Price formation on the futures market and the physical market for cocoa

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Abstract

This study examines the determinants of cocoa prices in the futures market as well as in the physical market for raw cocoa. This examination is organized in two interrelated project strands: In the first project strand, financial mathematical and econometric models are extended by data-driven modeling. The resulting models are evaluated for their predictive power and used to simulate fundamental and stock market-based effects on the cocoa production chain under changing regulatory and political conditions. The second project strand focuses on marketing structures and price formation as well as their socio-economic conditions and impacts in the main cocoa producing country, Côte d'Ivoire. Farming household data that is representative for all cocoa-growing regions in the country is evaluated and supplemented by an institutional analysis of the local cocoa market.

The first project strand on the futures market is able to identify the price determinants for cocoa price trends and daily cocoa returns. However, these do not contribute to predictive quality, and price trends are determined in particular by exogenously occurring news. This points to an efficient price discovery in the cocoa futures market which takes place in the spot market from 2015 and has an effect on the futures price trend. The second project strand on the physical cocoa market finds that regional deviations from the officially set producer price exist, despite the strong regulation of the cocoa sector in Côte d'Ivoire. An analysis of prices along the value chain shows that the price obtained by the cocoa regulator through forward contracts has been systematically lower than the world market price in recent years. Measures such as the "Living Income Differential" have so far failed to increase the livelihoods of cocoa farmers in the country.

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1 Aims and objectives of the project

Sixty percent of the cocoa-containing end products sold in Germany today come from sustainable cultivation. In the long term, this share is to be increased to 100%. To achieve this goal, the German government has developed a 10-point plan that emphasizes the formation of a sustainable cocoa sector with fair prices for cocoa farmers.

However, the price discovery process on the futures markets as well as on the physical market for cocoa is often non-transparent, is partly considered inefficient and existing data is partly outdated and provides inconsistent results. In addition, it is not yet clear how the increased participation of financially oriented investors in the recent past affects companies active in the production and processing of cocoa, particularly with regard to the benefits of futures markets for price hedging.

Against this background, the aim of this research project is to investigate the determinants of prices of the *soft commodity* cocoa on the futures market as well as of raw cocoa on the physical markets. For this purpose, existing financial mathematical and econometric models are extended. The resulting models are evaluated for their predictive power and used to simulate fundamental and stock market-based effects on the cocoa production chain under changing regulatory and political conditions. Furthermore, primary quantitative and qualitative data on transactions and socio-economic aspects of the actors along the value chain collected for this research is used to gain knowledge on price formation on the physical markets and the associated real situation of households involved in cocoa farming. The analysis of the physical cocoa market focuses on Côte d'Ivoire – also known as Ivory Coast – as the largest producing country, where about half of the cocoa consumed in Germany comes from.

The two project strands, futures market and physical cocoa market, are discussed in two separate thematic blocks in the chapters 2 and 3 before the individual results are interpreted and summarized in the chapters 4 and 5. The synthesis of the various research results is intended to provide a more comprehensive picture of the various price discovery and price formation mechanisms in the cocoa futures market and the physical cocoa markets. These results are intended to provide evidence-based policy advice to the German Federal Ministry of Food and Agriculture (BMEL), which has lead responsibility for cocoa as a commodity and represents the interests of the German government in this area in various national and international bodies.

The planning and sequence of the project proceeded as shown in Figure 1. The starting point for both project strands was the exploration and preparation of existing econometric models, data sets, and analyses of the institutional environment in the main cultivation areas of West Africa.

Topic block A on the functioning and efficiency of price formation and price determination processes on the cocoa futures market was supervised by Jacobs University Bremen. In work package 2 econometric

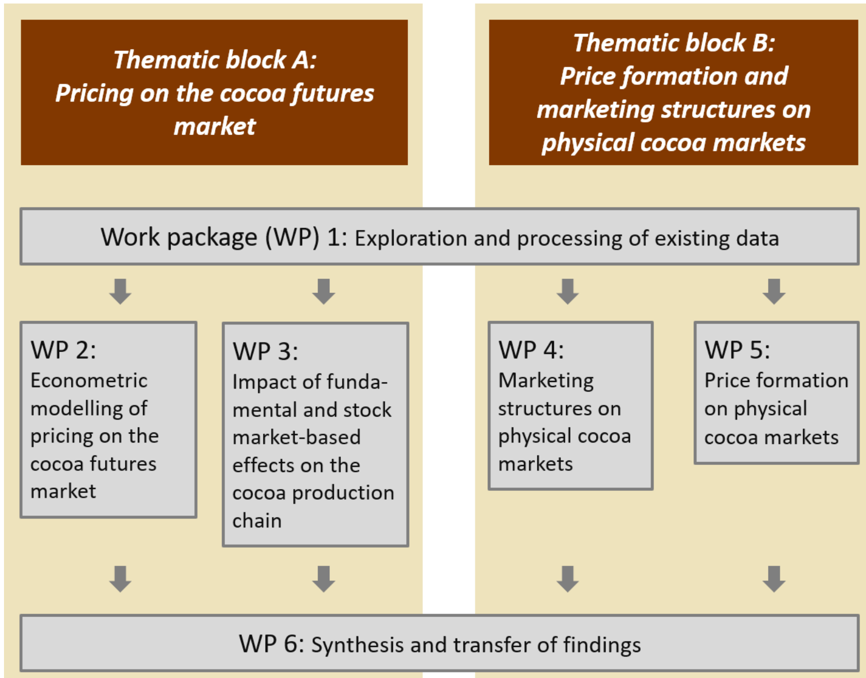


Figure 1: Planning and procedure of the project

modeling of price determination on the cocoa futures market and testing of machine learning for price predictions was carried out. In doing so, the models were not only transferred, but extended at four points in the modeling to increase predictive accuracy: first, as many potential predictors as possible were analyzed; second, model specifications were designed in such a way that the inter-dependencies often caused by changes in trade and marketing regulations could be soundly investigated; third, the consequences of the decoupling of commercial participants from finance-oriented investors were modeled; fourth, machine learning methods allowed the analysis of patterns and structures in unexplained deviations from actual observations. A joint prediction was then developed from these components – averaged across different methods. In work package 3, *Impact of fundamental and stock market-based effects on the cocoa production chain*, the impact of regulatory, fundamental, and stock market-based effects on price formation was investigated. This was first done through case studies covering prominent constellations in the recent past, such as financial regulations. Furthermore, simulation methods were used to generate scenarios in order to calculate stock market-based effects and derive their impact based on the historical case studies.

Work package 4, supervised by researchers from RWI - Leibniz Institute for Economic Research, dealt with marketing structures on physical cocoa markets. First, an overview of the prevailing marketing structures in Côte d'Ivoire and in Ghana as the second main producing country was created. Findings obtained during a scoping mission to both countries were incorporated into this work. The main purpose of this work package was to capture the institutional environment and broader contextual background for the planned data analysis during an observational study in Côte d'Ivoire, thus providing a better understanding on the mechanisms behind price formation for this case study. This data collection and analysis took place as part of Work Package 5, *price formation in physical cocoa markets*. An iterative exchange process in work package 6 also sought to identify and elaborate on linkages between the two work packages.

2 Pricing on the cocoa futures market

2.1 State of research

The volatile and non-transparent price formation on the London cocoa futures exchange poses a major challenge for European processors who want to hedge against price risks of the essential raw material cocoa. At the same time, West African producers are particularly affected by price changes due to their dependence on commodity exports, as futures prices are reflected in spot market prices. The functioning of futures markets implies futures prices to be linked to the underlying commodity (in this case, raw cocoa) and to be in line with expectations regarding supply and demand for raw cocoa. Uncertainty in weather, crop yields, and global supply and demand inevitably lead to high volatility in agricultural commodity markets, which have been the subject of multiple studies. However, no comprehensive scientific study has yet been conducted to investigate the origin of volatility in cocoa futures prices.

Over the past decade in particular, trading in agricultural commodities has become more popular among commodity indices and individual financial traders. Thus, the cocoa futures markets have also recently seen greater participation by financially oriented investors, potentially leading to an incremental disconnect from fundamental value and boosting the risk of inefficient pricing in futures markets (Irwin and Sanders, 2011). Increasingly, other factors are the basis of market participants' transactions, such as profit-seeking or hedging the price risk associated with equities (van Huellen, 2019; Main et al., 2018; Bohl et al., 2020).

Some studies test the financial theory that futures prices should include the cost of buying and selling futures contracts. The theory ”cost of carry” of futures contracts includes the cost of storage (in inventories), the interest rate, and the profit made by immediate availability of the commodity (Fama and French, 1987; Garcia, 2004; Brenner and Kroner, 1995). Jumah et al. (1999) confirm that interest rates have an effect on cocoa futures prices. An alternative theory to the cost of carry is the risk premium that should be included in the futures prices. Speculators demand returns for hedging the price risk market participants face in the cocoa cash market. Main et al. (2018) finds that risk premia have increased since 2004 in the cocoa futures market implying that cocoa futures prices still serve as price hedging mechanism.

Moreover, some authors of empirical studies have analyzed the influence of real economic and exchange-based market factors on cocoa futures prices. Ruf and Siswoputranto (1995) conclude that inflation plays a role in price formation insofar as agricultural commodity securities are an instrument for investors to hedge against inflation, since rising inflation causes agricultural commodity prices to rise (Huchet and Fam, 2016). Natanelov et al. (2011) find that crude oil and cocoa prices have a close, long-term relationship and that oil prices have influenced cocoa prices since 2002. Gold also appears to exert an influence on cocoa futures prices, as gold prices are known to be a fundamental measure of the overall global economic situation (Natanelov et al., 2011). Andreasson et al. (2016) found that political uncertainty does not have a significant effect on cocoa prices, but exchange rates – such as the US Dollar/ Great Britian pound exchange rate or the US dollar/euro exchange rate – affect cocoa futures prices due to the interdependence of the two major exchanges. The authors additionally note that exchange-based factors are involved in cocoa futures price formation. Nguyen et al. (2015) and Creti et al. (2013) elaborate that U.S. stock market prices (S&P 500) and cocoa futures market prices are negatively correlated. This supports the assumption that investors hedge the associated price risk of equities with cocoa futures. The increased share of financial instruments in agricultural commodity futures trading has an effect on the volatility of agricultural futures prices (Baldi et al., 2016). This in addition to the already high volatility that is common for agricultural commodities.

Dawson and White (2002) conclude that the major agricultural commodities traded on the LIFFE (now ICE London), which are not considered substitutes, do not exhibit common price discovery. This argues against the assumption that commodity index investors were shaping prices at the time the research was conducted. Index investors are not directional, but buy and hold futures contracts for their portfolio diversification strategy (Stoll and Whaley, 2011). Commodity indexes are financial instruments that track an industry benchmark, such as the Standard and Poor's-Goldman Sachs Commodity Index™ (S&P-GSCI), in which cocoa has a weighting of only 0.4%, or the Dow Jones-UBS Commodity Index™ (DJ-UBS), in which cocoa has a weighting of 0% (Irwin and Sanders, 2012).

Speculators have a directional view and are constantly re-taking their respective positions (buying or selling). However, the Commitment of Trader (COT) report published by the respective exchanges does not distinguish between speculators based on their speculative behavior, but between market participants who have hedging intentions and those who do not. In the literature, non-commercial traders are usually referred to as speculators because they do not hedge the price risk of the commodity (Kim, 2015). Nevertheless, no consistent results were found in terms of speculation and the effect on volatility or prices, although quantity of transactions, market depth, market participation, and speculation were explored (Haase et al., 2016; Huchet and Fam, 2016; Kim, 2015; Irwin and Sanders, 2012; Bohl et al., 2020; Wang and Yu, 2004; Han et al., 2017; Bryant and Haigh, 2004). van Huellen (2019)models the theoretical cocoa futures market and shows that cocoa prices are influenced by both market fundamentals and speculators. She also finds that prices form in the futures market and then spill over to the spot price. Ohemeng et al. (2016) find that price discovery occurs in the spot market and spills over to the futures market. The authors use only an approximation over futures prices for the spot price data. There is little other post-2000 literature on market efficiency and price formation between futures prices and spot prices.

2.2 Methods and material

The data used were taken from the Thomson and Reuters financial database, as well as from Internet databases in particular, the Food and Agricultural Organization (FAO) of the United Nations, the Intercontinental Exchange (ICE), and the International Cocoa Organization (ICCO). When available, all data sets were extracted for the period starting in 2000. Empirical analysis and modeling is performed on the InterContinental Exchange (ICE) cocoa futures contract data traded in British pounds, as it is essential for the European cocoa business. The data is extracted as the roll-over data which is characterized by the fact that once a contract matures, the data set is replaced by the next expiring cocoa futures contract. There are 10 contracts that are traded at the same time, as each contract has a length of 2 years with different maturities. Maturities occur in March, May, July, September and December (respectively 11 business days prior to the last business day of the maturity month). Cocoa futures prices are quoted for a contract equivalent to 10 tons of cocoa.

Econometric methods and efficient market theory were applied to examine the interactions between spot and futures market prices, and between futures prices at ICE New York and ICE London. Cointegration analyses were performed to test for long-run equilibrium. To test in which market price discovery takes place and which market responds for how long, the Impulse-Response Function was used in addition to the Vector Error Correction Method (VECM). For the transmission effect (spill-over) of the volatilities of the cocoa returns and the price predictors, the Generalized Autoregressive Conditional Heteroscedasticity (GARCH) model was used. Dynamic Conditional Correlation (DCC) was used for the time variation of the transmission effect.

Cocoa futures prices were calculated in returns as the log difference of price data and used for modeling. For the multivariate analysis of the fundamental data, various ”feature selection” algorithms were applied to extract variables that have an effect on cocoa returns. The algorithms used for this were Recursive Feature Elimination (RFE), Boruta, Lasso, Stepwise Feature Algorithm, Principal Component Analysis (PCA), and correlations. These variables were used in the next step to forecast cocoa returns, especially the daily price direction change (positive or negative returns). Machine learning algorithms such as K-nearest-neighbor (KNN), Kernel KNN, Random Forest, Gradient Boosting Machines (GBM), Support vector machines: SVM Linear, SVM Radial, Neural Networks (NN) such as Multilayer Perceptron (MLP), Gated Recurrent Unit

(GRU) and Long Short Term Memory (LSTM) were used to compute forecasting models.

To analyze the endogenous data generation process econometric models were used. The Autoregressive Integrated Moving Average (ARIMA) model is applied to model the dependence of time series data points. Returns typically exhibit conditional variances at the error term of an ARIMA model. However, it must be further ruled out that chaos is present in the data. Chaos is not present when a nonlinear autocorrelation arises from a known non-deterministic system. The time-dependent conditional variances can be represented using the GARCH model. ARIMA and GARCH models can also be used to forecast time series. However, financial data usually follow a random walk behavior, which means that prices are not predictable using their own time series.

In addition, machine learning algorithms were used for the forecasts to capture non-linear and non-parametric relations. The same models are applied as for multivariate forecasts. In addition, other statistical models such as TBATS, Exponential Smoothing: Error, Trend and Seasonality (ETS) and Moving Average were used. Also, Fast Fourier Transform (FFT) was used to test whether forecasting improves when data is converted to frequencies, allowing patterns to be detected more clearly. In a further step, concept drift detectors were tested. Because none of the models gave satisfactory results, a new method was developed based on the assumption of sliding time-varying windows. The principles of ARIMA, optimal input length and neural networks were combined to detect and forecast time-varying trends.

For the development of our own method, the behavior of the data was analyzed in more detail. After conversion to returns, economic data are usually considered stationary, i.e. each data point in the time series follows the same underlying distribution. This property does not hold for time series of financial prices, as can be observed for cocoa returns. The distribution of returns changes for each day, as illustrated by sliding windows with a fixed input length. Here, a sliding window, is a fixed length of days that rolls by one observation at each iteration. Time-varying distributions imply that the relation between observations changes over time; in other words, autocorrelation is day-dependent. While some days correlate with large data points in the past, others exhibit short-term autocorrelation. Therefore, machine learning (ML) algorithms can be adapted to estimate the day-dependent autocorrelations. The ARIMA method has a built-in parametric input length selection. Most common ML algorithms do not select the input length in advance and are trained with a large number of input data. However, using uncorrelated data can lead to biases. At the same time, a lack of sufficient data leads to inaccurate forecasts. ML, however, has the potential to transform ARIMA's selection of input data into a dynamic process. By adjusting for changing correlations, the relevant information can be captured for each individual day to be forecast and redundant inputs can be omitted. The selection of the length of past data used as input to the forecast appears to have a significant impact on forecast accuracy. Therefore, a new three-step method was developed in which a neural network first computes the optimal input lengths (for near-perfect prediction) for already known data. Then, the optimal input lengths are forecasts. In a final step, the forecasts optimal input lengths are used to forecast the returns and directional changes for unknown data.

2.3 Detailed presentation of the main results

Efficient price formation and price discovery of commodity futures contracts exist if they follow the theory of efficient markets. This basically results in four arbitrage rules to which futures contracts are subject. These represent risk-free profit opportunities for market participants that enable efficient price discovery. These profit opportunities exist only until the efficient price is established. These can be summarized as: a) spatial arbitrage between spot and futures prices, b) law of one price of futures prices of the same commodity between different exchanges, c) immediate integration of fundamental information in the price, and d) independence of successive price changes. Consequently, market efficiency requires that prices are formed solely by new information. Market participants immediately integrate all past, current, and expected information of prices and fundamental predictors into their transactions. This means that exogenous shocks and news determine price changes. However, this mechanism assumes rational expectations and risk neutrality of market participants (Fama, 1998, 1965). The growing participation of financially oriented investors raises doubts about whether efficient market theory continues to apply to cocoa futures prices.

In general, exchange-based financial prices also exhibit endogenous, self-generating dynamics. These are generated by the profit motive of market participants seeking patterns in past prices. However, when prices are endogenously generated, prices move back to their actual trend generated by fundamental news.

In the following, the four arbitrage rules for the cocoa futures market are reviewed to determine whether exogenous news drive the price trend even when endogenous dynamics exist.

2.3.1 Market participants

A futures contract is an agreement to buy or sell a standardized quantity at a predetermined price and time in the future. If a futures contract is entered into by two market participants, an open position is created. Thus, if a futures contract is purchased by one market participant and sold to another market participant, the number of open positions increases. An open position can be held until the maturity of the respective contract. However, a market participant's open position can also be liquidated before maturity by taking the opposite position. By offsetting the position before the contract expires, it is possible to avoid having to actually deliver or accept raw cocoa. This mechanism is used to generate profits through price differentials over time. Generally, open positions are reported only once a day in the exchange and are recorded cumulatively over time.

Commitment of Trader (COT) data are weekly data collected on Fridays and published the following Tuesday. Market participants holding more than 100 open positions are required to provide information on their trading purposes. The number of open positions and the number of traders are documented according to the type of market participant.

To specifically distinguish between market participants with and without hedging purposes, the categories of commercial and non-commercial traders are separated. Commercial traders are again divided into two categories, Processors/producers and merchants (PM) and Swap Dealers (SD). PMs are traditional commercial traders who trade in the physical markets and use futures contracts to hedge price risk. Swap dealers trade over the counter (OTC) swaps and hedge them in the futures market. However, the commercial, ”hedging” position of swap dealers is controversial. Swap dealers are often used as proxies for commodity index positions (Irwin and Sanders, 2012). The category of non-commercial traders is divided into managed money (MM) and other reportable traders (OR). Other reportable traders (OR) are market participants that hold enough open positions to be reportable but do not fit into any other category. Examples include (multi-asset) trading houses, algorithmic traders, market makers, ETF and ETN holders, or firms that manage their assets. MM are commodity trading advisors and hedge funds. These can be understood as traditional speculators (Irwin and Sanders, 2012). However, the COT data do not separately identify speculators who make their profits by buying and selling. Speculators cannot be distinguished from buy-only or sell-only investors (index investors) in the categories. Index investors can be found in the SD, MM, and OR categories (Irwin and Sanders, 2012). Non-reportable are those market participants who are not required to report their trading intentions because they hold less than 100 open positions. Additionally, there are market participants who do not hold open positions and only exercise daily transactions.

Weekly prices and the number of participants having open long positions are correlated. Figure 2 shows the number of market participants holding more than 100 open long positions in the futures market and weekly futures prices. The left axis shows that there are between 60 and 140 ”large” market participants over time. The mutual influence of the futures price and the number of buy traders is evident from the common trend. Content causality suggests that participants respond to prices and price changes result in a change in the number of buy traders.

In the course of 2017, a break in the data can be identified. The number of market participants with open purchase positions dropped drastically to more than half and at the same time the prices also dropped to almost half. Thereupon, both trends, of market participants and futures prices are rising in parallel. From 2020 onwards, a break in the data can be detected again. After that, the two time series have settled at a lower level.

