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POLICY REFORMS IN CÔTE D'IVOIRE : THE CASE OF THE RUBBER, COCOA AND OIL PALM SUB-SECTORS

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Abstract

Following the global economic crisis in the 1980s, Côte d'Ivoire adopted liberalisation reform within its agricultural sector. Although this shift in policy has led to notable achievements, evidence of its effects on improving farmers' incomes and enhancing growth is still mixed. Three decades later, the living conditions of rural agricultural households have not improved and their degree of vulnerability has further increased. In this context, this research sheds light on the impacts of the liberalisation reform on producer price dynamics, supply and agricultural services provision to farmers in Côte d'Ivoire. In particular, it focuses on three major commodities, namely Rubber, Cocoa, and Palm Oil, and addresses multiple questions using time series econometrics as well as game theory models. The first chapter analyses the transmission of rubber world prices to the domestic market. It highlights the link between world price and domestic Ivorian producer prices and tests the presence of asymmetry in the transmission process. The second chapter focuses on the cocoa producer price and supply responses to world price shock after the liberalisation reforms with a comparison to the neighbouring Ghana which has not fully liberalized its cocoa sub-sector. The third chapter presents a theoretical assessment of the impact of competition between processors on the provision of agricultural services to farmers. The key findings of this research will help to formulate policies to enhance the competitiveness of the agricultural export sector and improve farmers' incomes.

Contents

List of Abbreviations

ADF	:	Augmented Dickey-Fuller
AIC	:	Akaike Information Criterion
APPH	:	Association Professionnelle pour la Promotion Hévéicole
APROMAC	:	Association des PROducteurs et MAnucfacturiers de Caoutchouc en Côte d'Ivoire
AR	:	Auto-Regressive
ARCH	:	AutoRegressive Conditional Heteroskedasticity
CFA	:	Communauté Financière d'Afrique
CKP	:	Carrion-i-Silvestre, Kim and Perron
CNRA	:	Centre Nationale de Recherche Agronomique
CPI	:	Consumer Price Index
ECM	:	Error Correction Model
FAO	:	Food and Agriculture Organization
FOB	:	Free On Board
FOB	:	Free On Board
GDP	:	Gross Domestic Product
GLS	:	Generalized Least Square
ICCO	:	International Cocoa Organization
IMF	:	International Monetary Fund
IR	:	Impulse Response

JMN	:	Johansen-Moscow-Nielsen
KPSS	:	Kwiatkowski-Phillips-Schmidt-Shin
LCSEP	:	Laboratoire Central Sols Eaux Plantes
LP	:	Local Projection
LR	:	Likelihood Ratio
MGLS	:	Modified Generalized Least Square
MIC	:	Modified Information Criteria
MINADER	:	Ministère Ivoirien de l'Agriculture et du Développement Rurale
OLS	:	Ordinary Least Square
PP	:	Philips-Perron
SIC	:	Schwarz information criterion
SICOM	:	Singapore market exchange
TVECM	:	Threshold Vector Error Correction Model
USD	:	United States Dollar
VAR	:	Vector AutoRegressive
VAR	:	Vector Auto-Regressive
XOF	:	West African CFA Franc

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CHAPTER 1

Introduction

1.1 Context

Sub-Saharan Africa (SSA) is one of the most important development challenges of this century. The region lags far behind in terms of development and poverty reduction, and substantial efforts remain to be made in these areas. According to the World Bank, the number of poor people has decreased in many parts of the world, like in South Asia, but SSA is not following the same trend (Figure 1.1.1). In 2017, SSA accounts for 60 percent of the world's poor population (World Bank, 2020a).

