imported** and how much is consumed from local sources?

2. <u>**Regional Integration and Trade**</u>

- Are cocoa beans or products **traded within West Africa**? Which of the West African cocoa producing countries do engage in regional trade for cocoa beans and/or cocoa/chocolate products?
- Are there any **particular trade agreements** to enhance regional trade integration?
- What are the **obstacles** for further regional integration?
- Which **institutions** were established and are functional in order to promote and facilitate regional trade?

3. <u>**Data**</u>

- Producer price **bonus**.
- **Import/Export** of Cocoa beans, intermediate products, and chocolate by origin/destination.
- **Import/Export taxes** imposed on cocoa beans, intermediate products and chocolate.
- Who was granted **licenses** for **Ghana Free Zones** and is data on the specification of such licenses available?
- Data on **processing**. Percentage share of beans processed at origin by processor?

Technical Advisor, Cocoa Affairs, Ministry of Finance & Economic Planning

1. **Cocoa Board Budget**

- Who decides when and how about the **Cocoa Board budget**?
- Is the Cocoa Board running a **deficit or a surplus**?
- **Stabilisation fund**; what is if for and when was it implemented (crop finance, prices)?
- How does the government **extract revenues** from cocoa trade (export tax, Cocoa Board revenue)?

2. **Price Committee**

- How much of a say does the Finance Ministry/Minister have in **setting the prices**?
- What is **taken into consideration** by the Finance Ministry before entering into price negotiations?
- How much **political pressure** goes into the price negotiations (election promises, international organization pressing for higher producer prices)?

3. **Historical Context**

- **Why** implement **forward sales**? What was **before**?
- Why could Ghana **withstand liberalization**?
- **Why** did the government decide to **fix the producer prices**? Was this always case?

4. **Cocoa Producer Alliance**

- How good is the **cooperation among cocoa producing regions**? How much of a competitor are other countries and how much cooperation takes place?
- How much **information** is **exchanged** with one another? What kind of information exchange would you like to see not currently taking place? Are these information also shared with private entities?
- What is the **Alliance of Cocoa Producing Nations** (organized the World Cocoa Conference 2012)?
- Is there any **cooperation regarding cocoa prices** and bargaining power? Can you give an example for such cooperation?
- How much **supply coordination** is **possible** in cocoa?

5. **Regional Integration and Trade**

- Are cocoa beans or products **traded within West Africa**? Which of the West African cocoa producing countries do engage in regional trade for cocoa beans and/or cocoa/chocolate products?

- Are there any **particular trade agreements** to enhance regional trade integration?

- Who **owns processing capacities** at origin (privately owned, state owned)?

Pod Counting

1. **<u>Company Characteristics</u>**
    - Are you working for LBC or multinational buyer/exporter?
    - How many people are employed at your company?
    - When did your company start business in Ghana?
    - What is your task at this company?

2. **<u>Information and institutions</u>**
    - How important is forecast of future demand and supply for the price formation process?
    - How important is forecast of exchange rate for the price formation process?
    - How predictable are these things?
    - With which information do firms go into price negotiations?
    - Which other information would you like to have?
    - How do you determine how many beans you are sourcing from which country?
    - Are the beans traceable?

3. **<u>Transportation and logistics</u>**
    - How do you ensure buying clerks are selling only to you?
    - How do you ensure the quality of the beans?
    - How are the beans transported?
    - How do you select purchasing clerks?
    - How do you select hauliers?

4. **<u>Price discovery and price setting</u>**
    - How is the buying price for the beans determined?
    - How does this process vary from other West African countries?
    - How important is the future market in this process?

5. **<u>Price risk management?</u>**
    - Which techniques do you use to mitigate price and quantity risk?
    - Did these techniques change over the last decades?
    - Who owns the beans until delivery to the port? How do you insure yourself against risks while the cocoa is in your possession?
    - Why is vertical integration important?
    - What are potential barriers to entry into the cocoa business?