From September 2016, the number of traders has decreased drastically, while at the same time the number

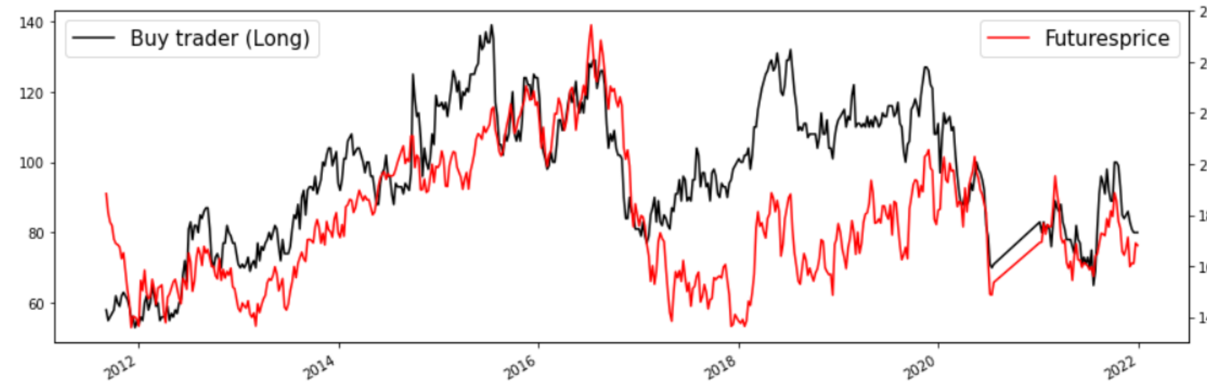


Figure 2: Weekly number of market participants with open long positions and weekly futures prices in the period from 2011-09-06 bis 2021-12-28

of open positions has increased. Thus, individual market participants had more influence on prices. After the number of traders increased again, the number of traders dropped sharply again in early 2020. This time, however, with a simultaneous decrease in open positions.

Processors/producers and merchants of raw cocoa (PM) dominate the market across all years in the number of open positions and in the number of market participants (see Figure 3 above). Figure 3 shows in pie charts that about half of the buying market participants and also the quantity of open buying positions in 2021 can be attributed to raw cocoa buyers. Nevertheless, the change in open positions is crucial for an impact on prices. In all years, the change in open positions of buyers and sellers in the PM category is highest on average. In 2020, the open positions of buyers in the managed money (MM) category had larger average changes than those of sellers in PM. In 2019, the change in MM's open buy positions was almost as large as PM's on average. This indicates the increased influence of speculators.

From 2011 to 2021, only managed money (MM) buyers and sellers respond significantly to last week's price changes. News about supply and demand of raw cocoa can thus have a long-lasting effect and can drive prices up or down disproportionately. This means that intervention in prices would hit speculators as they react to prices. Introducing a transaction tax would therefore have a direct impact on speculative opportunities. Additionally, for the period from 2011 to 2019, sellers Other and buyers PM respond significantly to the previous week's price change. Processors/producers and merchants and (PM) take fewer long positions when the price has increased in the previous week. As a result, they have a volatility-reducing effect.

The number of open long and short positions has a significant effect on weekly cocoa price volatility. For the entire period between mid-2011 to the end of 2021, volatility can be significantly explained by the change in open positions of PM sellers. Other and Nonrep buyers also have a significant effect on weekly volatility. These are large individual investors/long-term speculators. However, they are important in a futures market

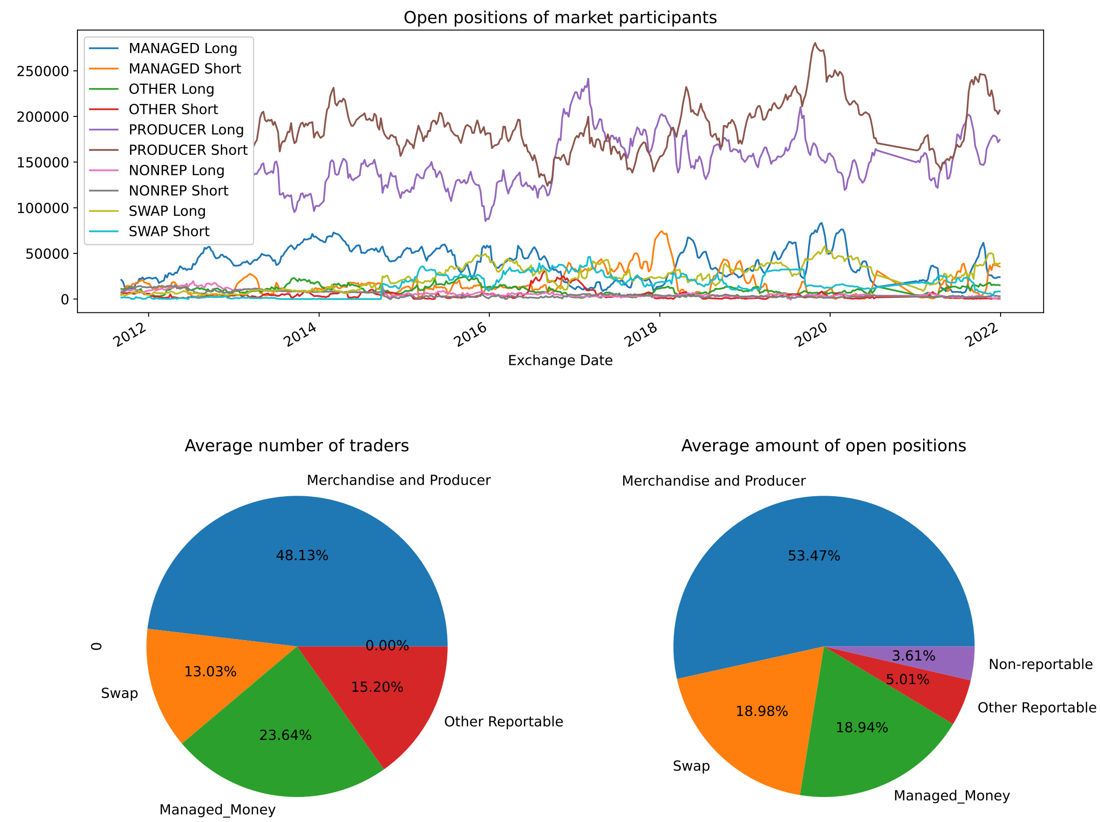


Figure 3: Top: Open positions of market participants from mid-2011 to the end of 2021. Bottom left : Average number of traders with more than 100 open buy positions in 2021, Bottom right: Average quantity of open positions of traders with more than 100 open long positions in 2021.

to meet the demand for price hedging. The open positions of PM sellers are usually higher than those of PM buyers (see Figure 3). Therefore, this demand for price hedging has to be balanced by other market participants.

In the period before October 2016, weekly cocoa price volatility can also be explained by buyer PMs. Figure 4 shows the weekly correlation of variances between cocoa returns and the change in open positions of PM buyers. In particular, after 2016, the correlation is negative. This means that PM buyers contribute to reduce volatility. PM sellers are constantly contributing to volatility. As of October 2016, none of the market participants are significant contributors to weekly cocoa price volatility. This may indicate that volatility is more likely to be shaped by daily transactions of prices. An indication of this is also the ratio of daily open positions and volume. Volume is the total transactions (buying and selling) made on a given day. This ratio includes both the opening and closing of open positions. The volume records transactions of large traders who offset or open positions. Transactions of speculators who buy and sell a contract in a few minutes to

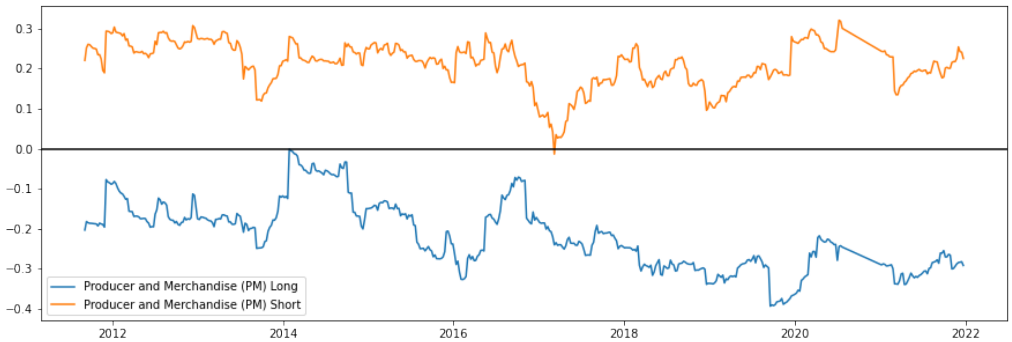


Figure 4: Correlation of modeled volatilities of producer/processor and merchant open positions with cocoa returns over time.

make profits from the price differences are also recorded. The volume is higher on average between 2012 and 2020 than in the years before. Since 2020 up to and including 2021, volume is less volatile and lower. Daily volume from March 2021 to December 2021 is on average 7.6 times higher than the change in daily open positions. There is an inverse relationship between volume and open positions. Around the maturity date of futures contracts, the changes in open positions are the largest. Volume decreases and drives away daily speculators because there is uncertainty about daily price changes. This, in turn, amplifies the effect of increased changes in market participants' open positions on prices.

Daily volume has a significant effect on the daily volatility of cocoa returns. An increase in volume raises daily volatility and therefore has a destabilizing effect on price. The daily price elasticity of demand shows that for positive price changes, volume decreases on average and that for negative price changes, volume increases. In "behavioral finance", negative returns are assumed to be associated with increased transactions, as market participants tend to trade irrationally and out of panic. To stabilize volumes and minimize daily speculators from the market, a price-stabilizing measure such as a financial transaction tax could be introduced. However, the stabilizing effect depends on the reactions of market participants. Price elasticity can be used to calculate the theoretical new volume after a tax is introduced. After the introduction of a financial transaction tax of 0.02% on each transaction, the number of transactions decreases, thereby lowering the positive effect on volatility and thus having a price-stabilizing effect.

2.3.2 Futures market and spot market

A futures commodity market can be used to hedge risk if price formation is efficient with respect to the commodity spot market. The current futures commodity price must include all information about past spot and futures market prices. This makes the current futures price an unbiased prediction of the future spot

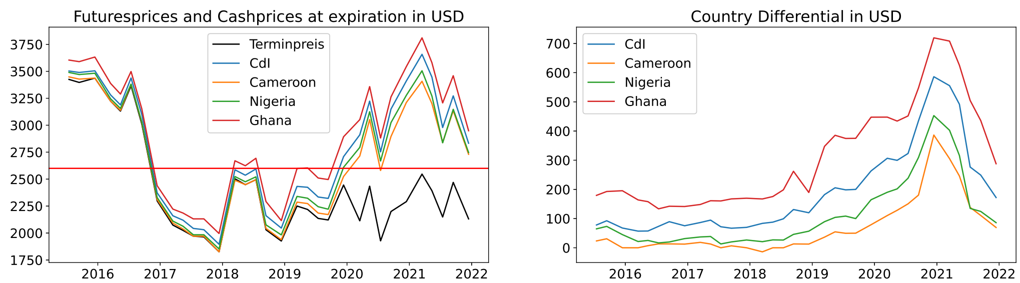


Figure 5: Left: Futures price and spot price at maturity in USD , right: country differential in USD, from January 2015 to December 2022

price at maturity. Deviations arise only from unanticipated fundamental shocks. If pricing is inefficient, there is a cost to a spot price hedger. Theoretically, the first risk-free profit opportunity (arbitrage) is between a difference in the spot price and the futures market price before contract expiration. Spatial arbitrage therefore requires that the spot price and the futures price converge at the maturity of the futures contract. Traders operate in both markets to exploit profit opportunities. Agricultural financial markets were traditionally created for the hedging purposes of agricultural commodity traders. As spot prices fluctuate until contract expiration, agricultural commodity traders have the opportunity to hedge by trading in both markets. Losses (gains) on the physical market are partially offset by gains (losses) on the futures market.

In the cocoa futures market, however, the functionality of convergence is different from traditional agricultural financial markets. In the cocoa futures market, spot prices are formed directly from futures prices. A distinction can be made between a) current futures price (e.g., six months before contract maturity), b) forward price, the expected spot price at maturity (six months before), c) the futures price at contract maturity, and d) the spot price at contract maturity.

Forward prices in the cocoa market consist of two components, the current futures price six months before contract maturity plus a country differential. The country differential is negotiated by the international raw cocoa buyers and the respective institutions of the exporting countries. Forwards are fixed 6 months before delivery and maturity of the London exchange futures contract and are not adjusted. The spot price at contract maturity on the London exchange then results from the same country differential and the future price at maturity. In addition, starting with the 2020/2021 selling season, the Living Income Differential (LID) of 400$ is added to the spot price. The difference between the forward price and the spot price (at maturity) is thus only the futures market price at the different times. The country differential does not change from six months before contract maturity. The country differential is usually positive (exception: rarely negative in Cameroon). Forward and spot prices are therefore mainly determined by futures price changes.

Spot prices at maturity for the four main producing countries and futures prices at maturity are visualized in USD in Figure 5. All four spot price time series follow a similar trend. The Living Income Differential (LID) of 400$ was added to spot prices starting in 2020, decoupling from the futures price trend at maturity. The LID is intended to guarantee a minimum price of 2600$. From 2020 onwards futures prices, are steadily below the 2600$ mark, spot prices are steadily above 2600$. However, this is also partly due to the fact that country differentials have increased significantly from 2020 (see Figure 5 right).

There is no arbitrage relationship/risk-free profit opportunity between futures prices before maturity and spot prices, as both are based on futures prices. Nonetheless, analysis can shed light on where price discovery occurs: in futures prices before maturity or in spot prices. If prices in the spot market are formed at maturity, this may mean that prices are created by exogenous news, which can indicate market efficiency.

Arbitrage and cost of carry imply that futures prices before maturity and spot prices are determined by the same stochastic trend, i.e. they are cointegrating. This implies that although both time series have an unpredictable trend (they are non-stationary), they share a common "initial equilibrium state" to which they always return. A shock in either time series, does not interrupt this course in the long run and both price time series tend to return to their original equilibrium. Therefore, for efficient price formation, futures and spot prices must follow the same movement in the long run, even if short-term deviations exist.

Spot prices are available from July 2015 up to and including December 2021. Futures price formation six months in advance and spot prices of the 4 main producing countries at maturity show that all 4 spot price time series are subject to efficient price formation. All past information of spot and futures prices is integrated. Not all past information is integrated in the futures price. Shocks in the spot market have a significant effect on the futures price that lasts for 9 periods (i.e., almost 2 years). That is, the price trend formed at maturity persists in subsequent futures prices (of other contracts). In two-thirds of the cases, the spot price is higher than the futures price six months earlier because the country differential and LID are added from 2020. For the spot prices of Ghana and Côte d'Ivoire, a long-term stable equilibrium with the futures prices can be observed. For all four spot price time series, the futures price adjusts to the spot price. Therefore, price discovery takes place in the spot market and determines the price trend.

The difference between the spot price and the futures price at maturity is only the respective country differential and the LID from 2020. The country differential is subject to a different stochastic process than the futures price at maturity. Therefore, an analysis between the price formation of the futures price before maturity and the futures price at maturity, can provide further insight into whether the price formation is efficient. The price formation of the futures price at maturity is efficient because it contains all the information of the past futures prices. The futures prices six months before maturity and the futures prices at maturity do not show a stable long-term equilibrium (just like the spot prices of Cameroon and Nigeria).

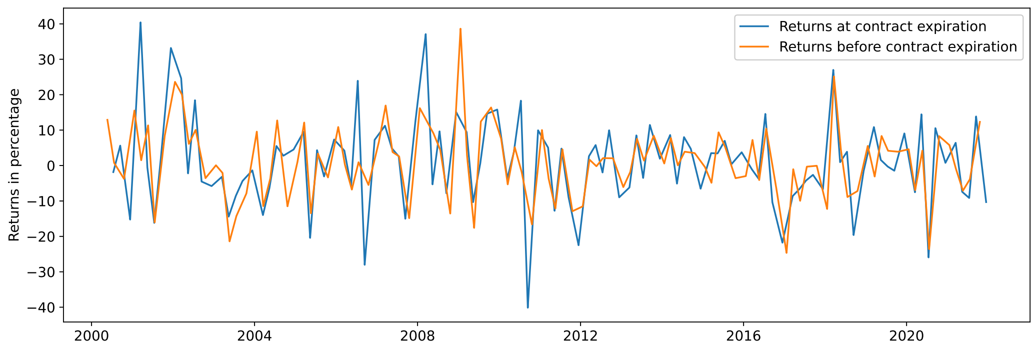


Figure 6: Futures returns at maturity and futures returns two months before maturity, advanced one period for illustrative purposes

The relation of futures prices two months before maturity and futures prices at maturity between the year 2000 to 2021 show long-term efficient price formation. Both markets follow the same data process over the long term. In case of deviations between the two markets, the adjustment takes place in the futures market and it can be inferred that the price discovery takes place in the physical market (futures price at maturity), this can also be confirmed by Ohemeng et al. (2016). The adjustment is significant and occurs within the next contract period. After that, no further adjustments take place with respect to the original shock.

Figure 6 shows the returns (price changes) of futures contracts two months before contract maturity and the returns of futures contracts at maturity. Short-term changes (within a contract period) cannot be significantly predicted in the futures price at maturity by the futures price two months before maturity. Nevertheless, the price direction change of the futures contracts two months before maturity can predict the direction change at maturity at 76%. As an example, the price direction change from March to May can be considered. This can be used to predict the price direction change at maturity from May to June with a probability of 76%.

The analysis with the data starting from 2016 shows that the price discovery takes place in the futures market prices two months before maturity. This indicates that market participants acting after maturity (and thus two months before the next contract due) influence prices.

The results show that market participants acting at maturity influence the price trend. Every 2-3 months, a "roll-over" of futures contracts takes place. That is, a contract expires (for example, in May) and then trader activity focuses on the next due contract (July). Prices are formed before 2016 at maturity and the futures prices (of the next due contract) adjust to it a few days later. After 2016, futures prices form immediately after a contract matures and then influence the price of the next contract at maturity.

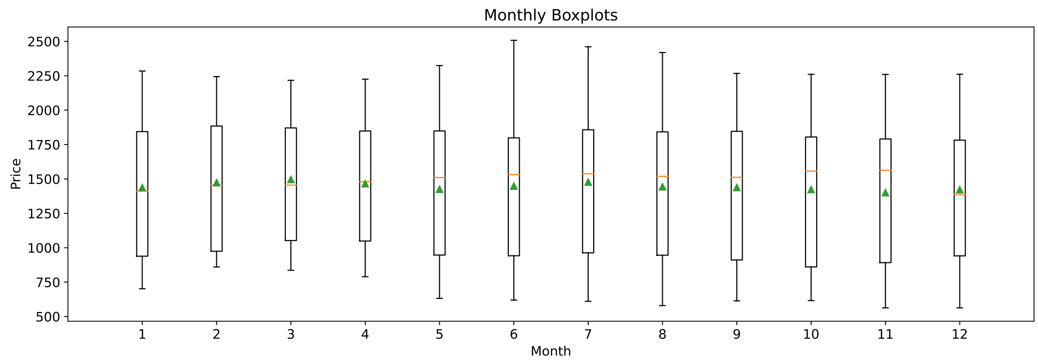


Figure 7: Monthly boxplots between the year 2000 up to and until 2021

2.3.3 Price trends and price reversals

The term structure represents the futures price changes within the same contract. Based on this, risk premiums demanded by speculators to hedge the risk of the spot price can be analyzed (Lee and Zhang, 2009). Between May 2012 and May 2016, maturity structures more often exhibit backwardation. That is, prices at maturity are higher than 2 months earlier. After a contract matures, prices subsequently fall again. From July 2016, a change in trend towards more contango can be observed. This means that in most cases the price at maturity is lower than the forward price two months before. The buyers of the futures contract, drive the price up, but it falls again until maturity. The risk premium therefore benefits the sellers of futures contracts (when they liquidate their open position by taking the opposite position before maturity, i.e. buying a now cheaper futures contract). Most sellers are producers/processors and merchants. As of 2016, oversupply of raw cocoa was responsible for falling prices. This has reduced the demand pressure for price risk hedging from processors in Europe. This may have created more room for profit-driven transactions in the cocoa futures market.