One of the key sectors through which this development and poverty reduction objective is achievable is the agricultural sector, particularly through the inclusion of smallholder farmers (De Janvry and Sadoulet, 2010; Barrett, 2010). As pointed by Dorward et al. (2004), agricultural development plays a critical role in poverty reduction in SSA, due to the large numbers of poor people in rural areas and the critical role of agriculture in driving growth in poor rural areas. Most SSA countries opted for an agriculture-based economy. Therefore, agricultural sector has been the object of various policies and investments since the in-

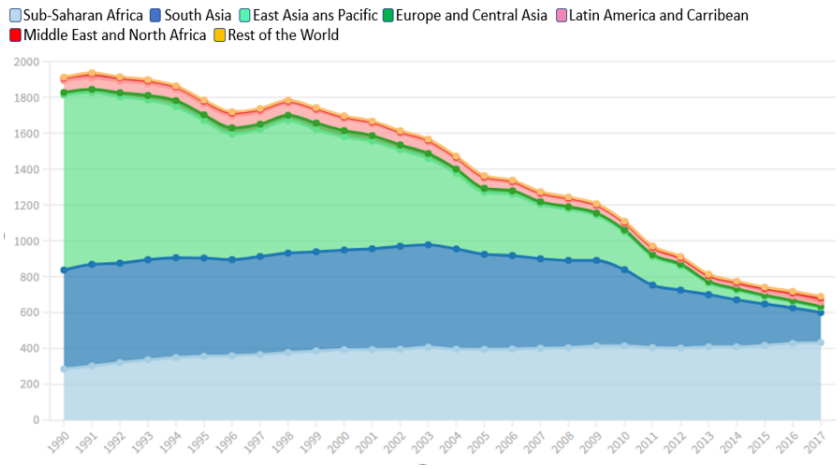


Figure 1.1.1 – Number of extremely poor people by region (millions), 1990-2017 (Source: World Bank)

dependences. For few countries, this development strategy bears fruit in the early years of independence and the agricultural sector strongly influenced their economy (Bernard et al., 1997; Zamfir, 2016; Chirwa et al., 2008). In the post-independence period, most SSA countries invested in the creation of state-owned companies involved in agricultural production, marketing activities, provision of inputs and services to farmers. Governments adopted an interventionist approach with state involvement at all levels of the value chain. This approach was criticised as inefficient because state-owned companies, which served the agricultural sector, were generally part of an inefficient state apparatus. So later, policy analysts and donors aware of the difficulties faced by state-owned companies, coupled with broader macroeconomic management problems, advocated for structural adjustment programmes and liberalisation reforms, which also lead to mixed results.
Basically, the performance of the agricultural sector in SSA over the past decades has been disappointing. According to Sahin et al. (2014), one part of the literature argues that direct state intervention in agricultural input and output markets, through price subsidies and state-owned companies, is most likely to produce inefficient and inequitable outcomes

because it distorts market signals and incentives. Another part of the literature argues that private sector investment alone is not enough and both public and private interventions and investments are needed to create sustainable agricultural growth. However, there is general agreement that the region's agricultural sector has great potential but remains underperforming due to the mismatch between agricultural policies and the local context. At this stage, and with the benefit of hindsight, it seems important to take stock of the current situation of the agricultural sector, especially smallholders. Then, based on the lessons learned from past failures, new policies and strategies need to be formulated and implemented to reverse the trends in the future and contribute to a sustainable economic growth and poverty reduction in the region.

1.1.1 Structural adjustment programmes in Sub-Saharan African countries

Prior to the 1980s, most SSA countries had an interventionist approach, aimed at reducing price risks from international markets, providing a guaranteed income for farmers, and generating public revenues. However, the oil shock of 1979, combined with the drop in world commodity prices and the rise in interest rates, plunged most SSA countries into a deep macroeconomic imbalance in the late 1970s and early 1980s. The desire to restore financial stability and boost economic growth led these countries to accept from the Bretton Woods institutions, namely the World Bank (WB) and the International Monetary Fund (IMF), financial assistance in exchange for the implementation of Structural Adjustment Programmes (SAP). These involved currency devaluation, tight fiscal management, and liberalisation reforms.