Appendix 7.8 Price for Shipping

COCOA MARKETING COMPANY (GHANA) LIMITED

3RD FLOOR COCOA HOUSE
KWAME NKRUMAH AVENUE
P.O. BOX 1017, ACCRA-GHANA.

TELEPHONE: +233 21 668352
+233 21 668464
+233 21 668281
FAX: +233 21 665076
E-MAIL: info@cocoamarketing.com

Our Ref: CMC/DS/G/12/32

Date: 1[st] October 2013

TO: ALL BUYERS

Dear Sir,

We publish below the Freight Rates for the various ports for 2013/2014 Cocoa Season for your information, please.

COUNTRY	COCOA BEANS	(BAGS & BULK)
UK & DUBLIN	£	39.00
GERMANY	EURO	53.00
HOLLAND	EURO	53.00
BELGIUM	EURO	53.00
BORDEAUX	EURO	53.00
BILBAO	EURO	53.00
SANTANDER	EURO	53.00
DUNKERQUE	EURO	53.00
LE HAVRE	EURO	53.00
ROUEN	EURO	53.00
MARSEILLES	EURO	60.00
TRIESTE	EURO	60.00
ITALY (GENOA)	EURO	60.00
BARCELONA	EURO	60.00
VALENCIA	EURO	60.00
LIVORNO	EURO	60.00
*RIVALTA. SCRIVIA	EURO	60.00
JAPAN	US$	100.00
KOREA (PUSAN)	US$	95.00
SINGAPORE	US$	95.00
PORT KLANG	US$	95.00
CANADA	C & I	
PHILADELPHIA	C & I	
NORFOLK/MIAMI	C & I	
BALTIMORE	C & I	
CHARLESTOWN	C & I	
MORRISTOWN	C & I	

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OTES:

1. Bunker surcharge is subject to change and therefore excluded in the freight. The rate applicable, if any, at the time of shipment, will be for buyer's account. Current BAF is 25% for all destinations except Japan, Korea (Pusan), Singapore & Port Klang.

2. Discount for contracts (Cocoa Beans) converted from CIF to C&I is £39.00 per tonne. Discount for contracts (mega bulk/bulk in barges/bulk in containers/break bulk to all destinations) converted from CIF to FOB is GBP 39.00 per tonne, plus Insurance premium of 0.5075% of CIF price.
Discount for contracts (Bags in containers to all destinations excluding Japanese ports, Pusan, Korean ports, Singapore, Port Klang) converted from CIF to FOB is GBP 39.00 per tonne, plus Insurance premium of 0.5583% of CIF price.
Discount for contracts (Bags in containers) to Japanese ports, Pusan, Korean Ports, Singapore, Port Klang converted from CIF to FOB is GBP 39.00 per tonne, plus Insurance premium of 0.7653% of CIF price.

3. Bill of lading for contracts concluded on CIF terms will be marked "FREIGHT PREPAID". The freight prepaid in the tariff currency, will be shown on the commercial invoice, payable by the Buyer to the collecting Bank on presentation of the shipping Documents.

4. Rate for Cocoa Beans out of Tema and Takoradi are loaded under FCL/FCL.

5. The basic UK freight of £39.00 is specifically applicable to Tilbury and Felixstowe ports. All other ports in UK may attract an on-carriage cost(s), which will be for the account of the Buyer.

6. Shipments to Rivalta Scrivia may also attract an on-carriage cost(s), which will be for the account of the Buyer.

7. Containerized shipment will attract additional container handling and dressing charge of USD1.50 per tonne.

8. Shipment both (bags and bulk) in barges and mega bulk shall attract additional handling charge of USD1.00 per tonne

9. These additional container handling dressing charges of USD1.50 and USD.1.00 per tonne respectively, shall be for the account of the buyers.

10. The rates published are applicable from 1st October 2013 (2013/2014 cocoa crop) to 30th September 2014.

Yours faithfully,
COCOA MARKETING COMPANY (GHANA) LIMITED

PAUL ISAAC KWOFIE
SHIPPING MANAGER
FOR: MANAGING DIRECTOR

Cc: Ghana Shippers' Authority