However, the bias of futures prices in predicting spot prices at maturity can also be attributed to the cost of carry (Fama and French, 1987; Brenner and Kroner, 1995). The cost of carry (also called basis) are the costs to hold a futures contract. Since these are not quantifiable, an approximation using seasonality can indicate whether the futures prices include the cost of carry. Cocoa futures prices have commodity-specific characteristics such as seasonality. Seasonality results from spot market characteristics, such as harvest periods and periods when cocoa is primarily held in warehouses, and leads to natural price changes throughout the year. In June and July, before the main harvest, prices are on average the most volatile, as the size of the expected harvest is already announced at this time (see Fig. 7). At the same time, only the price in October (the beginning of the harvest) provides a statistically significant influence on the price changes.

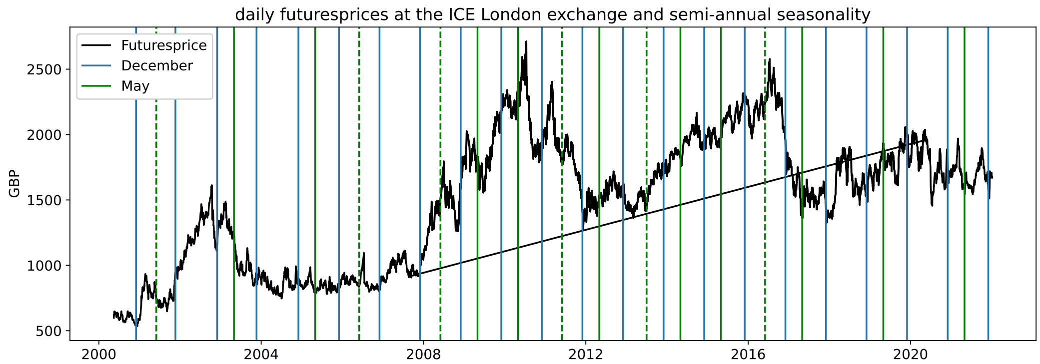


Figure 8: Illustration of trend reversals before maturity or after maturity (dashed).

In addition to seasonality in prices, the data also show other patterns in price trends. The following trends in cocoa term prices are characteristic of the entire period between the year 2008 (2000) up to and including 2021: (a) prices always return to their original long-term trend. Between 2008 and 2020, the value of cocoa increased on average (Figure 8). (b) Supply and demand for raw cocoa mark longer trends that can last 3-5 years. Prices rise sharply, but there is a turning point and prices fall again. c) Semi-annual seasonality is formed by harvests and longer storage life of raw cocoa in warehouses. d) Contract maturities cause other small trend reversals every 2-3 months. There are 5 contract maturities per year, in March, May, July, September and December each between the 12th - 17th of the respective month. Trend reversals in prices, therefore, happen in line with the increased activity of open positions around the date of contract maturity. If around maturity the change in open positions increases, there will be a trend change that will last until the next maturity. e) Between maturities there is excess volatility, which is also generated by news.

However, the seasonality in prices has changed over time. Prior to 2016, there is a half-year seasonality (see figure 8). In particular, there is always a trend change in early December. In December before maturity, prices are often at their lowest point, rising afterwards. This is caused by the falling open positions before maturity in December. Subsequently, the open positions still rise in December for the maturity in March. In May, prices usually also rise for the maturity in July.

From 2016, there are more frequent trend changes, but they are less pronounced. The six-month seasonality is no longer so clearly defined. However, according to ICCO, these trends can almost always be explained by expectations and new information regarding processing, weather, and raw cocoa arrivals at ports.

Figure 9 shows the seasonality of cocoa futures prices, precipitation, and average temperature in Cameroon. Precipitation reaches its lowest point in January with the end of the rainy season and then slowly increases

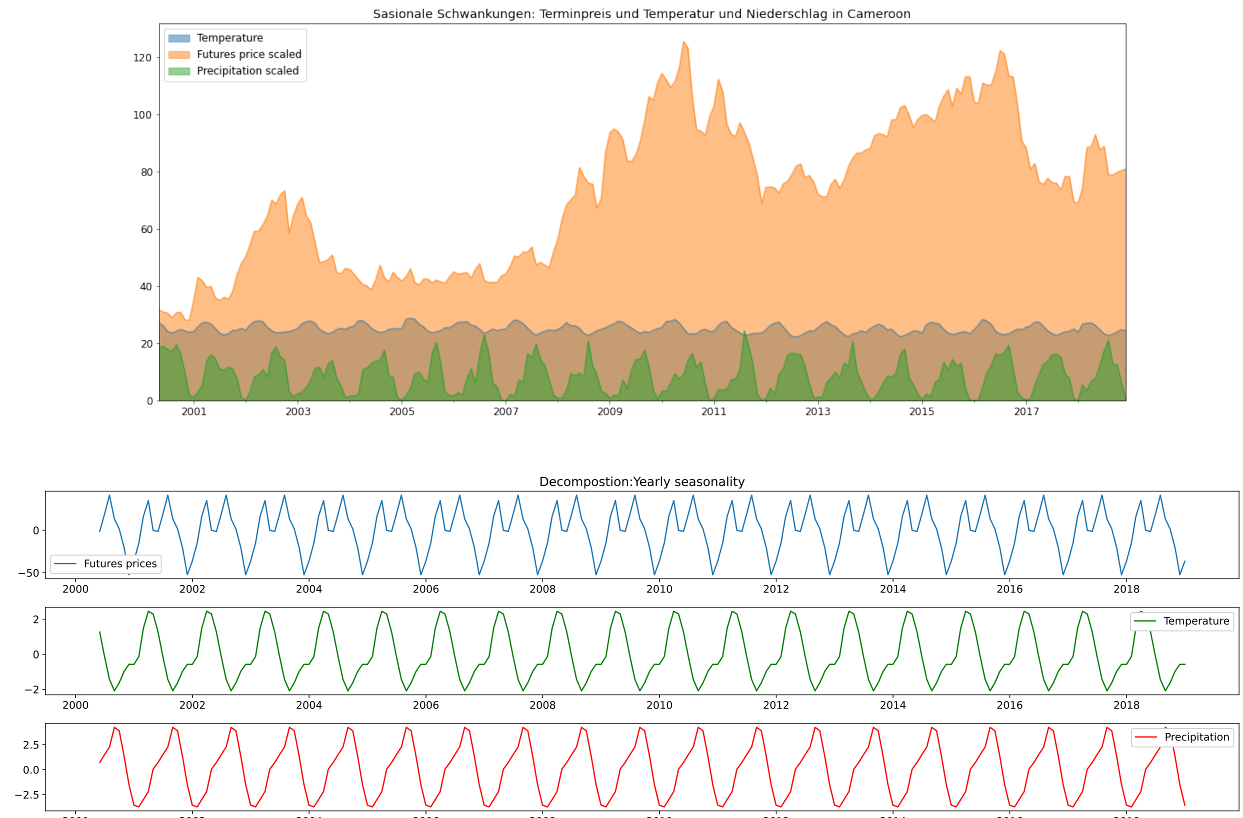


Figure 9: Annual seasonality of precipitation and average temperature in Cameroon and cocoa futures prices between May 2000 and December 2018.

again until the maximum rainfall in October. Temperature is lowest between September and early January and then rises sharply from mid-January. In April/May, the temperature reaches its maximum and then slowly drops until September. Therefore, the turning point in January in cocoa futures markets goes in line with he minimum in precipitation and a stronger increase in temperature in January. Another turning point marks September/October with the highest rainfall and the lowest temperature. From 2013 onwards, but especially from 2016 onwards, the half-yearly seasonality in futures prices is less pronounced and contract maturity dates mark the turning points.

The open positions data does not show which contracts have been traded. All ten current contracts can be traded and included in the number of open positions. In most cases, however, the activity is focused on the next mature contract. Differences between two simultaneously traded contracts with different maturities, so-called spreads, are often used by traders to make profits. Contracts are always related to each other because they relate to the same commodity but to a different time in the future. Figure 10 above shows the most prominent changes in the sequence of prices between the next contract maturity (l1) and the tenth contract

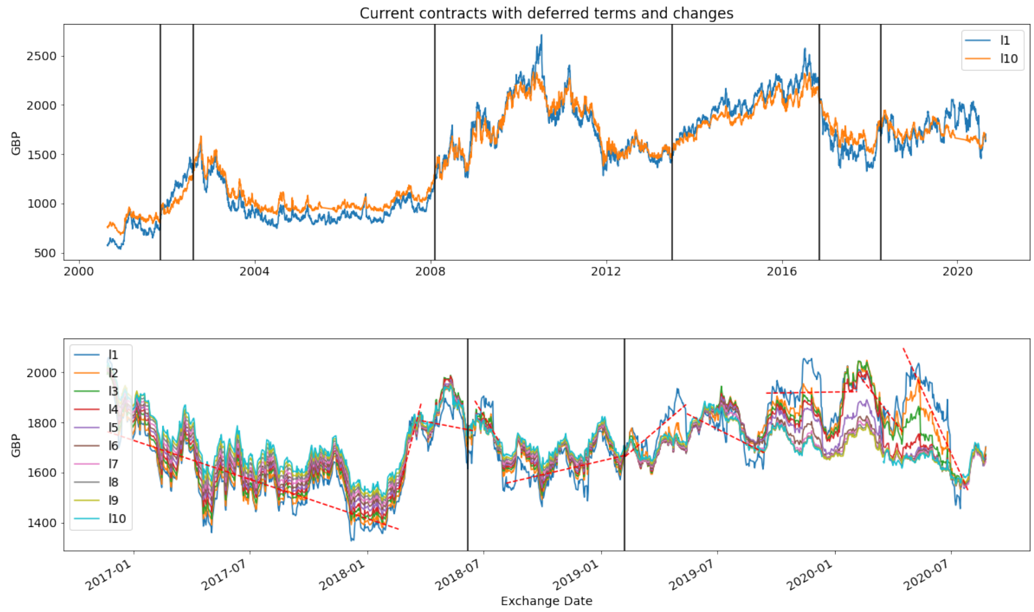


Figure 10: Top: Prices of the first and tenth contract. Bottom: Prices of the ten ongoing contracts with deferred terms.

maturity (l10). In most cases, the sequence of prices of simultaneously traded contracts contains information about how the futures price of the next-maturity contract will behave until maturity. If the next contract maturity has the highest price compared to the other contracts traded at the same time, the demand for cocoa is generally high. The trend (which may last for years) will therefore increase. For example, between mid-2013 and early 2017, the price differential of contracts was mostly in contango, meaning that futures contracts expiring in the far future were priced lower than forward prices at the next maturity. The price trend has increased accordingly. In Figure 10 bottom, the order of contracts traded at the same time changes often. From June 2018 to February2019 , the trend behaves differently. Although the prices of l1 are above l10, the trend falls. After that, although l1 is below l10, the trend increases. For the daily forecast of the prices next mature contract, the deferred contracts do not contribute.

The country differentials, are determined six months before the maturity date of the prices, but the pricing starts before that. The trend of the country differentials over the 2 months before fixing, also gives an indication of how high the demand for raw cocoa is or how high the supply (the harvest) is estimated to be over time, especially about 6-8 months before the contract is due and the raw cocoa is delivered. Between the producing countries, Nigeria, Côte d'Ivoire and Cameroon, there are partly different trends of the country differentials within the same contract. However, it can be concluded that clear trends exist for all three countries: Between 2015 and 2018, prices tend to decrease over time (contango) with some exceptions. A similar trend could also be identified in the spreads and the term structure. From 2018,

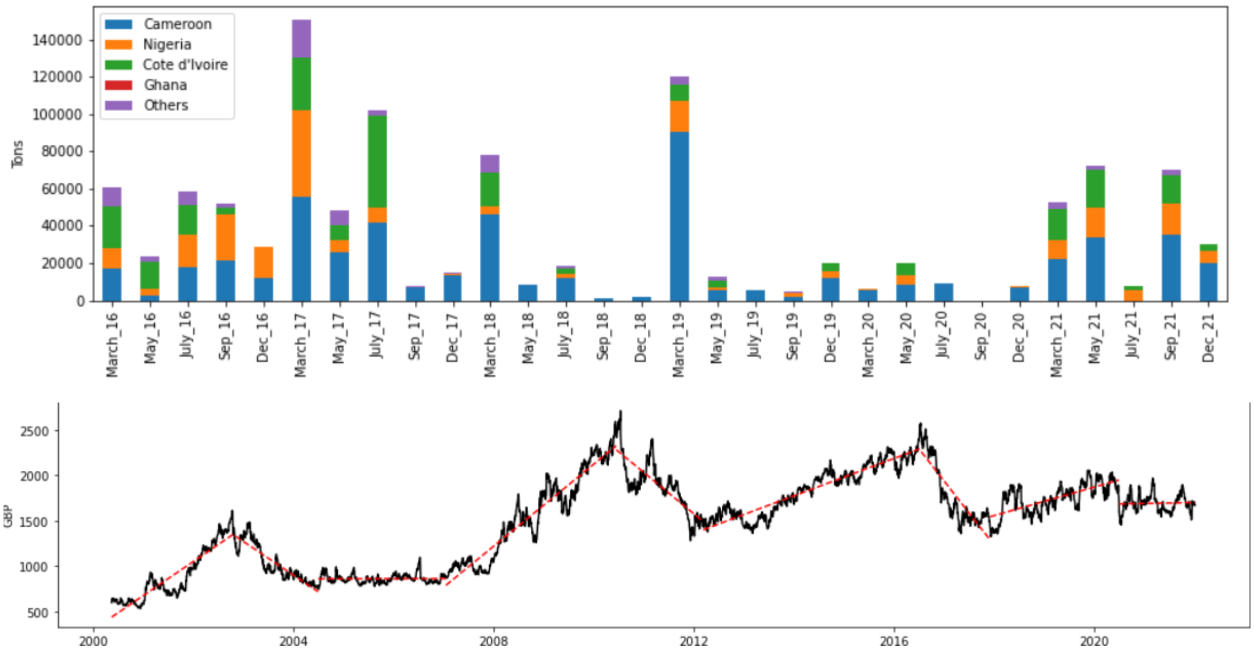


Figure 11: Top: Volume of raw cocoa sold in delivery month in tonnes on the ICE London exchange from March 2016 to December 2021. Bottom: Cocoa futures prices and nine main trends.

country differentials are increasing over time, rarely they decreased slightly. From May/September 2020, the trend changes frequently, but predominantly prices decrease again. For Ghana, a different picture emerges: prices mostly rise, and when they fall, they fall only very slightly.

Figure 11 shows that in recent years, the raw cocoa sold on the London exchange comes mainly from Cameroon. The second graph shows the nine main trends since the year 2000, showing that downward and upward trends are usually long-lasting. In 2016 to 2017, there was a very high supply of raw cocoa causing prices to fall sharply. In 2018, the price increased slightly again due to a comparably lower harvest in March and the following months. The results are consistent with fundamental arbitrage. Price discovery in the futures market should be driven by market participants' expectations of fundamental information, such as supply and demand of the underlying commodity, at contract expiration.

This theory of fundamental arbitrage is based on traditional agricultural financial markets. Agricultural financial markets were mainly used by agricultural commodity traders for hedging purposes. Therefore, traders traditionally based their decisions only on information about the fundamental value of the commodity. It can be concluded that an efficient price discovery function of price changes is triggered exclusively by anticipated new information, as all past, current and expected fundamental information should be directly reflected in the price. Therefore, fundamental predictors should not be useful in predicting futures prices in efficient markets. To test this hypothesis and further clarify the price formation process, the fundamental and exchange-based price determinants of futures prices of the soft commodity cocoa in the futures market were determined. There are few comprehensive fundamental market analyses to identify a multivariate model for derivative markets. Therefore, fundamental variables were first clustered from the literature focusing on price forecasts for cocoa and commodity futures markets. Based on this, various "feature selection" machine learning algorithms were used to extract 25 variables that have an effect on cocoa returns. The identified price determinants were then tested for their predictive power for daily cocoa futures market prices. This resulted in an intensive testing of various existing machine learning algorithms. Based on the results from multivariate forecasting, it can be concluded that all price determinants are directly integrated in the cocoa price and are not used for daily price and price direction change forecasting.

Figure 12: Correlation of modeled volatilities between the 3 news sentiments and cocoa returns over time.

Some price determinants contain important information about future cocoa prices, such as various time series on "Cocoa News Sentiments". These represent indicators of market sentiment in relation to publicly available financial and agricultural news. This daily information may be used by market participants to form their price expectations and to make their transactions on the futures exchange. A distinction can be made between negative and positive sentiment and these can be compared to negative and positive cocoa returns. In particular, news involving price directions, sentiment and buying/selling of cocoa futures prices (LongShort) correlate with the change in price direction. In the period between 2000 and 2020, the price direction news can predict the direction change one day ahead to 59%. However, the effect of these three news sentiments on the volatility of cocoa returns has declined sharply over time (see Figure 12). This may imply that market participants now integrate financial information directly into price. Therefore, there is now no predictability along this path.

In addition, indicators such as monthly prices of gold, oil, the S&P 500 stock index, and the Great Britian Pound (GBP) to U.S. Dollar (USD) exchange rate include information on some larger trends in cocoa futures

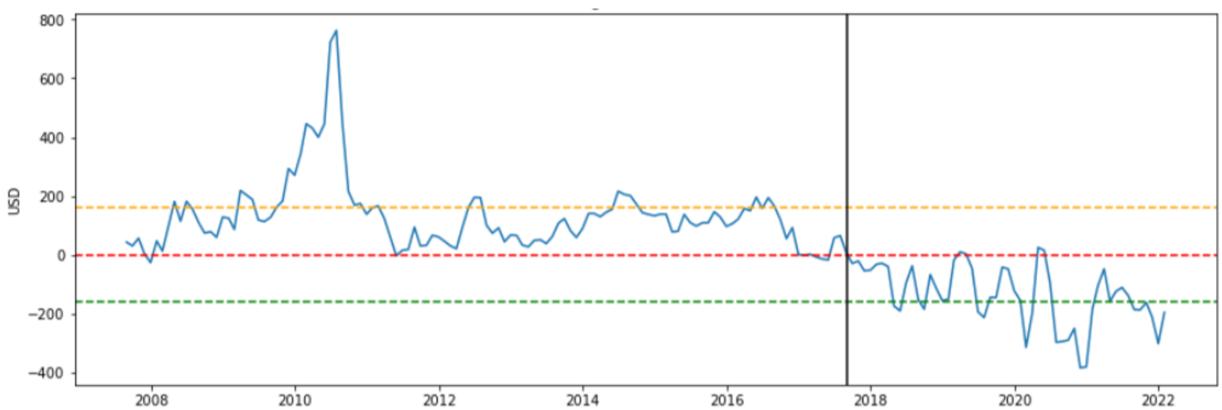


Figure 13: Monthly arbitrage between ICE New York and ICE London exchanges expressed in USD

prices. Prior to 2008, no causality in monthly returns can be identified. After 2008, there is a causal effect of monthly coffee, gold, and exchange rate returns on cocoa returns. However, returns have no effect on the volatility of cocoa returns. The prominent trends in cocoa futures prices — such as visible in late 2016 — are not reflected in the prices of these financial indicators. In addition, futures prices do not have information for the daily price direction changes of cocoa futures prices.

Exogenous news about supply and demand can explain price trends between maturities, and across years. Daily price trends can also be partially explained by news sentiment information on cocoa movements.

2.3.4 Price differences on the exchanges

The arbitrage of the law of one price, implies that between the two major agricultural futures exchanges, ICE London and ICE US, futures prices must be the same when expressed in the same currency. The U.S. market sells lower quality raw cocoa from Latin America, among other commodities, resulting in a natural price differential between the two exchanges. The price range is clearly defined and varies according to the country of origin. However, prices are usually lower on ICE New York, but the largest price difference is no more than 160$. Until October 2016, this relationship can be verified in Figure 13. However, cocoa prices in the futures exchange of ICE in London and New York (NY) show that the price relationships have reversed as of September 2017. This can be attributed to several factors. Most importantly, however, this reversal indicates that the expected availability of raw cocoa in London is higher, thereby prices have decreased compared to those in New York. According to ICCO, there was also excessive demand for West African cocoa in the US due to decreased supply from Latin America and Asia. However, in NY, raw cocoa from West Africa was trading at a higher price than in London. In addition, the grading rules in Europe were changed, so that the raw cocoa price in Europe decreased compared to NY.

The Euro/USD and the GBP/USD exchange rates contain information on deviations in the trends of cocoa futures prices in the two exchanges. As mentioned above, exchange rates have a negative correlation with cocoa futures prices. Thus, when the GBP depreciates against the USD, cocoa futures prices rise in London and fall in New York.

Over time, both time series keep adjusting to each other from period to period and do not drift away from each other. However, there is autocorrelation in the conditional variance, which further suggests that not all arbitrage relationships have been used and that the monthly cocoa futures prices of the two exchanges do not have a long-term stable relationship. The monthly volatilities of the NY and London cocoa futures prices cannot be significantly explained by the volatility of each other's cocoa futures prices. However, the monthly correlation of variances is very high until the end of 2018, averaging 0.95, after which it falls steadily to 0.85. This is consistent with the decoupling of prices observed earlier in Figure 13.