As part of the SAP, the liberalisation of cash crop markets in SSA has been implemented under the principle of "getting prices right" (Timmer, 1986). The objective was to eliminate public control over the export marketing chains and promote the involvement of private actors, with the expectation that the sector's competitiveness is strengthened and farmers can benefit from competitive prices (Shepherd and Farolfi, 1999b). Consequently, the mid 1980s witnessed the withdrawal of the state from the agricultural sector in most countries of SSA.

Evaluations of structural adjustment programmes in SSA have been inconclusive and often highly controversial. The effects were mainly analysed on overall economic performance rather than on sectoral growth (Musila and Yiheyis, 2015; Lawal et al., 2016; Keho, 2017).
Gries et al. (2009) tests for causality between trade openness and economic development for 16 SSA countries and do not find significant long-run relationships among the variables for most of the sample. Vlastou (2010) investigates the relationship between openness and growth for a sample of 34 African countries and, in contrast to previous analyses, finds that openness to trade has a negative impact on economic growth. Asfaw (2014) provides empirical evidence on the relationship between economic growth and trade policies using a panel data covering 47 SSA countries and finds that openness to international trade stimulates economic growth.
With respect to the agricultural performance, attempts have been made to analyse the impact of the reforms mainly on supply, productivity, input provision, producer price, and market integration (McIntire and Varangis, 1999; Akiyama, 2001; Baffes, 2002; Larsen, 2002; Kherallah et al., 2002). Kherallah et al. (2002) provide a complex set of factors influenced by agricultural market reforms depicted in Figure 1.1.2. This figure is a graphical representation of the actors, influences and components on which markets reforms impacts are expected. As can be seen from the graph, impacts of market reforms are expected in terms of price levels, price volatility, price transmission, market volume, etc. More details on the whole conceptual framework are provided in Kherallah et al. (2002).
Market reform experience has varied widely across countries with clear results in some areas and mixed results in others. For supporters, the reforms have generally led to more efficient crop marketing through the private sector and increased the share of the Free On Board (FOB) price received by farmers. For opponents, the reforms have destabilised agricultural prices, widened the income distribution gap, and reduced access to low-cost inputs. Kherallah et al. (2002) report that producers' share of export prices were higher in countries where reforms have been completed compared to countries where reforms have been slow or have not taken place. Varangis and Schreiber (2001) report that prices received

by cocoa producers in Nigeria and Cameroon increased to over 70 percent of the FOB price, up from 20 and 40 percent respectively, prior to reforms. They also report that market liberalisation has exposed cocoa farmers to price volatility due to fluctuations in the world market, with seasonal variations in producer prices rising from almost zero before the reforms to international levels. In other words, the welfare gained from increasing the producers' share of export prices may be offset by increased price volatility.

The response regarding supply response has been mixed. Akiyama (2001) reports that Uganda's coffee production increased sharply following the reform. Baffes (2001) reports similar results for cotton in Uganda and Zimbabwe. However, Akiyama et al. (2003) mention that weak institutions and physical infrastructure can lead to a lack of supply response as appears to have been the case for cocoa in Nigeria and coffee in Madagascar. They also mention that strong evidence related to change in productivity is missing. Moreover, in most cases, efficient private markets quickly emerged when monopolies were lifted. However, the provision of inputs and services to smallholders has been more problematic, as processing monopolies have sometimes facilitated the provision of inputs and services.

Overall, the general consensus is that reforms programmes in SSA have not met expectations. As pointed by Dorward et al. (2004) liberalisation has not provided the substantial agricultural growth needed to reduce rural poverty and increase food security. The mixed results have been justified by the incomplete implementation of the reform and the weak institutional support. At this point, a new generation of reforms needs to be designed and implemented without making the simplification of considering SSA as homogeneous whole this time. The heterogeneity of the economies in terms of economic conditions, technological and institutional developments must be taken into account. With this in mind, this study examines policy reforms in the specific case of the agricultural sector in Côte d'Ivoire, one of the most dynamic economies in sub-Saharan Africa.