2.3.5 Data generating process

Endogenous, self-generating daily price trends are created by technical analysis of market participants. Technical analysis is a widely used method for trader forecasting. It is based on the assumption that price patterns tend to repeat in the future. However, the efficient market hypothesis (EMH) contradicts this assumption and it is postulated to be effective for all efficient exchange-traded financial price time series. This hypothesis assumes that the arbitrage relationship results in market participants having all past price information already integrated into their transactions. Therefore, successive price changes in efficient financial markets are independent of each other. Prices are assumed to follow a random walk behavior, i.e. no durable profitable forecasts can be made on the basis of past price changes, since all past price information is already integrated in the current price.

Figure 14 shows the futures prices and the moving average of the last 180 days. The futures prices exhibit typical random walk behavior. A random walk implies that the best prediction for the next day's price consists of the previous day's price and a random "shock." Prices are highly autocorrelated, meaning that prices are highly interdependent, but the change in prices is random. This means that future price changes occur solely through independent and random adjustment to new information. Furthermore, efficient markets should therefore not contain systematic patterns in past prices.

For the arbitrage relationship, we first examined the data generation process of daily returns. The returns, shown as the log difference of the price data, are illustrated in Figure 15. Finance typical properties of the price distribution are detectable, as well as the typical data generating process of the "random walk". As a result, the time series model "ARIMA" cannot capture the dependence of the time series data points. For efficient pricing, we must additionally rule out the presence of chaos in the data (Adrangi and Chatrath,

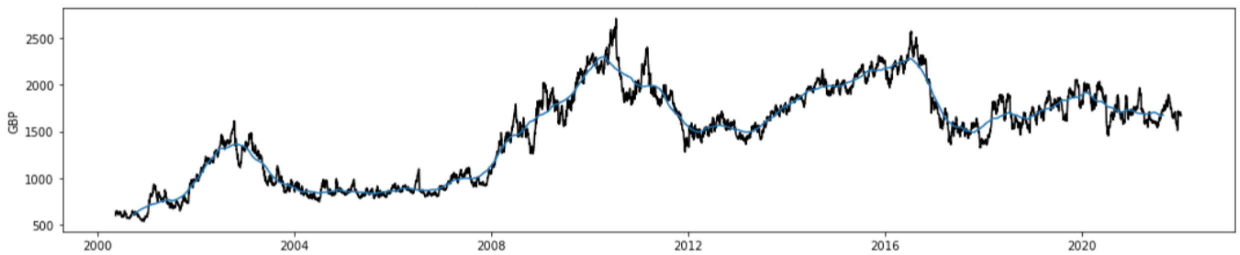


Figure 14: Daily cocoa futures prices on the ICE London exchange

2003). Chaos is not present if a nonlinear structure arises from a known nondeterministic system. The BDS statistic suggests that one of the GARCH models captures the nonlinear autocorrelation and the markets do not follow chaos. The time-dependent conditional variance in returns can be represented using the GARCH model. The model is well suited for modeling and understanding conditional volatility (see Figure 15). Volatility clusters form as variances are dependent on each other over time. A more detailed analysis shows that the model does not help to forecast directional changes in prices, since the forecasts are a copy of the past.

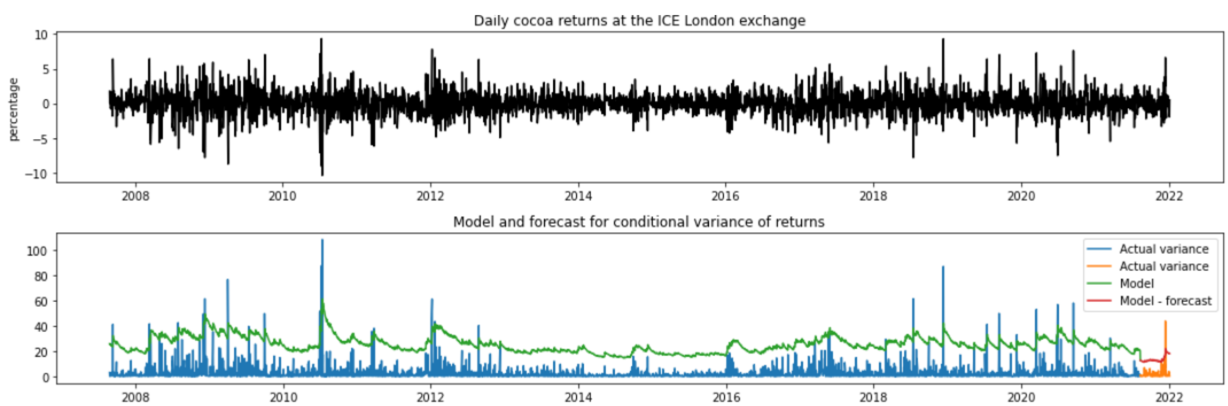


Figure 15: Modeled and forecasted variance

Machine learning methods were used to find additional existing patterns and structures in the data that could not be captured by the ARIMA and GARCH econometric models. The advantages of machine learning have been mentioned numerous times in the literature: the ability to detect variable and non-linear connections and structures over time that cannot be captured by parametric models in a dynamic data generation process. The same models that were used for multivariate forecasting were applied for forecasting the returns based on its own past returns. The univariate forecasting suggests that all past price information is already integrated in the price and based on the price time series no price direction changes can be predicted.

The volatility of the daily return time series is not constant over time (it is non-stationary). Theoretically, this can be explained in this way: Investors' actions are based on their forecasts, and these in turn affect returns. Returns depend on forecasting models, which aim to find patterns in past price changes by recursively updating parameters. This replicates past patterns in the future. Three assumptions can be derived from this: First, sliding window return distributions depend on investors' forecasts and are therefore time-varying, resulting in a non-stationary return time series. Therefore, to find profitable patterns, knowledge of the conditional probability density (of the sliding window) known at time t is conducive. Second, time-varying distributions imply that the autocorrelation is time-dependent. Therefore, the optimal input length of the returns used for forecasting is also time dependent. Third, the theory of EMH states that traders' adjustment to new information is random and independent. This claim is questionable because forecasting models are formed on past prices. Therefore, adjustment to new price information could depend on past distributions. The adjustment mechanism could therefore be forecastable. More precisely, the input length needed to predict a return as a function of its distribution could be forecastable. In addition, several studies have highlighted the fact that changes in price directions, i.e., return signs, could be forecastable. The results of these studies showed that the conditional distribution of returns have explanatory power for sign forecasting for financial data (Christoffersen, P.F., Diebold, F.X., 2006). In particular, the conditional variance is not independent of the sign of the return. Concept drift detectors are existing algorithms for detecting dynamic changes in the distribution of input data. After the algorithm detects the change in the distribution, the input length for the forecast is adjusted. A notable implementation of adaptive windowing algorithms is the so-called ADWIN algorithm. In this method, drifts within past moving windows are detected and the window size (input length) is adjusted in response. In general, concept drift detectors focus on past changes in the distribution and subsequently correct them, while not making forecasts for changing optimal window sizes. After gaining insight into the data generating process and realizing that already known algorithms cannot help forecast daily cocoa prices, a method for univariate forecasting of daily prices was developed. Unlike other adaptive input length methods, our developed method forecasts the adaptive windows for forecasting subsequent return signs.

ARIMA has a built-in parametric, time-invariant selection of input length, i.e., window size. However, in such a dynamic data generation process, it is helpful to adjust the input data to the relevant day-dependent autocorrelations. The selection of the length of past data used as input for forecasting appears to have a significant impact on forecasting accuracy.

Therefore, a three-step procedure was developed that can forecast the price direction change at a high percentage (compared to the literature of other price direction change forecasts). For the adaptation of the algorithm, the focus was on forecasting daily prices and especially the price direction change was of

		Results for return sign forecasting accuracy			
Method	Window size	Cocoa returns	Sugar returns	Coffee returns	Wheat returns
ARIMA	10	52%	43%	41%	54%
ARIMA	20	50%	50%	46%	58%
LSTM	10	52%	52%	50%	54%
LSTM	20	53%	51%	49%	45%
MLP	10	54%	55%	51%	49%
MLP	20	53%	52%	50%	55%
Proposed method	Adaptive	60%	59%	57%	60%

Table 1: Different forecasting methods and their corresponding accuracy for return direction of 4 agricultural futures. The results are reported for 200 days between 12 June 2020 and 24 March 2021

interest, in other words, it forecasts whether the price will fall or rise compared to the previous day. For the method, a neural network (NN) is first used to determine the optimal input lengths (for near perfect prediction) for already known data. Then, the optimal input lengths are forecasted in a second NN. In a final step, using a third NN and the forecasted optimal input lengths, the returns and directional changes are forecasted for unknown data. Table 1 shows the forecasting accuracy for cocoa return signs and three other agricultural commodities. The forecasting accuracy of the developed method for all price time series tried so far outperforms all standard algorithms with fixed input lengths used for forecasting financial data, such as Long Short Term Memory (LSTM) NN, Multilayer Perceptron (MLP) NN and ARIMA. Cocoa return signs can be forecasted with an accuracy of 60%.

In efficient markets, there may be short-term arbitrage opportunities. However, these profitable patterns disappear as the number of investors exploiting these patterns increases. Therefore, to reject market efficiency, these profitable patterns must be consistent across different markets, and the forecasting model must be robust to prove inefficiency. The method we developed has therefore been applied not only to cocoa futures, but also to other financial data, such as equities, and provides similar predictive accuracy in forecasting direction. The method works consistently over time and is robust in hyperparameter settings. In addition, the following inferences can be made: While there is little structure in the data itself that can contribute to forecasting, there is structure in the relationship of the price data to each other. These relations with each other are generated by the price formation mechanism as market participants execute their trades based on forecasts that are based on past univariate price data. This information, in turn, can then be used to forecast the change in price direction change. By developing a forecasting method and an corresponding algorithm, the results of the research so far suggest that price formations of different price time series follow a similar underlying process, as investors and speculators invest across markets and with similar decision-making processes.

3 Price formation and marketing structures on physical cocoa markets – the case of Côte d'Ivoire

3.1 State of research

In line with the regional focus of this topic block, the following overview focuses on the two main West African cocoa producing countries, Côte d'Ivoire and Ghana. Little literature addresses the cocoa market systems in the two countries in terms of degree of liberalization or specific national policies such as price regulations (Gibson, 2007; Quarmine et al., 2014; Abdulai and Rieder, 1995; Ayinde, 2014). Likewise, few studies examine the regulations under the *Conseil du Café-Cacao* (CCC), the Coffee and Cocoa Council in Côte d'Ivoire, which received its mandate as a regulatory body in 2012. Attention has instead been directed to the period prior to the establishment of this authority, hinting to a particular need for more recent research.

With regard to pricing along the value chain, it should first be noted that there are some key differences between countries in the stylized value chains, which are presented in the literature with varying degrees of complexity (see Mohammed et al., 2011; Abbott, 2013; Boansi, 2013). For instance, beside being regularized or liberalized, differences between the role of middlemen and their dependency on other buyers or the regulatory body may exist. Abbott et al. (2005) provide a detailed, if somewhat dated, account of price mark-ups along the value chain. The authors' model of a liberalized cocoa marketing chain indicates that if market power exists, these margins could be reduced by multi-national cocoa processors sharing part of their profits, e.g. through guaranteed minimum prices. However, farmers are unlikely to benefit from those cost savings or guaranteed prices as they simultaneously create market imbalances that instead benefit intermediaries and consumers. Quality assurance as a relevant cost factor in Ghana is analyzed by Kolavalli et al. (2012). As one of the few countries that has never fully liberalized its cocoa sector, Ghana lends itself for study of the impact of the institutional setting on the competitiveness of the cocoa sector. In their study, Kolavalli et al. (2012) point out that quality control, as one of the functions of the Ghanaian Cocoa Board, offers an international reputation that allowed Ghana to forward-sell a high percentage of cocoa with high premiums to the world market price, so-called "origin differentials". Nevertheless, the authors identify scope to streamline operations and reduce costs of quality control.

Similarly, the study of English (2008), as one of the few empirical studies that are available on the determinants of farm-gate prices, suggests that improving quality of cocoa could increase farm-gate prices in the liberalized cocoa sector of Liberia. Further determinants identified by English (2008) are limited credit opportunities and asymmetric price information that impede cocoa farmers from negotiating prices with buyers. The geographic dispersion and lack of communication infrastructure of farmers contribute to the lack of bargaining power in setting prices vis-à-vis exporters and processors (Lambert, 2014). Nevertheless, studies of the Ghanaian and Nigerian cocoa markets did not support the existence of buyer-side market power (Wilcox and Abbott, 2004; Ajetomobi, 2014; Barrientos et al., 2015). Oomes et al. (2016) point out that farmers are usually very dependent on cocoa farming, as there exist little to no alternatives to cocoa production for income generation. This dependency diminishes farm-gate prices in combination with potential in-transparency about weights, prices and taxation even in regulated markets such as in Côte d'Ivoire. To increase the farmers' income on a macro level, the authors suggest that it is necessary for many farmers to transition away from cocoa, while the remaining ones could then focus on improving the quality of their product (Oomes et al., 2016).

There is also some heterogeneity in marketing and production models. One such model is that of certified cocoa production, which provides various incentives for sustainable cocoa cultivation along the value chain (Laven and Boomsma, 2012). Existing evaluations of the effectiveness of sustainability certification and organic cocoa farming show mixed results (Victor et al., 2010; Onumah et al., 2013; Ruf et al., 2006). Hainmueller et al. (2011) evaluate a large-scale training and extension program for cocoa farmers that is specifically designed to facilitate Fairtrade certification. However, for various reasons, this study was not continued, leaving important research questions remain unanswered. Sellare et al. (2020) stress the interaction of cooperatives, certification and outcome. They find generally higher cocoa yields, prices and living standards for Fairtrade certified farmers in Côte d'Ivoire, even when controlling for cooperative characteristics. Their study also provides indication that the size of the effect of certification varies with the prior endowment of the respective cooperative, as better-endowed cooperatives might generally provide more to help their members increase productivity, even without any certification.

Finally, a recent comprehensive study from the Royal Tropical Institute (KIT) on the cocoa sector in the two main producing countries Côte d'Ivoire and Ghana thoroughly describes cocoa farmers' livelihoods and farming activities (Bymolt et al., 2018). The authors find for their cocoa-producing research sites that cocoa is perceived as the most important crop and also cited by cocoa farmers to be the crop that generates the highest income. Both in Ghana and Côte d'Ivoire, farmers express appreciation for the guaranteed price structure. Further other reasons why cocoa farmers like to plant cocoa include the relatively low labour demand and faster maturity than other tree crops. Given this attractiveness of cocoa the authors conclude that it is unlikely that a substantial proportion of farmers will move out of cocoa and into other crops in the short or medium term (Bymolt et al., 2018). With respect to the marketing and pricing of cocoa, the authors point out that farm-gate prices are determined by the international futures and spot markets and that critique of prices paid by companies should therefore be directed at the price formation mechanism on international futures markets.

The improvement of cocoa farmer's livelihoods remains a pressing issue despite various efforts of governments, chocolate traders and manufacturers, and civil society groups to increase cocoa farmers' living standard (see e.g. Gibson, 2007; Fountain and Hütz-Adams, 2018). In a new effort, Ghana and Côte d'Ivoire announced a so-called "Living Income Differential" (LID) in 2019, which was implemented for the cocoa season of 2020/2021 (FCC, Federation of Cocoa Commerce, 2019). Representing a mark-up of 400 US dollars per ton on top of the Free on Board price (FoB) of cocoa beans, this mark-up is supposed to be fully passed through to the smallholder cocoa farmers and raise their income. There are no empirical analyses of the effect of the LID yet given the recent implementation of the LID. A simulation study by Boysen et al. (2021) finds a range of null to positive effects of the LID on cocoa farmers' prices and welfare.

To conclude, there is generally little empirical research on the subject that has been published in peer-reviewed journals, whereas the existing gray literature in part has to be read with caution as some of it has been funded by advocacy groups or companies.

3.2 Methods and material

The work packages of thematic block B were broadly implemented in three phases: research design, field study implementation, and data analysis.

In the research design phase, the literature assembled in Work Package 1 was first synthesized and then subjected to a fact-check in the form of a scoping mission to Ghana and Côte d'Ivoire. More specifically, this mission served to further deepen the understanding of processes and pricing along the cocoa value chain in both countries together with a local partner, to determine the extent to which previously unprocessed data or unused relevant data was available, and to prepare field study implementation. In addition, these findings on the institutional environment, pricing and general processes were incorporated in a case study in the following reporting period.

The following key research questions were defined to guide the design of the field study as primary-data collection effort:

- Which factors differentiate cocoa farmers from non-cocoa farmers?
- What are the main determinants of the livelihood of cocoa farmers and how does it vary among them?

- Which role does the marketing of cocoa (for instance the type of buyer) play for the effective farm-gate price of cocoa farmers and which mark-ups exist?

The design of the field study, which linked the research design and field study implementation phase, had to be stalled for about 1.5 years due to the Covid-19 pandemic. Contacts were maintained and further established with various international and local researchers and institutions during that period, including the authors of the above-mentioned studies. Different potential collaboration options were developed to mitigate the uncertainties surrounding the feasibility of field work in the study countries. Foreseen synergies with the study commissioned by the International Growth Center (IGC), (Hainmueller et al., 2011), could not be reaped owing to the termination of this study. Instead, it was eventually decided to conduct an observational study in Côte d'Ivoire. This decision was taken in light of the given time and budget constraints, but also because synergies could be harnessed through a collaboration with the European Commission's Joint Research Centre (JRC). This helped to cover all cocoa-growing regions in the entire country with a representative survey, as JRC had previously conducted a representative cocoa farmer study in Côte d'Ivoire in 2019. Not least, Côte d'Ivoire was chosen for because it is the largest cocoa-producing country and because of strong engagement of the German development cooperation in the country's cocoa sector.

In-country field work preparation and implementation took place in August and September 2021 in collaboration with the Brainland Consulting Group. Data collection thereby took time towards the end of the 2020/21 cocoa season, with the cocoa season typically spanning from October to September of the following year. The local team included a survey expert and 23 local enumerators. The sampling plan defined target interview numbers for each of the 102 enumeration areas in JRC's study from 2019. These enumeration areas cover the entire cocoa belt of Côte d'Ivoire and thus make up around half the country's area, with Côte d'Ivoire having around the size of Germany. As a slight modification of the sampling applied by JRC, RWI considered any farming households as eligible for the survey in 2021, not only cocoa-growing households. This made it possible to calculate the share of cocoa producers and to compare them with non-cocoa farmers. Mobile applications used for data collection directed enumerators to a GPS location that represented the enumeration zone of individual JRC interviews conducted in 2019. The application then requested the enumerator to go towards the closest house in search for a farming household. The sampling thereby mimicked the sampling by JRC implemented in 2019, but covers a new sample of farmers given that the 2019 survey did not obtain consent from survey participants regarding the sharing of their personal information.

If an identified farmer remained inaccessible during the time the survey team was in the respective enumeration area, or if the farmer irrevocably refused to give consent to participate in the survey, basic information on the reason for non-participation was stored in the digital questionnaire. A replacement respondent was then searched by approaching the closest house nearby. A comprehensive agricultural and socio-economic survey questionnaire was then administered. Enumerators were instructed to interview a household member that is well-informed about the household's finances and agricultural activities, preferably the household head. The interviewed person was identified as the household head in 96% of the cases. Respondents were asked to give information about their household and agricultural activities as of the previous year, i.e. 2020 or in the context of the cocoa season, for the season of 2020/2021.

The structure and individual questions in the questionnaire were as well designed along JRC's 2019 survey in order to hold open the possibility of pooling the data set from 2019 and 2021 with comparability of households at the enumeration area level. As of publication of this report, RWI did not yet avail of the 2019 data so that the results presented in this report are based solely on the RWI survey conducted in 2021.

Target interview numbers could be reached for all enumeration areas. The final sample consists of 1,052 complete interviews with farming households, of which 972 (92%) identify as cocoa farmers and 80 (8%) as other farming households.

The survey data was then used to both descriptively and econometrically analyse the determinants of physical cocoa prices and farmers' living conditions in the data analysis phase. Beside descriptive between-household comparisons of cocoa and non-cocoa farmers, cluster analyses were performed to identify different groups of cocoa farmers. The econometric models employed include standard ordinary least squares (OLS) regression to analyse price determinants, among others. To analyse a farmer's buyer choice, we make use of a multinomial logit model, which is suited to analyse relationships between a nominal scaled response variable and possible explanatory variables.

3.3 Detailed presentation of the main results

This section presents main results on the physical cocoa market in Côte d'Ivoire from the household perspective based on the survey data collected in 2021.

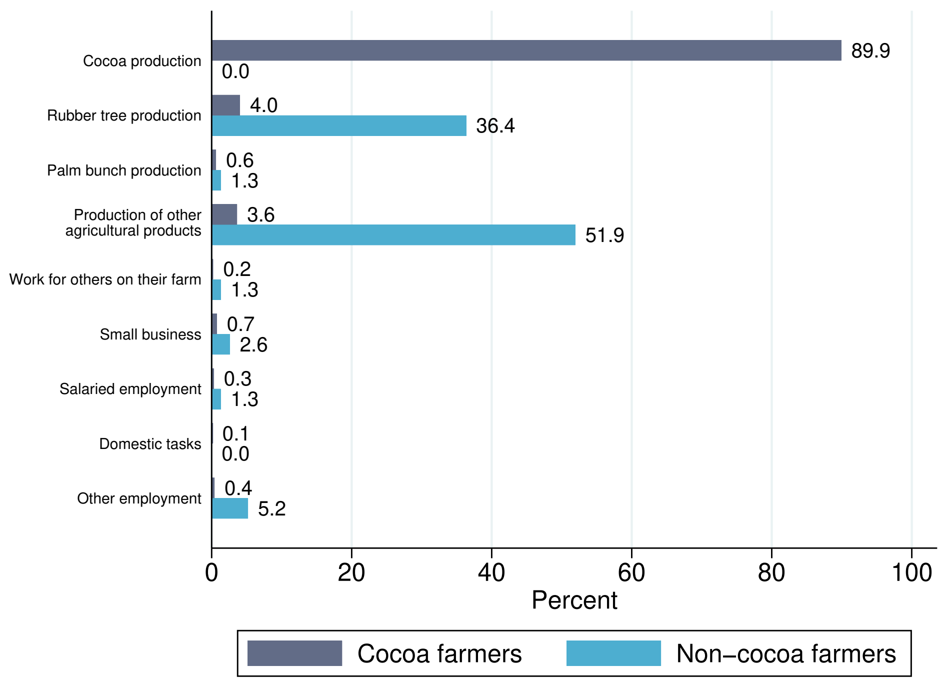
3.3.1 Socio-economic characteristics of agricultural households

Our sample portraits a representative picture of agricultural households in the cocoa belt of Côte d'Ivoire. A main distinction we make in our analyses is between farmers who grow cocoa and farming households that do not cultivate cocoa at all. This helps us to differentiate between characteristics specific to cocoa households and characteristics generally typical for farmer households. Ninety-two percent identify as cocoa-farmers and 8% – in total 80 households – identify as non-cocoa farmers.

The production and selling of cocoa is also the main activity and main income source of cocoa farmers

(Figure 16). For non-cocoa farmers, the main activity and main source of income is very often rubber tree production with a share of 36%, and agriculture is generally their main activity as well. Together with the production of other agricultural products such as cashews, 90% of non-cocoa farmers are mainly working in agriculture, mostly independently, but partly also as salaried workers. Households who do not engage in farming have not been sampled in our study. Since they were encountered by surveyors only in exceptional cases, it can be stated that they make up a minimal single-digit share of the total population in the cocoa belt. All households have a long employment history in their main activity with on average about 20 and 16 years for cocoa and non-cocoa-farmers, respectively.

Figure 16: Main activity among cocoa and non-cocoa farmers



A few key socio-economic household characteristics are presented in Table 2. The table shows mean values and results for tests on the statistical difference in means between the two groups of cocoa and non-cocoa farmers in the last column. These p-values range from zero to one and values below 0.1 are conventionally referred to as statistically significant differences suggesting structural differences if such differences occur more frequently.

We see that the household size of non-cocoa farmers is slightly smaller with an average household size of six members, of which four members are adults above 14 years of age. Cocoa farmers often live in remote places as can be seen by the distance of a cocoa household's house to the nearest asphalt road, which measures about 19 kilometre (km) on average. Only 14% of cocoa households have direct access from their house to an asphalt road, while about 52% reaches the house by a track in good condition during the dry season but in bad condition during the rainy season. With an average distance of about 12 km, non-cocoa farmers usually live significantly closer to the nearest asphalt road compared to cocoa farming households (Table 2). Related to that, about 25% of both cocoa and non-cocoa farmers report a bad phone network where they have to move around, mostly less than a kilometre, to find network connection (not shown in the table).

Despite the remoteness of farmers' households, almost half the interviewed cocoa farmers and more than half of non-cocoa farmers have access to grid electricity. With other households having standalone electricity sources at their disposal (mainly solar home systems), about 20% of both farming households lack any access to electricity. This share of households without access to electricity is significantly higher among non-cocoa farmers.

In both farmer groups, the share of female household heads is generally low with average shares lying between 5 to 6%. In contrast to recent findings from Ghana, where cocoa farmers tend to be significantly older than non-cocoa farmers (Bymolt et al., 2018), our data does not provide any evidence for cocoa farmers to differ significantly in age from non-cocoa farmers, at least not for household heads. Cocoa farmers are less often from the village they reside in at the time of interview and more often migrated from outside the district or from Burkina Faso, the main country of origin of international immigrants. Lastly, Table 2 shows that educational levels do not differ significantly across the compared groups. Over 40% of household heads are without any formal education. To the contrary, the share of household heads that finished high school is low at 4% for both cocoa and non-cocoa farmers (not shown in the table).

Hence, farming and non-cocoa farming households are rather similar in several socio-economic characteristics as age and education. A factor that seems to underlie part of the differences among the groups is the households' origin, with cocoa farmers being more often from outside their current village of residence or even from outside Côte d'Ivoire, particularly from Burkina Faso.

3.3.2 Households' agricultural activities

About 68% of cocoa farmers own the land they cultivate their crops on, which is significantly more than the 57% of land owners among non-cocoa farmers (Table 3). Average landholdings amount to seven and five hectares (ha) for cocoa and non-cocoa farmers, respectively. The size of the cultivated land is moderately higher among cocoa farmers, though the difference is not statistically significant. Among cocoa farmers, around 60% of cultivated land is planted with cocoa, often separated across multiple plots of land. To reach these plots from their home, farmer's travel an average distance of 4.6 km.

The overall number of crops cultivated and the number of different crops that are the main crops on individual plots reflect the level of diversification of agricultural households. These figures provide a first

Table 2: Socio-economic household characteristics

	Mean			Difference
	All	Cocoa	Non-cocoa	*p*-value
Household size	6.75	6.80	6.21	0.13
Number of adults in household	4.22	4.24	4.09	0.58
Number of children in household	2.53	2.56	2.13	0.06
Distance from house to asphalt road, in km	18.59	19.13	11.70	0.01
Household with electricity, share				
no electricity	0.20	0.19	0.28	
grid electricity	0.45	0.44	0.58	0.00
standalone electricity source	0.35	0.37	0.15	
Female-headed households, share	0.05	0.05	0.09	0.11
Age of household head	48.51	48.40	49.90	0.31
Origin of household head, share				
same village	0.44	0.43	0.55	
same district	0.12	0.11	0.19	
elsewhere in Côte d'Ivoire	0.27	0.27	0.18	0.01
Burkina Faso	0.16	0.17	0.08	
other country in West Africa	0.02	0.02	0.01	
Level of education of household head, share				
no formal education	0.47	0.48	0.40	
primary school	0.30	0.29	0.34	0.43
higher education than primary school	0.23	0.23	0.26	
Number of observations	1,052	972	80	

Note: Any household member above 14 years is defined as adult. p-values refer to the statistical significance level of t-tests (continuous variables) and chi-squared tests (categorical variables) on the difference between the two groups of cocoa and non-cocoa farmers.

indication that cocoa farmers are more diversified than the non-cocoa farmers, with cocoa farmers cultivating on average almost four different crops and non-cocoa farmers almost three. These crops are often cultivated in the form of inter-cropping, such that about two crops on average are planted on the same plot.

This finding of higher diversification among cocoa farmers is partially substantiated by Figure 17, which shows how diversified the two farmer groups are with respect to income from selling different agricultural products. The figure shows individual farmers' values of the Shannon Diversity Index, which indicates the degree of diversity (or entropy) of a unit of interest, in our case sales of agricultural products. An index

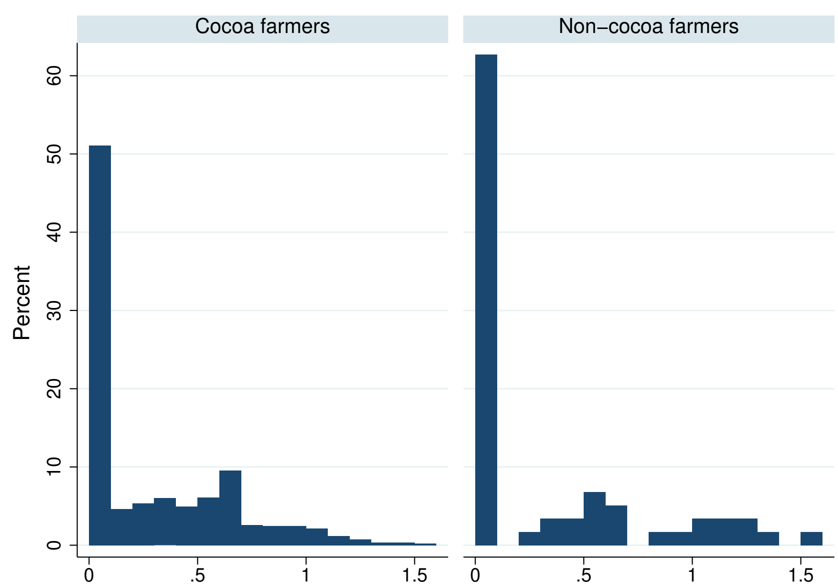
Table 3: Agricultural land and crop cultivation

	Mean			Difference
	All	Cocoa	Non-cocoa	*p*-value
Households owning land, share	0.67	0.68	0.57	0.05
Area of land owned, in ha	6.79	6.93	4.92	0.22
Cultivated land, in ha	7.74	7.84	6.61	0.31
Number of cultivated plots	2.28	2.32	1.81	0.00
Distance from house to plots, in km	4.65	4.65	4.64	0.99
Number of crops cultivated	3.60	3.67	2.77	0.00
Number of crops cultivated as a plot's main crop	1.96	1.99	1.60	0.00
Number of observations	1,052	972	80	

Note: Area sizes of land owned and cultivated land were both top-coded at the 99% level, that is the highest 1% land area values have been set to the value of the 99 percentile in order to mitigate the effect of outliers on the average values. p-values refer to the statistical significance level of t-tests on the difference between the two groups of cocoa and non-cocoa farmers.

value of zero implies no diversity at all, i.e. the farmer sells only one single crop type. This applies to more than 60% of non-cocoa farmers compared with just over 50% of cocoa farmers. Larger values of the Shannon index indicate higher levels of income diversification. However, a clear pattern distinguishing farmer-types in this respect is difficult to discern.

Figure 17: Shannon Diversity Index for cocoa and non-cocoa farmers



To glean more insights into the determinants of diversification, we estimate an ordinary least squares (OLS) regression using the Shannon index as the dependent variable. Two models are specified. The first includes a single binary variable indicating that the respondent is a cocoa farmer and the second includes additional socioeconomic- and regional control variables (columns (1) and (2) of Table 4). Neither model indicates statistically significant differences between cocoa and non-cocoa in the level of diversification. In fact, the only two variables that register statistically significant effects in the second model are the number of adults and an indicator of whether the respondent was born in the village. Both variables have positive associations with diversification.

We further pursue the question of diversification by focusing specifically on cocoa farmers and re-specifying the dependent variable as the share of agricultural income derived from cocoa sales. These models, presented in columns (3) and (4) of Table 4, include additional cocoa farmer-specific variables: an indicator stating whether the cocoa is certified, indicators for the type of buyer, and the number of buyers that come to the village to buy cocoa during the main cocoa season (October to March). The model in column (4) is distinguished from the model in column (3) by the inclusion of district controls. The results show that a higher area of cultivated land significantly reduces the share of agricultural income from cocoa, indicating that more cultivation is associated with more diversification. Similarly, corroborating the model of the Shannon index, more adults in the household is associated with a lower share of income from cocoa and thus higher diversification (column (4)). Place of origin also plays a role: While the model in column (3) indicates a lower share of cocoa-based income from those born in the village, the model in column (4) indicates a higher share from those born outside of Côte d'Ivoire. These latter farmers may have specifically come to Côte d'Ivoire to cultivate cocoa and therefore show lower levels of diversification. Compared to independent middlemen (the comparison case in the estimations), cocoa farmers who sell their harvest to a cooperative also tend to be less diversified.

Turning to agricultural production inputs, Table 5 presents details on agricultural labour and other inputs. Hired labor is rather common both among cocoa and non-cocoa farmers. Forty-four percent of farmers stated to have paid workers on their plots, while around 10% of cocoa farmers and almost 15% of non-cocoa farmers employ *Manoeuvres* on their farms, i.e. workers who are usually paid in kind. About 31% of farmers stated that only family members work on the plot. Among cocoa farmers, 21% practice sharecropping. These so-called *Abusantiers* rent parts of the respondent's plot in return for a portion of their harvest. This kind of sharecropping is very typical for cocoa cultivation, and farmers often have multiple Abusantiers, but it is less common for other crops. Accordingly, merely 3% of non-cocoa farmers have Abusantiers working on their plots.

Looking closer into cocoa-farming households, on average about two household members are mainly active

Table 4: Econometric results on diversification

	Shannon Diversity Index		Share of cocoa sales income	
	(1)	(2)	(3)	(4)
Cocoa farmer	-0.013	0.029	–	–
	(0.059)	(0.068)	–	–
Cultivated land	–	0.001	-0.001***	-0.001***
	–	(0.000)	(0.000)	(0.000)
Fertilizer	–	-0.033	0.025	0.011
	–	(0.024)	(0.016)	(0.016)
Distance to plots	–	-0.002	0.002	0.001
	–	(0.002)	(0.001)	(0.001)
Number of adults	–	0.009*	-0.005	-0.006*
	–	(0.005)	(0.003)	(0.003)
Elderly household head	–	-0.022	0.018	0.020
	–	(0.025)	(0.017)	(0.016)
No formal education	–	-0.013	0.008	0.006
	–	(0.024)	(0.016)	(0.016)
Born in village	–	0.047*	-0.039**	-0.021
		(0.027)	(0.018)	(0.019)
Born outside Côte d'Ivoire	–	-0.041	0.028	0.036*
	–	(0.028)	(0.019)	(0.019)
Wealthy household	–	0.001	-0.024	-0.021
	–	(0.028)	(0.020)	(0.020)
Some cocoa certified	–	–	-0.020	0.009
	–	–	(0.017)	(0.019)
Cooperative as buyer	–	–	0.048**	0.039**
	–	–	(0.019)	(0.019)
Pisteur working for a buyer	–	–	-0.001	-0.004
	–	–	(0.021)	(0.021)
Private buyer/traitant	–	–	-0.004	0.008
	–	–	(0.040)	(0.042)
Number of buyers in village during main season	–	–	-0.001	-0.000
	–	–	(0.000)	(0.000)
Constant	0.296***	0.335*	0.877***	0.579*
	(0.058)	(0.171)	(0.025)	(0.349)
District controls	No	Yes	No	Yes
Number of observations	993	929	809	809
R-Squared	.0001	.1459	.0690	.1137

*Note: For consistency with the other econometric models employed, we also controlled for whether a household was aware of the Living Income Differential, which we assess in detail in Section 3.3.4. Robust standard errors in parentheses. ***, ** and * denote statistical significance at the 1 %, 5 % and 10 % level, respectively.*

in cocoa production. With respect to inputs other than labour, about 75% of cocoa farmers purchased in 2020 inputs such as fertilizers, whereas only 13% used and received inputs from the Coffee and Cocoa Council,

Table 5: Agricultural labour and other inputs

	Mean			Difference
	All	Cocoa	Non-cocoa	*p*-value
Farmers with Abusantiers working on plots, share	0.20	0.21	0.03	0.00
Abusantiers working on plots (if any)	1.60	1.59	2.50	0.24
Farmers with paid work on plots, share	0.44	0.43	0.55	0.03
Farmers with manoeuvre working on plots, share	0.11	0.10	0.14	0.37
Household members active in cocoa production	1.74	1.88	–	–
Cocoa households that purchased inputs, share	0.74	0.74	–	–
Distance to market for inputs, in km	6.09	6.09	–	–
Cocoa households that received inputs from CCC, share	0.15	0.15	–	–
Number of observations	1,052	972	80	

Note: p-values refer to the statistical significance level of t-tests on the difference between the two groups of cocoa and non-cocoa farmers.

the organisation that concerns itself with the stabilization, regulation, and development of the cocoa and coffee market in Côte d'Ivoire. The most often used inputs are insecticides, herbicides and three-component fertilizers providing nitrogen, phosphorus, and potassium. Most cocoa farmers have already experienced diseases and mortality of their cocoa trees: The three most common diseases observed by cocoa farmers are brown rot (reported by 81% of all cocoa farmers), damage by insects (reported by 69%) and the occurrence of Loranthus (66%), which steal minerals and water and block sunlight from the trees.

Diseases are a well-known issue of cocoa cultivation, and they are cited by 26% of the non-cocoa farmers as a reason for not planting cocoa. The reason that was given most often (54%) was poor soil conditions, and the third most often reported reason was a too high price volatility (13%). Only 8% of non-cocoa farmers cited low profitability as a reason for not growing cocoa. About 40% of the interviewed non-cocoa farmers even used to plant cocoa in the past. As a reason to why they stopped planting cocoa, these farmers similarly most often stated the poor soil conditions (55%), followed by the occurrence of diseases (48%) and a high price volatility (16%).

Overall, natural conditions like soil conditions or diseases seem to be a stronger constraint for our interviewed non-cocoa farmers than economic aspects or a disinterest in cocoa cultivation. Non-cocoa farmers seem to be mostly able to compensate for this by growing other cash crops such as rubber, even though the level of diversification is low in both groups.

3.3.3 A typology of cocoa farmers

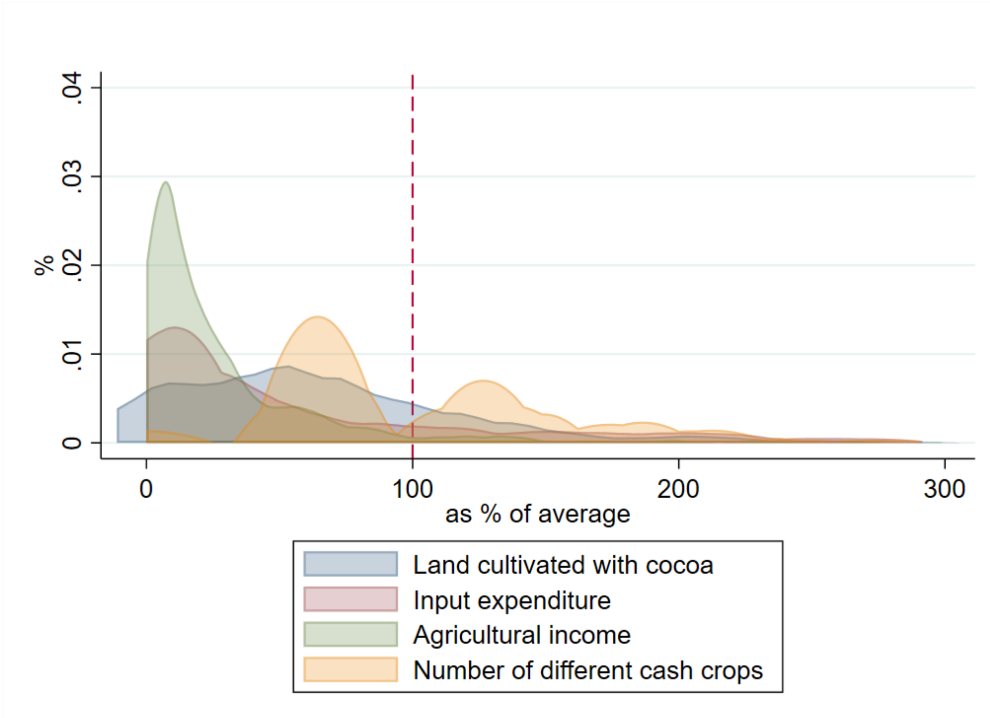
The above analysis depicted the situation of cocoa farmers in comparison with non-cocoa farmers based on average conditions in the two groups. We now zoom into the group of cocoa farmers to better understand in how far conditions differ across differently resourced farmers and how this affects farmers' livelihoods.