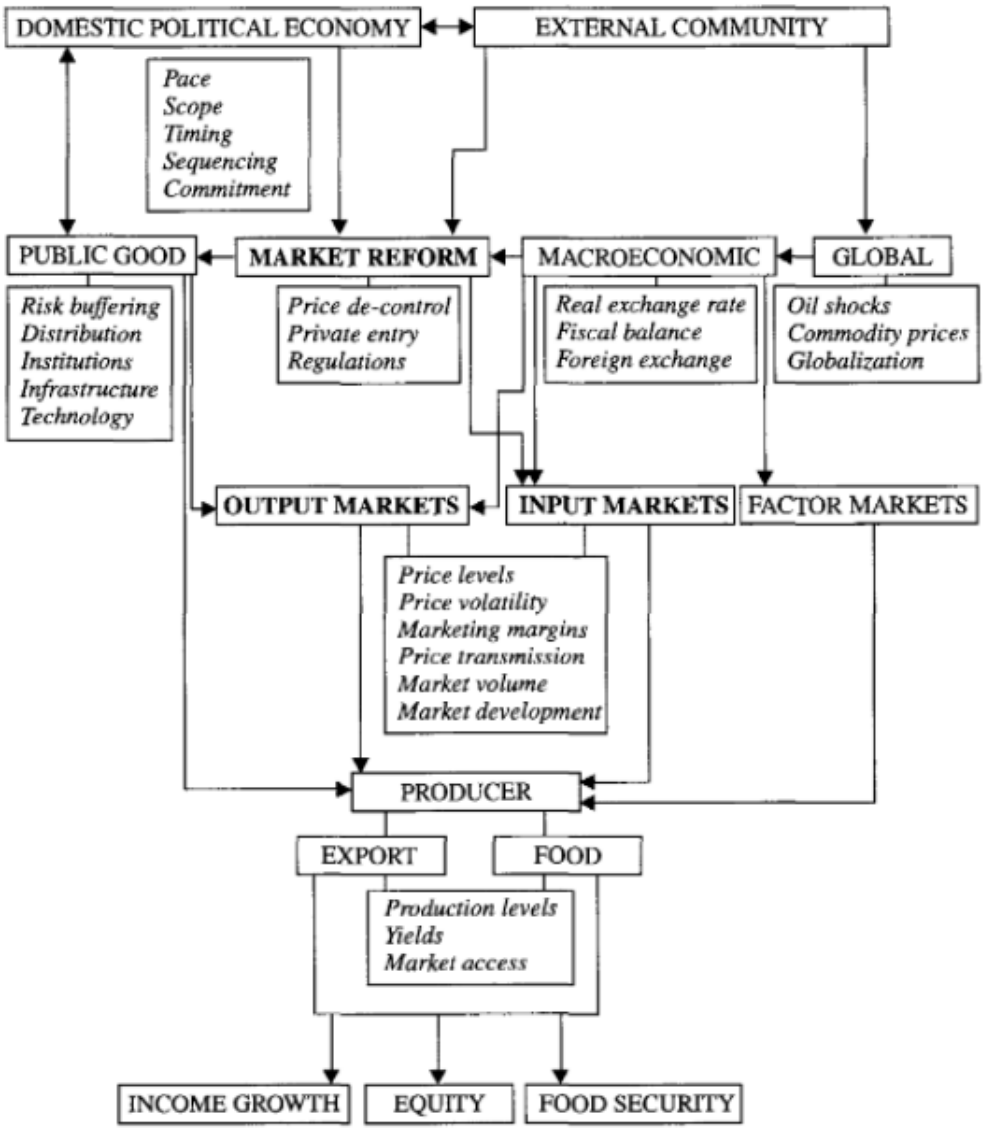


Figure 1.1.2 – Agricultural market linkages, (Source: Kherallah et al., 2002)