For that purpose, we first identified four characteristics elicited in the survey, which describe the level of resources available to individual farming households. These are the farmers' cocoa land availability, expenditures on farm inputs such as fertilizers and fungicides, the number of cultivated cash crops and the agricultural income. Based on these characteristics, we build groups of cocoa farmers that are similar in characteristics within the groups but differ across groups. The idea of building so-called "farmer profiles" has been adopted in recent cocoa research to account for heterogeneity in cocoa farmers, information that can be used to target interventions and policies more efficiently and effectively (see e.g. Rijn et al., 2015; Bymolt et al., 2018).

In a both conceptually motivated and data-driven approach, we first account for differently-sized households by splitting them into two groups according to the number of household members. One group includes households with up to six household members and the other households with more than six members – we consider this approach in the given context more appropriate than expressing each characteristic in per capita terms. Within these two groups, we relate the value of each characteristic to the group-specific mean and then join these values, as illustrated in Figure 18. The figure shows the dispersion of the four characteristics. Cash crop income shows a strong peak at the lower end of the distribution, which means that there is a non-negligible share of cocoa farmers whose crop sale income is substantially lower than the mean value of around FCFA 6,500,000 (EUR 10,000). The distribution of input expenditure is less skewed but also shows that input expenditures are far below the average for many cocoa farmers. Land area cultivated with cocoa seems least dispersed, but nevertheless displays heterogeneity that is concealed when looking at mean values only.

In a next step, we aggregate the information of the four characteristics to a single overall "score". We compared different options and eventually decided on an indicator with the following three characteristics: a) percentage values of each characteristic according to Figure 18 are simply summed up such that a perfectly average household would have an aggregate score of 400; b) before summing up the four values, the bottom and top 5% of each characteristic are coded to the 5th and 95th percentile, respectively, in an effort to reduce the effect of extreme outliers in individual characteristics; c) the overall score is used to split farmers into five equally sized groups, so-called quintiles. The lowest quintile represents farmers with low levels of area planted with cocoa, input expenditures, agricultural income and number of different cash crops compared to

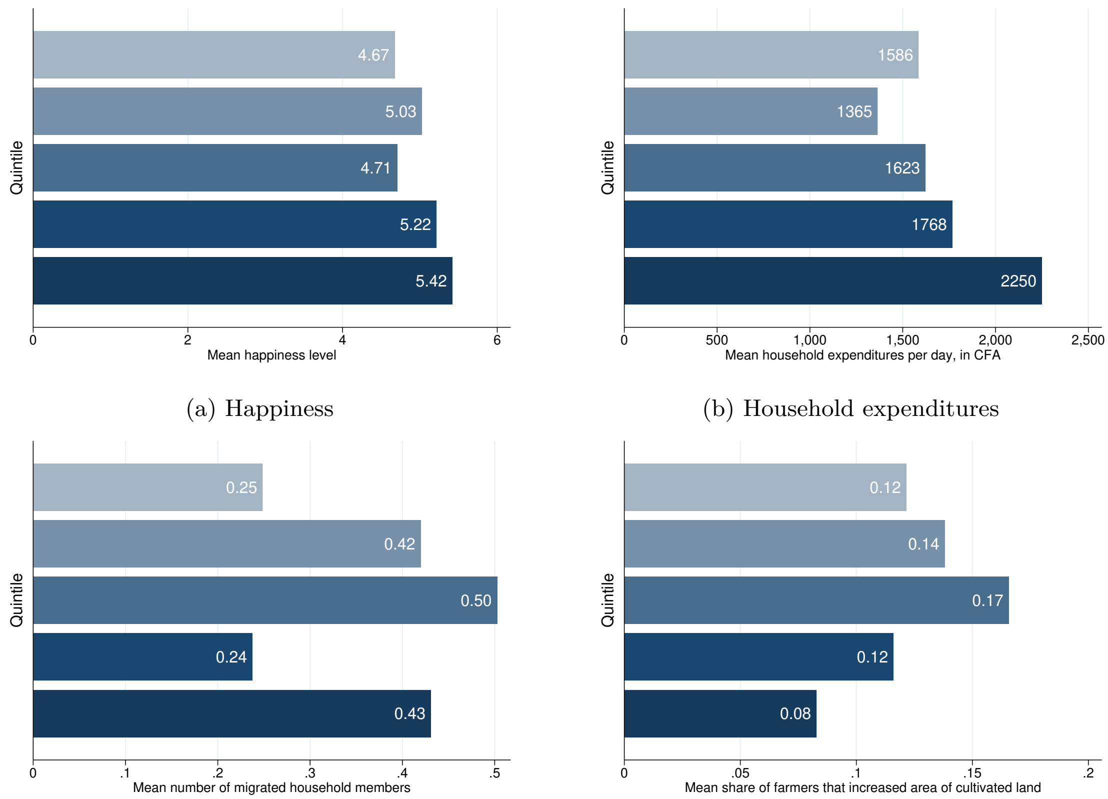
Figure 18: Relative distribution of cocoa farmers' resources



the mean. As the quintiles are built based on the sum of these four characteristics, the lowest quintile may nevertheless also contain farmers with a rather high value for one or two of the four characteristics. On the other extreme, the fifth quintile represents those cocoa-farming households who score rather high on all of those four characteristics. Hence, they represent well-diversified farmers with a large area of land cultivated with cocoa, a high income from selling crops and high input expenditures.

This typology of cocoa farmers can now be used to analyze differences in farmers' well-being according to their level of resources available. We study four socio-economic outcome indicators in Figure 19: a happiness index, which was elicited in the survey with a scale ranging from 1 (low happiness) to 10 (high happiness), average daily household expenditures as proxy for a households' living income, the number of household members that have migrated away from the household in the past and have been absent for at least a month, for instance to find a new job elsewhere, as well as a binary indicator equaling one if a farming household has increased the area of cultivated land in the two years leading up to the survey.

Figure 19 (a) shows how the happiness level differs between the five groups on a range from 1 to 10. Happiness does not vary substantially and is overall neither very low nor very high. The mean happiness score is highest in the fifth quintile, i.e. the best-resourced cocoa farmer group: With a value of 5.42, it is higher than the mean value of 4.67 in the lowest quintile by almost one full step on the happiness scale. Not surprisingly, daily mean household expenditures as a proxy for a living income and the wealth of a household



(a) Happiness

(b) Household expenditures

(c) Migration

(d) Land increase

Figure 19: Socio-economic outcomes for different cocoa farmer quintiles

Note: Darker-shaded quintiles refer to better-resourced farming households.

tend to increase over the quintiles, with an exception in the first quintile (Figure 19 (b)). Households spend on average between 1,770 and 2,250 FCFA (EUR 2.60 to EUR 3.30) in the top two quintiles, whereas expenditures in the second and third quintile are lower at about 1,380 to 1,620 FCFA (EUR 2 to EUR 2.40). Altogether, the mean household expenditures are rather low, revealing an overall low living income.

Interestingly, low levels of migration are observed in both worse- and better-off cocoa farming households (Figure 19 (c)). Overall, few households stated that a member had moved out, but the farmer profiles show that migration of a household member is more common in certain cocoa farming households, especially in the third quintile. Such a hump-shaped pattern is not uncommon in migration and emigration decisions, which is typically explained as follows: low levels of income, or more generally low levels of available resources (incl. credit constraints), prevent aspiring migrants from migrating. In contrast, decreasing economic incentives for migration dominate over less binding credit or other constraints at higher resource levels.

The highest share of farmers who increased their cultivated land is again in the third quintile (Figure 19 (d)). In that cocoa farmer group, about 17% stated to have increased their cultivated land area in the two years leading up to the survey, whereas this share is only 8% in the fifth quintile group. In the other groups, the share lies around 12 to 14%. One possible explanation is analogous to the migration outcome variable – cocoa farming households with already high levels of cocoa land, input expenditures, diversification and high crop earnings do not feel the need to further expand their production. On the other hand, households with very low values in these characteristics may not have the means to do so.

To conclude, we find that cocoa farmers differ in well-being according to their level of resources available, which we identify as the area of land cultivated with cocoa, input expenditures, income from crop sales and the number of different cash crops. Daily mean household expenditures as a proxy for living income and the wealth of a household are rather low across all five differently-resourced farmer groups but increase with rising available resources. Whereas differences in the happiness level of the five groups are small, low- and highly endowed cocoa farmers are less likely to increase their cultivated land area or report migration of a household member compared to cocoa farmers with medium levels of resources.

3.3.4 Cocoa marketing

We now turn to the price mechanisms in the physical cocoa market in Côte d'Ivoire, maintaining a focus on the cocoa-producing farmer. For that purpose, we first examine cocoa farmers' relationship to buyers as their main counterpart in the cocoa value chain. We then assess variation in local farm-gate prices and underlying drivers, and particularly assess the recently introduced ”Living Income Differential”. In a last step, we turn to the added value along the cocoa value chain, which itself is briefly portrayed in Box 3.1, and compare the situation in Côte d'Ivoire with that in other cocoa-growing countries.

Box 3.1 The in-country cocoa value chain

Many actors are involved along the cocoa value chain in Côte d'Ivoire. The *Conseil du Café-Cacao*, the Coffee and Cocoa Council (CCC), as public institution has a key role in carrying out sector regulation, stabilization and development and thereby affects all other actors along the cocoa value chain.

The cocoa value chain starts with the producer, predominantly smallholder farmers, who sell dried and fermented, unprocessed cocoa beans to buyers. Three types of buyers exist: so-called *pisteurs* (trackers) and *traitants* (literally meaning processors) as well as cooperatives. Pisteurs are local intermediaries. They are either envoys of traitants or they work independently, which is common in Côte d'Ivoire. Traitants are regional intermediaries located in marketing centers closer to the ports in the south of the country. Like cooperatives, they may have a warehouse to consolidate all the collection before delivering the product to a processor or grinder. The processor merely prepares the beans for exportation (drying, winnowing, and repackaging) and main exporters avail of such processing units themselves. Seventy percent of cocoa beans from Côte d'Ivoire go this way to the rest of the world as raw cocoa. Another 30% of the beans are ground in the country and then exported. It is typically the exporters or grinders who also provide the pre-financing and equipment (such as vehicles and weighing equipment) to intermediaries.

The farmer-buyer relationship

Virtually all (96%) interviewed cocoa farmers reported to have sold their entire cocoa from the harvesting campaign 2020/2021 (Table 6). The few farmers that did not sell all harvested cocoa reported to either having sold only part of their harvested cocoa or none since their cocoa trees had not borne any fruits yet or because they had planned to sell the cocoa later. The vast majority of the cocoa harvest is sold during the main harvest, which spans from October to March of the following year. On average, cocoa farmers sold 6.4 tons of cocoa to their buyers during that period, and another 0.8 tons during the side harvest from March to summer. Most cocoa farmers sell mainly to one buyer (about 86%), with only 11% selling to two buyers and another few farmers engaging with more buyers.

Table 6: Farmers' cocoa sales in the 2020/2021 season

	Mean	Min	Max
Farmers who sold all harvested cocoa, share	0.96	–	–
Number of buyers	1.18	1	5
Number of cocoa buyers in village during main harvest	10.42	0	200
Cocoa sold during main harvest 2020/2021, in kg	6,447	0	4,500,000
Cocoa sold during side harvest 2021, in kg	826	0	150,085

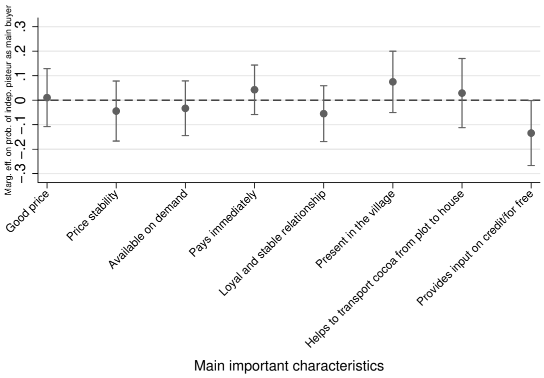
Note: The number of cocoa buyers in village during the main harvest was top-coded at the 95% level, that is the highest 5% of number of buyers have been set to the value of the 95 percentile in order to mitigate the effect of outliers on the average values.

Buyers typically fetch the cocoa beans from the cocoa farmers, whereas 30% of farmers stated to transport the cocoa to the sales point/warehouse of their buyer. For the majority of farmers (59%), the buyer is a local pisteur, often an independent one (38% versus 21% pisteurs working for a private buyer). The second-most frequent buyer type, at 38%, are cooperatives. Only about 3% of cocoa farmers sell their cocoa directly to private buyers/traitants.

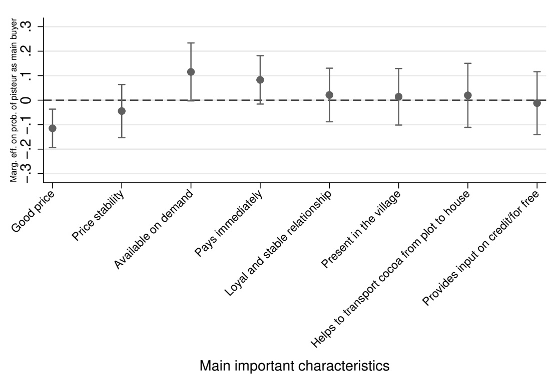
Cocoa farmers report an average of ten different buyers who regularly buy cocoa in their village during the main harvest (Table 6). Similarly, almost 72% report that their neighbors sell their cocoa to a different buyer. Hence, the average variety in available cocoa buyers seems to be rather good. In line with this, more than half of cocoa farmers say that it would be very or rather easy for them to switch buyers. However, slightly over 30% report that it would be difficult for them to switch buyers.

To better understand a cocoa farmer's choice of buyer, we elicited the buyer's characteristics that cocoa farmers consider the most important. Figure 20 shows for the different buyer types, in how far certain characteristics were more or less frequently mentioned. We can see from Figure 20 (a) that cocoa farmers who report the provision of input on credit or for free as the main important characteristic are significantly less likely to sell to an independent pisteur. Even though farm-gate prices are formally fixed by the Coffee and Cocoa Council, 13% of cocoa farmers in our survey consider a good price as the most important buyer characteristic. Farmers who consider a good price as a buyer's main characteristic are less likely to sell to a pisteur who works for a buyer. This finding slightly indicates that the price of these kind of pisteurs is lower or at least believed by farmers to be lower than for other buyers. Nevertheless, farmers who put a high value on the availability of a buyer on demand, are likely to sell to these dependent pisteurs (Figure 20 (b)). On the contrary, farmers who consider this availability to be important, are statistically significantly less likely to sell their cocoa to a cooperative (Figure 20 (c)). Selling to a cooperative is also less likely for cocoa farmers who consider the immediate payment as important. This matches the information about the time at which the buyer pays the cocoa farmer: Whereas between 70 and 80% of cocoa farmers report to be paid at once when selling to pisteurs or private buyers, only 46% report so for a cooperative. For cooperatives, it is instead more common to pay a few days after the sale, often 3 to 6 days, sometimes 1 to 2 days. Finally, we do not find any characteristics to significantly influence the likelihood of a farmer selling to a private buyer/traitant (Figure 20 (d)).

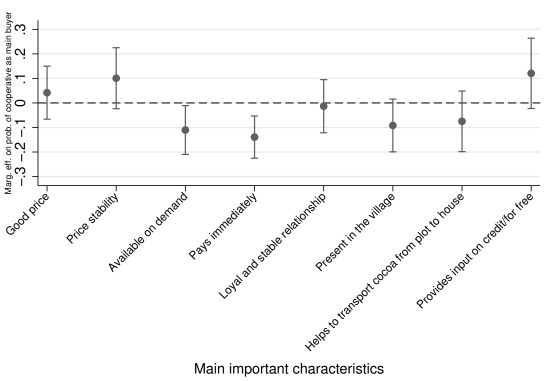
Overall, cocoa farmers seem satisfied with their main buyer. 90% of our interviewed cocoa farmers believe that their main buyer pays the same price to other farmers and only about 2 to 3% think that the price paid to other farmers is higher or lower, respectively. Similarly, cocoa farmers largely think that other buyers in their area pay the same price as their own main buyer. Six percent even think that their own main buyer pays a better price than other buyers and only 3% think that other buyers pay a higher price. This leads us to conclude that cocoa farmers are generally satisfied with their buyer and also trust their buyer with respect to pricing. Even though about half of the cocoa farmers consider the price paid by their main buyer to be the right price and 15% think that it is even a very good price, there is a non-negligible part of cocoa farmers that considers the price as unfair. Their share of one-third is larger than the share of cocoa farmers that believes that other farmers receive a higher price from the same buyer or that other buyers pay a better price. This points at a general criticism of the price level set by the Coffee and Cocoa Council and determined in the world market, which we discuss in the following.



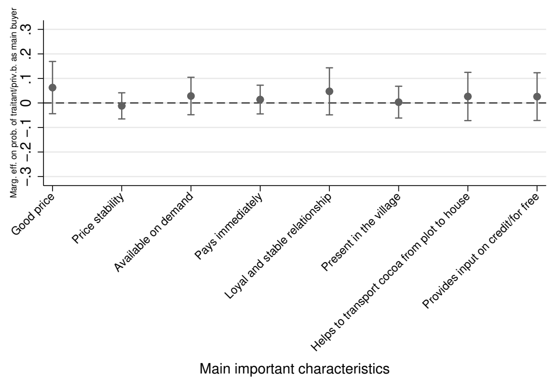
(a) Independent Pisteur



(b) Pisteur working for a buyer



(c) Cooperative



(d) Private buyer/Traitant

Figure 20: Buyer characteristics considered important by cocoa farmers' type of buyer

Local variation in cocoa prices

In a perfectly competitive market in equilibrium, economic theory predicts that a single price should prevail for an identical good sold at different locations (von Cramon-Taubadel and Goodwin, 2021). The basis for this prediction, referred to as the strong version of the law of one price (LOP), is that profit seeking traders will exhaust all opportunities for arbitrage. A weaker version of the LOP holds that transaction costs, such as transporting the good and covering risk premia, will render the price difference between identical goods in different markets equal to the cost of trade between these markets:

$$p_{m1} = p_{m2} + c \tag{1}$$

where p_{m1} and p_{m2} are the prices in the two markets and c captures the transaction costs (Olipra, 2020). The LOP is a theoretical concept, but nevertheless provides a useful point of departure for gauging the extent of spatially integrated markets. Spatial integration ensures that local prices reflect local scarcity, in turn incentivizing producers to specialize based on comparative advantage.

Box 3.2 Regulated price setting in Côte d'Ivoire

The marketing of cocoa is highly regulated in Côte d'Ivoire. The marketing system as it exists today was implemented in 2012 after two decades with a liberalized system. It guarantees a minimum price and eliminates intra-seasonal price risks for producers. A key component of this stabilization system is a mechanism called *Programme of Anticipated Sales* (PVAM). In the six months before a new crop year, about 70 to 80% of next year's crops are sold to exporters via forward sales auctions. Exporters thereby acquire permits from the Coffee and Cocoa Council that allow them to source a specified quantity of cocoa beans on the domestic market at harvest time for export. The resulting average forward price is used together with projections on the remaining spot sales and exchange rates to define a benchmark price for the next year. This benchmark price is defined as CIF (cost, insurance, and freight price) price, which is the price that covers all costs to the port of destination. This CIF value in FCFA ("guaranteed CIF" in the following) then serves as the basis for calculating the remunerations for all actors in the national cocoa value chain. This includes the farm-gate price, which the government assures to exceed 60% of the guaranteed CIF (or at least 50% of it in times of falling global prices). The farm-gate price and remunerations for all other actors along the in-country value chain are fixed at least for the entire main harvest season; sometimes a revised price is set in April for the side harvest (KPMG, 2018). This system of using a *barème* (scale) in Côte d'Ivoire to allocate parts of the export price to different actors along the value chain goes back to the 1950's (Benveniste, 1974).

The marketing of cocoa is highly regulated in Côte d'Ivoire and guarantees a fixed farm-gate price (Box 3.2). For the main season of 2020/2021 for which data was elicited, the Coffee and Cocoa Council had set a guaranteed producer price of 1000 FCFA/kg for the main harvest (equivalent to EUR 1.5/kg). This level could not be maintained for the side season and was therefore reduced to 750 FCFA. For comparison, the guaranteed farm-gate prices in both the 2019/2020 and 2021/2022 season amounted to 825 FCFA. Fixed producer prices mean farmers in principle cannot negotiate prices or differentiate prices, e.g. by quality, making an assessment of price variation seemingly moot. However, the possibility of non-compliance with this guaranteed price cannot be ruled out, and the survey indeed revealed some heterogeneity in the price that farmers reported to receive from their cocoa sales for the cocoa harvest of 2020/2021. Some 32% of farmers reported a price below 1000 FCFA, with a low of 500, while 4.6% of farmers reported a price higher than 1000, with a high of 1100. The average price is 922 FCFA during the main harvest, and 637 FCFA during the side harvest (Table 7).