1.1.2 The cash crop sector in Côte d'Ivoire

Just like many countries in SSA, the promotion and diversification of agricultural production were unavoidable for economic growth in Côte d'Ivoire. Indeed, the country's natural resources and climatic conditions were suitable for achieving a rapid expansion of agriculture. The Ivorian government initially focused on the production of cocoa and coffee, which strongly supported the country's economy and, then from the 1970s, promoted alternative export crops such as rubber and oil palm, for diversification purposes. For several years, these two crops in addition to cocoa significantly contributed to the country's export earnings. Up to now, the Ivorian economy is heavily dependent on the agricultural sector. The sector employed about 46 percent of the working population and accounted for 28 percent of the Gross Domestic Product (GDP) in 2018 according to the World Bank. Agricultural export equally provides over 40 percent of merchandise export revenue in 2018 according to the World Bank. Moreover, at global level, Côte d'Ivoire is the leading producer of cocoa, the fifth largest producer of palm oil (the second largest in Africa), and the seventh largest producer of natural rubber (the argest in Africa). Figure 1.1.3 shows the most important export products in Côte d'Ivoire from 2017 to 2019 in terms of value.
Therefore, this study focuses on the rubber, cocoa and palm oil subsectors mainly because of their relative importance in the country's economy, the availability of reliable producer price data, and the fact that these sub-sectors have been subject to policy reforms.

1.1.3 Market reforms in the Ivorian cash crop sector

From the 1990s, Côte d'Ivoire also embraced the new trend which advocated market liberalisation as a way to increase competitiveness and farmers' incomes. Actually, in the wave of structural adjustment programmes implemented in SSA, the agricultural export sector in Côte d'Ivoire was also subject to the removal of the public control and the introduction of competition in internal market. As Cheyns and Akindes (1999) pointed, liberalisation reforms required the sector to an institutional recomposition. The sector had to move away from the autocentred model and evolve towards the empowerment and differentiation

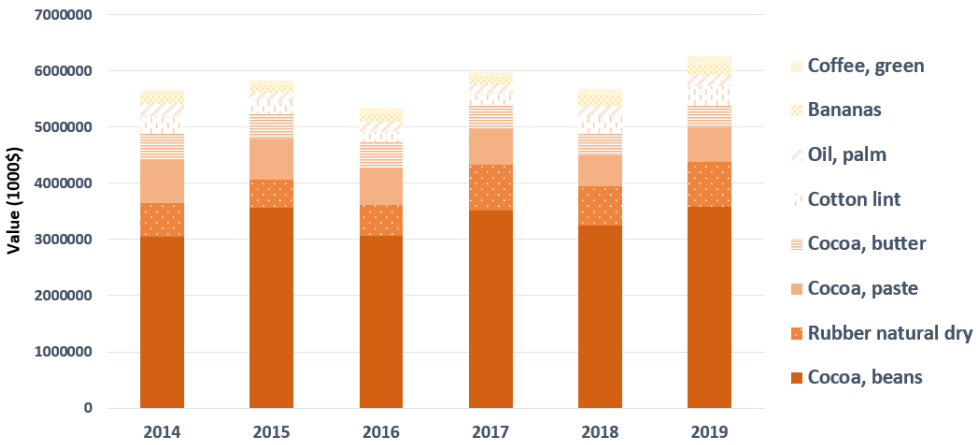


Figure 1.1.3 – Main export products in Côte d'Ivoire from 2017 to 2019 in terms of value (Source : FAOSTAT)

of actors, with farmers who were not really prepared for it. The control of the sector's governance thus shifted from the state to nascent private entities and markets (Ducroquet et al., 2017).
In the cocoa sub-sector, the liberalisation began in the early 1990s but was completed in 1999, while in the rubber and palm oil sub-sectors, liberalisation process occurred in 1994 and 1996 respectively (MINADER, 2016). The Ivorian government equally encouraged the organisation of the various stakeholders within the sector into professional associations, as a way to facilitate the institutional reorganisation. As a result, there has been a proliferation of professional and inter-professional associations in which mainly farmers and agro-processing companies define, without state intervention, new regulatory frameworks for the management of the sector's activities.