Figure 21 (a) presents the average absolute main harvest price level for all districts in Côte d'Ivoire,

Table 7: Cocoa Pricing and Marketing of Cocoa Farmers

	Mean	Min	Max
Price during main harvest 2020/2021, in FCFA/kg	922	500	1,100
Price during side harvest 2021, in FCFA/kg	637	450	1,000
Distance to sales point, in km	1.08	0	110
Expenditure for transport to sales point, in FCFA	1,249	0	200,000

while Figure 21 (b) depicts the heterogeneity in these prices, color-coded according to the deviation between the average price in a district and the overall average price from the survey. The districts of Comoé and Sassandra-Marahoué have the highest positive deviations of 65 and 87 FCFA, respectively. They correspondingly register the highest price levels that translate to a difference of 7 to 10% to the overall mean price. Conversely, Worouba and Zanzan have the highest negative deviations of 74 and 182 FCFA along with the lowest price levels. Consistent with the LOP, transportation costs may play some role in these differences. The road network extending into rural areas of the country is relatively sparse and poorly maintained, making transportation from more remote regions in the north costly in terms of fuel expenses, vehicle maintenance, and travel time (see also Table 7).

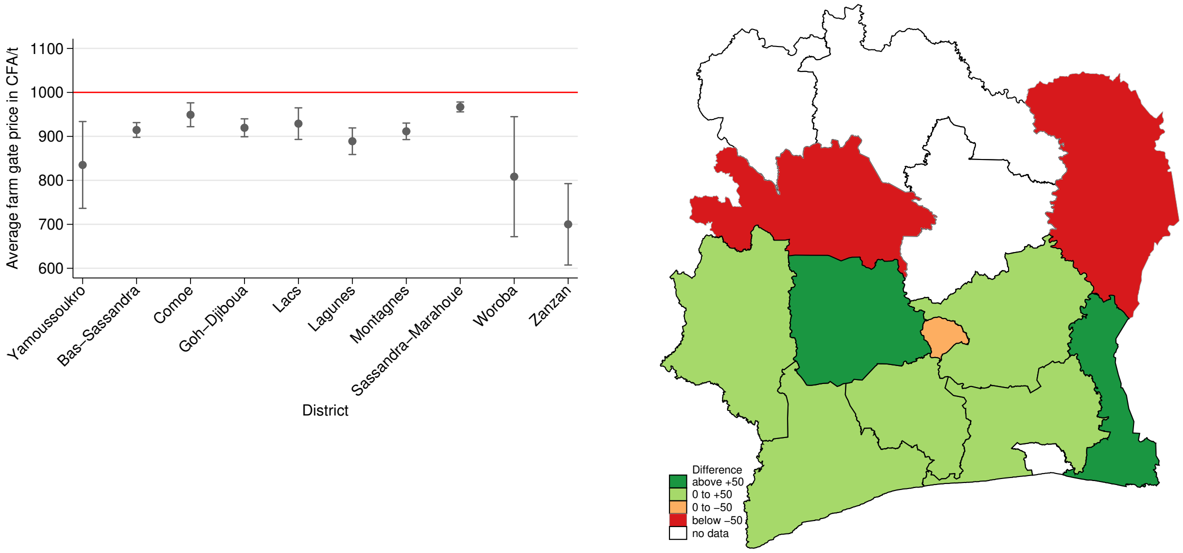
Other factors, not all of which are readily observable, likely also play a role. We attempt to account for as many of these factors as possible in an OLS regression of the determinants of the cocoa price received by the farmer, which is presented in columns (1) and (2) of Table 8. These factors are briefly discussed before turning to the results. One such factor is product homogeneity. To the extent that there are differences in cocoa quality across locations, buyers will treat the goods as imperfect substitutes, which could compel sellers to charge different prices depending on location. We control for this by including dummy variables that indicate each district, which serves to capture market and environmental conditions across regions. We also include a dummy variable indicating certified cocoa, since this is one quality aspect by which prices are allowed to be differentiated. In our sample, as many as 31% of cocoa farmers sell at least some certified cocoa. Most of them do not know the exact name of the certification, another third of them referred to UTZ/ Rainforest Alliance; other certificates such as Fairtrade were mentioned by at most 10% of them.

Access to price information is another important factor. Arbitrage is predicated on an awareness of price differences across regions, allowing traders on both sides of the market to pursue riskless profit opportunities. Several studies have pointed to the importance of radio, television, telephone and the internet as channels through which price information is conveyed (Jensen, 2007; Donner, 2008; Muto and Yamano, 2009). We accordingly include dummy variables indicating whether each of these channels is a farmer's main source of

Figure 21: Price variation at district level for the main harvest 2020/2021

(a) District average prices

(b) Differences from overall average price



information on agriculture markets. Several other variables cover other dimensions of access to information and the ability to process it: membership in a cooperative, whether the farmer is from another country, whether the farmer was born in the village, and whether the farmer had no schooling.

The degree of competition is a final factor that receives attention in the models. Notwithstanding a fixed cocoa price set by the government, there may be some scope for cocoa buyers to bargain down the price in regions where the absence of competitors confers them with market power. We control for this by including a measure of the number of cocoa buyers reported to visit the village. We also include dummies indicating the main type of buyer that each farmer reported selling to.

The results presented in columns (1) and (2) of Table 8, first, imply that all districts correlate significantly with the price. As the models in this table suppress the constant term, these coefficients can be interpreted as the mean price level for cocoa conditional on the other explanatory variables. They are thus very similar in magnitude to the estimates in Figure 21 (a), which are unconditional means. It bears noting that while the estimates are each individually statistically significant from zero, they are not statistically different from each other, as evidenced by the overlap of the 95% confidence levels in the figure.

Otherwise, only one of the estimated coefficients reaches the level of statistical significance, that capturing the effect of certified cocoa. This effect is associated with a price premium of about 21 FCFA relative to uncertified cocoa. The statistical imprecision of the remaining estimates likely owes to the regulated structure of the Ivorian cocoa market, leaving little room for negotiation, even if differences in the price level are seen across districts.

Table 8: Econometric results on determinants of prices and awareness of LID

	Price		LID	
	Coefficient	Std. Err.	Coefficient	Std. Err.
	(1)	(2)	(3)	(4)
Awareness of LID	14.495	(9.630)	–	–
Some cocoa certified	20.623**	(9.092)	0.183***	(0.036)
Elderly household head	-16.127*	(9.667)	-0.024	(0.031)
Distance to plots	-0.024	(1.050)	-0.000	(0.003)
No formal education	9.479	(8.679)	-0.046	(0.029)
Born in village	-17.461*	(9.680)	-0.034	(0.033)
Born outside Côte d'Ivoire	2.662	(10.852)	-0.062	(0.039)
Wealthy	5.372	(10.565)	-0.039	(0.036)
Cooperative as buyer	-39.782	(63.479)	0.778***	(0.051)
Pisteur working for a buyer	-18.251	(23.440)	0.054	(0.141)
Private buyer/traitant	-17.533	(33.266)	0.181	(0.128)
Main source about agricultural markets: phone	-25.298	(24.475)	0.155**	(0.077)
Main source about agricultural markets: TV	-2.728	(13.700)	0.070	(0.044)
Main source about agricultural markets: Radio	10.803	(11.410)	0.126***	(0.034)
Main source about agricultural markets: Village chief	22.378	(19.351)	-0.090**	(0.038)
Main source about agricultural markets: Cooperative	13.901	(8.772)	-0.039	(0.035)
Number of buyers in village during main season	-0.329	(0.202)	0.001	(0.001)
district = Yamoussoukro	817.972***	(51.589)	-0.072	(0.112)
Bas-Sassandra	898.554***	(15.867)	0.192***	(0.047)
Comoé	933.327***	(22.266)	0.305***	(0.087)
Gôh-Djiboua	911.746***	(17.523)	0.132**	(0.055)
Lacs	917.608***	(25.025)	0.103	(0.082)
Lagunes	875.720***	(21.303)	0.100*	(0.057)
Montagnes	905.562***	(17.848)	0.169***	(0.048)
Sassandra-Marahoué	960.347***	(17.231)	0.134**	(0.057)
Woroba	818.698***	(73.239)	0.214	(0.151)
Zanzan	696.935***	(58.638)	-0.095	(0.072)
Number of observations	903		903	
R-Squared	.9839		.3112	

*Note: Robust standard errors are in parentheses. ***, ** and * denote statistical significance at the 1 %, 5 % and 10 % level, respectively.*

Living Income Differential

In 2019, Ghana and Côte d'Ivoire jointly announced a new policy to help raise the farm-gate price in an attempt to bring the cocoa farmers' income closer to a decent living standard. The so-called "Living Income Differential" (LID) is an extra fee of 400 US dollars per ton of cocoa, added on top of the forward sales price. The LID policy additionally stipulates that, as soon as the export price including the LID goes above

2,900 US dollars, the surplus is transferred to a stabilization fund, which in turn can be used to guarantee a minimum price of 2,600 US dollars, if the export price including the LID is otherwise below 2,600 US dollars (FCC, Federation of Cocoa Commerce, 2019). For the 2020/21 season, the Coffee and Cocoa Council converted the LID to 229 FCFA/kg, which was included in the guaranteed farm-gate price of 1000 FCFA/kg.

Columns (3) and (4) of Table 8 present results of a model with the binary dependent variable indicating whether the farmer reported having heard of the LID in the first place. As the LID directly bears on the price level for cocoa, this second model in the table is intended to capture the farmer's awareness of their negotiating position in selling cocoa. More generally, the model intends to show whether certain features such as cooperative membership make it more likely that farmers know about such policy changes. Awareness is generally low and below 50% in all surveyed districts and regions.

The model of LID awareness identifies a handful of statistically significant correlates. This being a linear probability model, the coefficients can be interpreted in terms of percentage points. Among the statistically significant effects, we see, for example, that the probability of having heard of the LID is 18 percentage points higher among farmers who sell certified cocoa. It is even 78 percentage points higher among cooperative members. Several of the dummies for the main source of information on agricultural markets are likewise statistically significant. The excluded comparison case here is neighbors. Thus, we see that the probability of LID awareness is nearly 16 and 13 percentage points higher among those who have access to their information by phone and radio, respectively, compared to those who receive information from neighbors. Conversely, the probability is 9 percentage points lower among those who primarily receive information from village chiefs.

Beyond awareness, the crucial question is how effective the LID is in raising and stabilizing farmers' incomes. While indeed a majority of cocoa farmers aware of the LID believe that it reduces price volatility (70%), less than 25% believe they have received the entire LID. It is indeed the case that the above-mentioned price premium of 400 US dollars per tonne of cocoa could not be implemented consistently. In particular, international buyers in the individual price negotiations have pushed to reduce Côte d'Ivoire's origin differentials in return, which had a corresponding effect on the prices actually achieved. To gauge the difference made by the LID, we compare real farm-gate prices fetched by the cocoa farmers before and after the introduction of the LID. We first weight the main and side harvest farm-gate prices of the 2020/2021 season by the respective cocoa production levels in order to arrive at an effective farm-gate price for the entire season. Second, we account for inflation by calculating farm-gate prices in real terms based on the beginning of the 2019/2020 season. Accordingly, real farm-gate prices for the three seasons 2019/2020 to 2021/2022 amount to 810, 900 and 750 FCFA/kg, respectively. In absolute terms, the farm-gate price in the first year with LID was thus higher than in the previous season, even though the difference is smaller than 229 FCFA, which is the equivalent of an LID of 400 US dollars per metric tonne. At the same time, the farm-gate price decreased below the level of the 2019/2020 season in the second year with LID, the 2021/2022 season. Here, an LID was not even specified anymore in the price scale (*barème*) set by the Coffee and Cocoa Council. It was hypothesized that the envisioned price and thus profitability increase induced by the LID would induce farmers to expand their cocoa production. Against the background of little knowledge of the LID and a lack of such a price signal from the LID so far, it can not be expected that this policy will affect production in the coming years.

This assessment of absolute farm-gate prices may miss capturing the effects of world market prices, which determine in how far the LID raised farmers' incomes from a counterfactual perspective. For example, farm-gate prices might have been even lower in the absence of the LID. To shed further light on this aspect, we compare farm-gate prices to world market prices as part of the following sub-section.

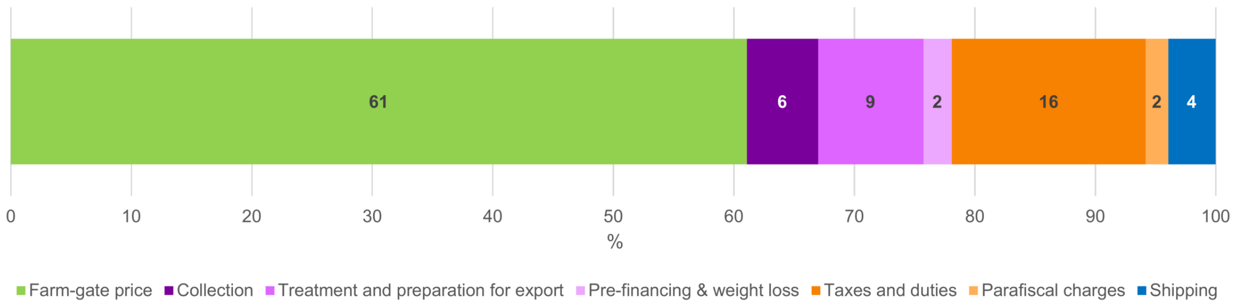
Added value along the local cocoa value chain

In this section, we first describe how the value added is spread across the in-country cocoa value chain. Additionally, we compare farm-gate prices and guaranteed CIF prices with world market cocoa prices. Figure 22 shows how the guaranteed CIF price is distributed across different steps from the individual farmer up to the port of destination for the season 2019/20, in which the structure of the guaranteed CIF remained constant over the entire season. We see that 61% of the guaranteed CIF price accrues to the farmer, who usually receives this amount instantly at the time of selling the unprocessed beans to intermediaries. These intermediaries receive 6 and 9%, respectively, for all the services performed before the beans are ready for export. Such services include the collection and storing of the beans, quality assurance and processing, payment of port fees, and paper work related to the export of the beans. Given that the beans are a natural product and completely pre-financed, another 2% is added for pre-financing and weight losses.

Distinguished from other cocoa-producing countries like Ecuador or Cameroon, Côte d'Ivoire relies strongly on cocoa as a taxable export product. Accordingly, taxes and duties on cocoa export are relatively high compared to other countries (totalling 16% in the 2019/2020 season) and make it an important source of government revenue (more than 10% of total national tax revenues). Another 2% go as parafiscal charges to the Coffee and Cocoa Council and multiple other funds and institutions related to the cocoa sector, such as an Agricultural Investment Fund. Lastly, shipping accounts for the last 4% of the guaranteed CIF price.

All these shares remained very stable over the years. The share of the farm-gate price stayed in a corridor of 60 to 61% in all seasons from 2012/13 to 2021/22, except for the main season in 2020/21. Here, the farm-gate price had a higher share, which, however, could not be maintained and had to be reduced in the side

Figure 22: Remunerations across in-country cocoa value chain



Source: Own calculations based on *barème* for the 2019/20 season (*Paramètres de calcul du diferentiel recolte principale cacao 2019-2020*) provided by the Coffee and Cocoa Council.

season. The fact that the share is back at 61% in the 2021/22 season provides another indication that the LID had thus far no significant effect on farmers' incomes.

A main lever for the government to maintain these shares over the years has been the registration tax paid by exporters, which varied between 0 and 5% and is now at 3% in the 2021/2022 season.

In light of the poor living conditions of many cocoa farmers in the country (Fountain and Hütz-Adams, 2020), the question arises as to the role played by the high degree of regulation: Does it mitigate or exacerbate the hardship faced by cocoa farmers? We briefly discuss three potential mechanisms through which the specific regulation adopted in Côte d'Ivoire may play a role.

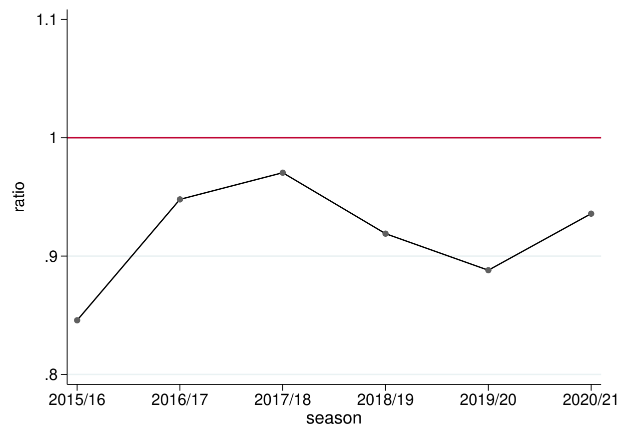
First, regulation may provide disproportionately high remunerations for other actors along the value chain, in that they can achieve excessive margins. Moreover, regulation may shield low-efficiency enterprises and services from competitive market pressures. Overall, however, we find little evidence in support of these possibilities. It is difficult to judge how financially attractive individual tasks along the national value chain are, also because most activities are licensed by the Coffee and Cocoa Council such that the number of parties willing to enter the respective businesses is not observable. Similarly, the concrete definition of the individual remunerations in the price scale (*barème*) remains opaque. Nevertheless, a deeper look into them does not suggest obviously high margins for any of the activities, and sector actors instead report weak margins (KPMG, 2018, see also Aka Zebra Sas, 2021). Many individual remunerations were furthermore not increased since 2012 such that price rigidity rather forces these actors to become more efficient. This first hypothesis related to potential inefficiencies also touches the parafiscal charges, as part of these cover services provided to farmers or are more broadly reinvested in the sector, including input provision and training. A recurrent critique is that such services by parastatals are vulnerable to corruption or patronage and tend to be rendered less efficiently (Kolavalli and Vigneri, 2017; Bymolt et al., 2018). While these concerns remain valid, and productivity could not be increased significantly in the regulated system, the physical quality of the cocoa beans has, for example, significantly improved over the last years in the regulated system. For example, the difference in the price including the origin differential paid for cocoa beans from Côte d'Ivoire and Nigeria at the London exchange increased from 0.7 to 4.6% and 4.8% in the period 2015 to 2019 (before implementation of the LID) and 2021, respectively. A similar increase in the gap of origin differentials can be observed when comparing Côte d'Ivoire with Cameroon. Accordingly, one can as well observe price-relevant advantages of the regulatory system.

Second, regulation may impose an excessive tax burden on the sector and thereby on the farmers. The taxes and duties indeed make cocoa farming the most heavily taxed income-generating activity in the country (World Bank, 2019), and it seems appropriate to reduce that burden in the future. For the time being, this source of government revenue, however, seems indispensable to fund public goods in the country.

Third, the adopted PVAM price-setting mechanism (Box 3.2) may result in selling the cocoa too cheaply at the international market such that the guaranteed CIF itself could have been higher in the first place. The reasons for that may be that sales are not well-timed or negotiated, or that export-licenses are allocated below the market price to influential stakeholders in the country (Oomes et al., 2016). There are no substantive indications for either of the two explanations, however. While comprehensive audits by international auditing firms in 2014 and 2017 both detected important governance issues, the World Bank later concluded that the firms' recommendations were implemented, which it had set as a prerequisite for a financing agreement in 2018. To provide tentative indications on how well the PVAM functions in capturing potential rents, in Figure 23 we compare guaranteed CIF prices for the last six seasons with related prices at the London future exchange as the relevant exchange for cocoa from West Africa. More specifically, the reference for each season is the average price of cocoa futures six months ahead including the origin differential for cocoa from Côte d'Ivoire. This reference can thus approximately be seen as the CIF that can be fetched if cocoa would be sold evenly over the marketing season. We see that the ratio of the guaranteed CIF to this reference is close to one, but averages significantly below at 0.92 over the six seasons. There may be different reasons for why this ratio is below one, including exchange rates. Nevertheless, this difference is non-negligible and therefore deserves further in-depth analysis (for which we, however, lack the necessary information). To provide an idea of the extent of this potential inefficiency, we note that the farm-gate price could have been increased by 16% for the 2019/2020 season investigated above (or by 20% if the difference would be entirely allocated to the farmers in line with the initial announcement that the entire LID would go to farmers).

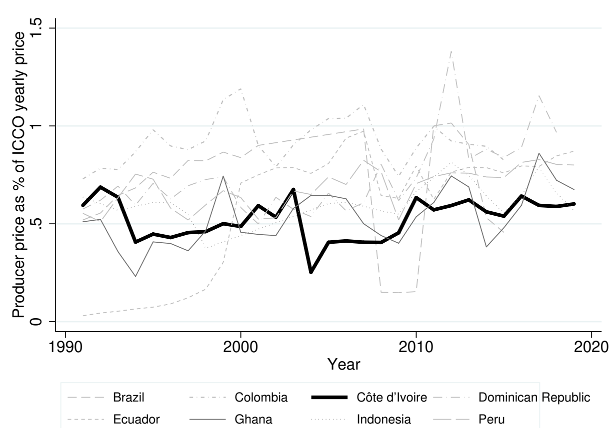
In combination, these factors contribute to the fact that Ivorian cocoa farmers receive among the lowest cocoa prices in the world. This can be taken from Figure 24, which shows producer prices in real US dollars as a percent of the global cocoa price. Data on producer prices for cocoa is obtained from the Food and Agricultural Organization (FAO, 2022). The world price is recorded by the International Cocoa Organization

Figure 23: Ratio of guaranteed CIF to average London prices of cocoa futures incl. origin differential, by season



and measured in US dollars per metric ton, obtainable from the International Monetary Fund (IMF, 2022). It represents the annual average of CIF quotations of the nearest three active futures trading months at the Europe and US cocoa futures markets. Data on exchange rates is obtained from the St. Louis Fed (FRED, 2022). Bymolt et al. (2018) present a similar analysis through the year 2015, albeit with different comparison countries and (presumably) nominal figures. They likewise identify low cocoa prices for Ivorian farmers, which they attribute primarily to the high taxes levied. Of course, factors other than taxation and the efficiency of the internal market system may also contribute to the price differences across countries, including the general quality of the beans, exchange rates and the cost of transportation to consuming countries.

Figure 24: Producer prices in real US dollars as a percent of the ICCO yearly price



A final question related to the above discussion concerns the extent to which variations in world prices are transmitted to domestic prices. Cocoa, as with agricultural products in general, is a tradable good. In the absence of price-distorting government interventions, we would therefore expect that cocoa prices vary proportionately with world prices. To test this hypothesis, we draw on a simple framework employed by Mundlak and Larson (1992), who explore agricultural price transmission in an international framework that pools commodities for individual countries. Their point of departure returns us to the law of one price, according to which the domestic price of the commodity at time t, P_t, equals the product of the world price, W_t, the exchange rate, E_t, and tax policy, S_t:

$$P_t = W_t * E_t * S_t. \tag{2}$$

Other determinants of price differences across countries, like transport costs, are accommodated through the inclusion of a disturbance term. We control for tax policy through a yearly time trend. Writing the natural log of the variables in the above equation in lower case letters, we estimate the following regression:

$$p_t = \beta_0 + \beta_w w_t + \beta_e e_t + \beta_{year} year_t + \varepsilon_t \tag{3}$$

where the βs are parameter estimates and ε_t is a normally distributed disturbance.

The annual data used to estimate the model is the same as the one underlying Figure 24. Temporal coverage of the data varies by country but generally spans from the mid-1990s to nearly 2020. For Côte d'Ivoire, we have 29 data points spanning 1991 to 2019. The model is estimated for each country individually; the list of countries included in the analysis was based on data availability.

Figure 25: Passthrough of global to local cocoa price

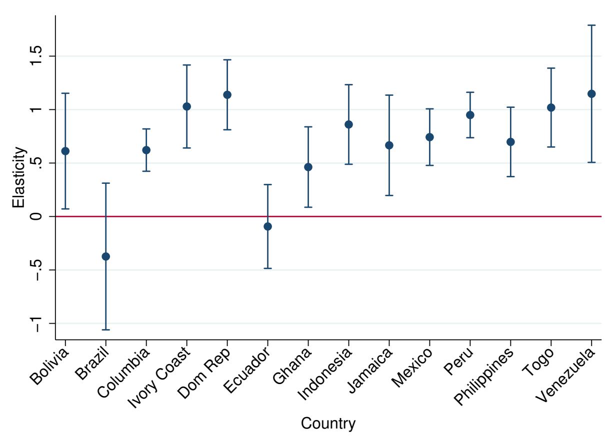


Figure 25 presents the estimates of β_w, which, borrowing from Mundlak and Larson (1992), are referred to as transmission elasticities. With the exception of Brazil and Ecuador, all of the transmission elasticities are statistically significant. The null values for Brazil and Ecuador imply no (to very low) transmission of world prices for cocoa in these countries. Otherwise, the 95% confidence intervals of most of the remaining estimates all contain the value one. In the case of Côte d'Ivoire, the point estimate is nearly exactly one (= 1.03), implying that variation in the world price is fully transmitted to the domestic prices. This near spot-landing may seem curious in light of the preceding discussion concerning the heavy role of the state in the regulation and taxation of Côte d'Ivoire's cocoa markets. Two explanations offer themselves. First, while these interventions will affect the local *level* of cocoa prices, this does not necessarily preclude domestic prices from moving in tandem with world prices (Mundlak and Larson, 1992). This seems plausible given that taxation as well as price regulation for the regulated sub-periods remained very stable over the observation period. Second, as the world's largest cocoa producing country, we cannot rule out reverse causality, whereby market conditions in Côte d'Ivoire affect world prices. This caveat prevents us from ascribing a causal interpretation to the estimate of β_w. Interestingly, the transmission elasticity of neighboring Ghana is about half the magnitude of Côte d'Ivoire, likely reflecting at least in part the influence of interventions that are poorly synchronized with fluctuations in world prices.

The statistically insignificant deviations from unitary elasticity that are evidenced for most of the countries in Figure 25 highlights the centrality of world prices in driving fluctuations in domestic prices. This aligns with the findings of Mundlak and Larson (1992), whose analysis pools different agricultural commodities for the period 1968 to 1978. An important upshot is that policies that attempt to decouple domestic from world prices are unlikely to be sustainable, at least in the absence of persistent public financing. To the extent that domestic and world prices covary over the long run, policies to support the cocoa sector such as the LID, which in part shields farmers from global price signals, may ultimately prove costly if unaccompanied by structural adjustments.

4 Expected benefits and usability of the results

Scientifically based findings on price formation on cocoa market that are relevant for practitioners represent the expected benefit of the present research project. They are to serve the evidence-based policy advice of relevant actors from politics, industry and society. The suitability of the cocoa futures exchange for risk management of stakeholders in Germany was the focus of topic block A. As summarized again later in chapter 5, the price formation mechanism in the cocoa financial market could be identified based on the data-driven analyses. The results confirm the suitability of the futures market for risk management. In particular, the research showed that since the end of 2016, futures market price discovery has taken place two months before maturity. This indicates that price discovery is primarily influenced by market participants prior to the maturity date and subsequently has an impact on prices at maturity. The futures price before maturity is then considered a predictor of the futures price at maturity. Through the interaction of the futures and spot markets, it was found that the emergence of price developments take place in the spot market and have a long-lasting effect on the futures price trend.

Fundamental price determinants generate cocoa price trends. Around the maturity date, price trend reversals are caused by market participants basing their decisions on exogenous news. Indicators of fundamental market sentiment have lost direct influence over time. This indicates an accelerated integration of available financial information into prices and strengthens the assumption of efficient markets.

The study showed that no evidence against the fundamental efficiency of the cocoa futures market was found in the data during the study period. Thus, there is no immediate need for the raw cocoa processing companies in Germany to adjust their established hedging strategies. The identified influence of algorithm-based securities trading should be intensively monitored and tracked, as this could result in potential market distortions and inefficiencies. In particular, there is a risk that the increase in algorithmic securities trading could extremely potentiate shock-like changes in fundamentals, putting massive pressure on markets. The analyses performed and, in particular, the application of our adaptive forecasting method indicate that daily price changes of different price time series are subject to a similar underlying process, as investors and speculators make their investment decisions across markets and based on similar decision processes.

It may therefore be recommended to further reduce the participation of short-term speculators – for example, through a transaction tax – since short-term speculation does not serve producers and processors to hedge uncertainties in the spot price. Long-term speculators who magnify price trends would also be hit by a transaction tax, so overall a transaction tax is expected to strengthen the market position of processors and producers.

In a future data-driven study, individual fundamental weekly news items could be extracted from the Thomson and Reuters financial news database. Using machine learning, clustering various events could then be used to examine how individual market participants react to specific events and thus influence the price.

The analyses of the physical cocoa market of Côte d'Ivoire made it possible to contribute to greater transparency with regard to living and working conditions in cocoa cultivation as well as pricing mechanisms in the world's largest cocoa producing country. Cocoa is considered an attractive crop in Côte d'Ivoire, despite price volatility, challenges with crop diseases, and overall low income opportunities in absolute terms. Accordingly, measures to reduce expanding cultivation quantities, as has been discussed periodically as a means of increasing prices, would require clear compensation mechanisms for cocoa farmers. Furthermore, the survey established profiles of different types of cocoa farming households, indicating that unequal resource distribution has a noticeable impact on the living conditions of cocoa farmers. While cross-sectoral improvements in quality and production volumes should remain the primary objective of interventions in the domestic cocoa value chain, both public and private sector actors are encouraged to expand targeted interventions for vulnerable households.

The ”Living Income Differential” (LID) measure introduced jointly with Ghana has so far proved ineffective. The two countries’ expectation was that they could push through a mark-up beyond the quality-differentiated origin premium, which at current world market prices would be equivalent to a roughly 15% surcharge. The motivation was to allow raising the ”guaranteed CIF” price funded through the forward sales system of the cocoa regulator and thereby increase the money available for the actors in the national cocoa value chain – first and foremost the cocoa farmers. Preliminary experience with the LID, however, suggests that even a market share of global cocoa production of over 60% between Côte d’Ivoire and Ghana does not appear to provide sufficient leverage in the cocoa market to dictate prices. The desire to establish a kind of ”COPEC” along the lines of OPEC seems to be doomed to failure, in particular by the fact that raw cocoa – unlike crude oil – is a perishable commodity. As such, purely price-based measures will unlikely prevent the covariation of domestic cocoa prices and world prices in the long run, as was demonstrated in the analysis of the transmission of world cocoa prices. Conversely, ensuring exposure to market signals will afford farmers with the information needed to make optimizing decisions with respect to crop choice and diversification.

The decisive question is how to maintain such market signals while providing cocoa farmers with a living income. Current estimates say that below 10% of cocoa farmers in Côte d’Ivoire earn a living income and less than 25% earn above the poverty line (True Price, 2018; Tyszler et al., 2019; Fountain and Hütz-Adams, 2020). The above-mentioned improvements in terms of quality and production volumes can only be part of the solution. Transfer systems would generally be an option, but they would have to cover a very large share of the national population and themselves involve high set-up and administrative costs and inefficiencies because of imperfect targeting and scope for corruption. Not least, these transfers would have to be funded, but national funding is hardly imaginable at the moment given that the cocoa sector is instead an important source of tax revenue as shown above. Considering the highly skewed distribution of value in the international supply chain, a stronger involvement of the international cocoa industry therefore appears to be necessary in order to achieve serious improvements in the income situation of farmers.

In the context of the utilization of the results of this research project, it is intended to ensure the transfer both to politics and to science. Presentations and discussions of the research results involving relevant decision-makers are planned, as well as exchanges at national and international research conferences and publication in peer-reviewed journals.

5 Summary

The results of Topic Block A on the futures market can be summarized as follows: Although the analyses show that there are price determinants for cocoa price developments and daily cocoa returns, these do not contribute to a daily forecast. It is mainly exogenous news that determines price trends. This is consistent with the theory of efficient markets, according to which prices are formed solely by new information. The existence of market efficiency can thus be confirmed for the cocoa futures market.

Major price changes are caused by those market participants who anticipate changes in the supply and demand of raw cocoa. In particular, price trends turn around near the maturity date of a contract. Producers/processors and merchants hold the most open positions and have the greatest influence on price trends through changes in their open positions. However, large speculators react primarily to past price changes, further intensifying existing price trends.

For spot prices of cocoa from Ghana and Côte d'Ivoire, a long-term stable equilibrium with futures prices 6 months back can be observed from 2015. The futures price adjusts to the spot price, so that price discovery takes place in the spot market and determines the price development. However, the year 2016 forms a break in the futures prices: before 2016, prices in the futures market formed on the maturity date of the contracts. After 2016, prices form two months before the maturity date and have an effect on the price trend until maturity. In the 2016/2017 harvest season, there was an oversupply of raw cocoa. Therefore, prices fall until the maturity date and the price difference benefits the speculative sellers of the futures contracts. From September 2016, the number of traders dropped dramatically, while at the same time the number of open positions increased. A few large traders thus had a greater influence on price developments. Accordingly, changes in price formation were identified from 2016. A comparison of the two commodity futures exchanges, New York and London, revealed a strong correlation in cocoa price volatility. Nevertheless, the oversupply in 2016 also changed the relationship between the two exchanges.

In addition, the influence of major market participants such as producers and processors on volatility is no longer significantly present. Daily volatility between contract maturity months is caused by short-term speculation, especially since 2016, and daily price direction changes can be predicted with some accuracy using proprietary cocoa returns. This indicates increased algorithmic transactions by market participants. Other agricultural futures prices but also stock prices exhibit the same endogenously generated data process. However, these daily directional price changes do not disrupt price trends based on fundamental information.

Price formation in the physical market of the main producing country, Côte d'Ivoire, was elaborated in topic block B. This was based on a combination of in-depth institutional analyses and statistical and econometric evaluations of primary data collected from a nationally representative survey of farmers. The representative survey conducted with 1,052 farmers in August and September 2021 reveals that cocoa production is the main important activity of the majority of farmers in the cocoa belt of Côte d'Ivoire. Only 8% of farmers report to not grow cocoa and instead cultivate cash crops like rubber or cashews. Even though cocoa farmers cultivate on average a slightly higher number of plots and different crops than non-cocoa farmers, both farming groups show low levels of diversification. The majority of cocoa farmers make more than 50% of their total sales income from cocoa sales. The survey data was additionally used to create detailed profiles of different types of cocoa farming households, which exposes the consequences of unequal resource endowments for the living conditions of cocoa farmers. Even though mean household expenditures of all cocoa farmers are rather low and reflect an overall low living income of cocoa farmers, household expenditures and other welfare indicators tend to be substantively higher for cocoa farmers that are well-equipped and have high levels of cultivated land acreage, use of inputs and number of cash crops.

Even though the marketing and price setting in Côte d'Ivoire is highly regulated and guarantees the same minimum price for all cocoa farmers, some variation in prices can be observed: roughly a third of surveyed farmers reported receiving a price that was lower than the officially sanctioned level. This represents an additional source of variation in a farmer's cocoa sales income and overall welfare. Certification is one observed lever through which price premia are achieved. In addition, there are indications for some scope for cocoa buyers to bargain down the price in regions where the absence of competitors confers them with market power. This scope is limited due to the high regulation of all remunerations along the in-country value chain. Yet, certain buyer types are less frequently observed for those farmers who mention a good price as a buyer's main important characteristic, thus indicating some possible level of price discrimination. Most farmers sell to one specific buyer type, this being commonly a local buyer (*pisteur*), a private regional intermediate buyer/*traitant* or a cooperative. The majority of farmers seems to be satisfied with their main buyer and trusts their buyer with respect to pricing. Nevertheless, one third of all cocoa farmers consider the price paid by their main buyer as unfair.

We furthermore find little awareness among farmers of the "Living Income Differential" (LID), the joint effort from the Ghanaian and Ivorian governments to increase farm-gate prices via mark-ups to cocoa forward contracts. This measure has only been shown to increase the farm-gate price in the first season of implementation, 2020/2021, compared to the previous season, but not in the following season of 2021/2022.

Finally, a possible inefficiency that keeps farm-gate prices below their potential is identified at the interface of the physical and futures cocoa market. As identified in topic block A, price determination has been taking place in the futures market rather than the spot market since 2016/2017. An analysis of the price pass-through of world prices to farm-gate prices shows that variations in world prices are almost perfectly transmitted to domestic prices in Côte d'Ivoire. Bearing in mind the caveat that market conditions in Côte d'Ivoire may reversely affect world prices, the analysis of the cocoa futures market reveals that the influence of producers on volatility has no longer been significant since 2016. The farm-gate price has been stable over time at a share of 61% of the guaranteed CIF price, the price that is a result of forward sales, with which Côte d'Ivoire sells 70 to 80% of its crop in advance. Since the "guaranteed CIF" is built according to forward sales that are based on prices on the futures market, the guaranteed CIF price should be close to the related prices at the London future exchange. The results of topic block B, however, reveal that the guaranteed CIF averages significantly below the futures price including the origin differential, with a ratio of 0.92. If the guaranteed CIF had equaled the average price of cocoa futures, the farm-gate price could have been increased by up to 20%. Overall, despite an efficient cocoa futures market and the parallel movement of prices in the physical and futures cocoa market, some inefficiencies remain in the value chain and pricing mechanisms in the producing country Côte d'Ivoire. However, overcoming these inefficiencies seems insufficient to achieve decent farm-gate prices for smallholder farmers in the country.

6 Comparison of original goals with actual achievements

The original goals of this research were defined by work packages (WP).

The overarching goal of *WP 1 - Exploration and preparation of existing data (Block A & B)* was to provide a solid basis for the following analytical steps by deepening the knowledge of the cocoa sector through extensive literature and data search as well as stakeholder engagement. All of these goals were successfully achieved both for topic block A and B. Among others, a kick-off workshop and stakeholder mapping were conducted in the first four quarters of the project, including participants from policy, industry and civil society.

In *WP 2 - Econometric modeling of price discovery in the cocoa futures market (Block A)*, extensions of existing models for the cocoa futures market were to be developed and applied. This was to increase the predictive accuracy of the models and to answer the question whether market participants can use the futures market for price hedging purposes on the spot market. Econometric models and machine learning algorithms for price formation on the cocoa market were successfully developed and evaluated and price determinants were identified. Potential predictors were tested for their price-determining power for cocoa derivatives and an econometric model was adapted so that the model's calculations using a neural network (a machine learning method) could be used to increase the forecasting accuracy of cocoa futures prices.

WP 3 - Impact of fundamental and stock market based effects on the cocoa production chain (Block A) examined the effects of regulatory, fundamental and exchange-based effects on pricing. This was planned to be done through case studies covering prominent constellations in the recent past, such as financial regulation. In addition, simulation methods were to be used to generate a broad range of scenarios for which fundamental and exchange-based effects are calculated and whose effects can be derived from the historical case studies. Based on the results of WP 2, potential regulatory price stability measures were evaluated using past regulatory measures, as well as fundamental and stock market-based effects and their impacts. In addition, based on the results from the analyses of market participant data, market participants were included in the simulations of regulatory price stability measures. In particular, a financial transaction tax was evaluated to model the impact of *MiFiD II* as one case study.

WP 4 - Marketing structures on physical cocoa markets (Block B) primarily served as another preparatory step of the ensuing field study planned in WP 5. The objective was to gain a better understanding on the institutional environment, price formation, and general processes along the cocoa value chain for a focus region in Ghana or Côte d'Ivoire. In both countries, the RWI research team worked together with local partners to enhance their knowledge of the physical cocoa sector, including a scoping mission in February 2020. An overview of the structures in the physical cocoa market was created for Ghana and Côte d'Ivoire, which was then incorporated into the analyses of WP 5.

The purpose of *WP 5 - Price formation on physical cocoa markets (Block B)* was to conduct a quasi-experimental field study among cocoa farmers to investigate the determinants of producer prices as well as their socio-economic conditions, including the impact of price movements. Data appropriate to answer these research questions could successfully be collected through a representative survey in all cocoa-growing regions of Côte d'Ivoire. The implementation of the field study had to be stalled for about 1.5 years due to the Covid-19 pandemic, which was the main reason why the project period was extended by one year in agreement with the project executing agency. In addition, transactions along the value chain were to be quantitatively recorded and descriptively processed and, if the data situation allowed, econometrically analyzed using panel methods. As the scoping mission in February 2020 showed microdata on transactions along the value chain in Ghana as well as in Côte d'Ivoire are difficult to access, partly because key actors are reluctant to publish their data. At the same time, price regulations in both countries proved to be strict across all players in the cocoa value chain. It was therefore decided to conduct this analysis rather in the form of a qualitative institutional analysis.

The scientific investigations and results of the work packages 1 to 5 were to be finally synthesized in *WP 6: Synthesis and transfer of results (Block A & B)*. The focus of this iterative exchange between the two research teams was kept on addressing the questions mentioned in the project announcement: The suitability of the cocoa futures exchange in London for the risk management of the stakeholders in Germany and in the producer countries as well as the questions regarding the quality of the price formation process on the cocoa futures market and its effects on the stakeholders in Germany and in the producer countries.

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