1.2 Problem statement

Over three decades after the introduction of trade reform policies in SSA countries, several empirical investigations have attempted to confirm or refute some of the economic theories underlying these policy reforms.

Although the impact of market reforms in SSA has been widely studied in the literature as discussed in section 1.1.1, studies on the impact of this reform on price transmission and input supply for the specific case of Côte d'Ivoire is scarce. Existing studies focus on the response of the cocoa sub-sector, which is the most important sub-sector in Côte d'Ivoire. Other important sub-sectors such as rubber and oil palm are rarely studied, probably because of lack of data.

In Côte d'Ivoire specifically, while market liberalisation may have resolved some of the state failures, it can be observed that, several decades after its implementation, the living conditions of rural agricultural households have not yet improved and their degree of vulnerability has further increased (Ponte, 2001). Actually, vulnerable farmers may have limited means to protect themselves from increased price volatility, following the removal of stabilisation systems. So, questions about the relevance of the reforms remain one of the most contentious debates today. This debate has intensified with the observation of agricultural commodity price spikes, such as those in 2008 and 2011, followed by sharp price declines. Moreover, as farmers now deal directly with private processing companies, it is also important to study the nature of price transmission, i.e., whether or not there is a presence of asymmetry in the world price transmission process[1] This can happen when private processors have market power.

The Ivorian export crops is also characterised by a decline in inputs and agricultural services provision. Consequently, concerns have increased about negative side effects of market liberalisation, including the replacement of the public agencies with imperfectly competitive marketing. Under public control, farmers benefited from input and services supply but, with liberalisation, some public responsibilities were transferred to agro-processing companies. The transition to a more commercial system in the absence of market for inputs and credit has not been without drawbacks for farmers. While many arguments have been made on the inefficiency of public institutions, relatively little attention has been paid to the capacity of the private sector to provide the services formerly provided by the state. Based on the above discussion the following research

[1] Transmission is asymmetric when prices from one integrated market to another react differently to an increase than to a decrease.

questions emerge :

Question 1 : What is the degree of integration of the Ivorian export crop market to the world market after market liberalisation?

Question 2 : Does the presence of private agribusiness companies creates asymmetry in the world price transmission process ?

Question 3 : How the Ivorian supply responds to world price shocks after market liberalisation ?

Question 4 : Does the response of the Ivorian export crops sector differs to those of neighbouring country, Ghana, which did not fully implement liberalisation reform?

Question 5 : How does the increasing competition among processing companies after liberalisation impacts the provision of inputs and services to farmers ?

The formulation of these different research questions is motivated by issues specific to the three sub-sectors studied, namely the rubber, cocoa and oil palm sub-sectors.
Research questions 1 and 2 are addressed in the specific case of rubber. In this sub-sector, producers seem to be more affected by the relationship between the international price and the producer price because rubber is a product for which local processing is not developed and is almost entirely exported, as one can see on Figure 2.1.1, where the two curves for both Ivorian rubber production and export are almost merged. Furthermore, this sub-sector is also characterised by the presence of a limited number of large companies that buy the production from farmers. If these companies have a strong market power, one could imagine that there will be an asymmetry in the transmission of the world price to the producer price. Finally, the drastic fall in prices that has left farmers in a precarious situation, dividing their revenue by a factor of almost three between 2011 and 2015, is an additional motivation for analysing the transmission between the world price and the producer price.
Research questions 3 and 4 are addressed in the specific context of the cocoa sub-sector. Similar to rubber, cocoa is destined for export and is

not heavily consumed locally. For this reason, we analyse the response of the producer price and production to a world price shock for this sub-sector. However, this sub-sector has a particular characteristic, namely the presence of two major world producers, Côte d'Ivoire and Ghana, which together account for nearly 60 percent of world production. These two countries are certainly neighbours but have implemented reforms at different degrees. Thus, we not only analyse the impact of market reform on the sub-sector's response to a world price shock but also compare the responses of both Côte d'Ivoire and Ghana.
Research question 5 is addressed in the specific case of oil palm. In contrast to the products mentioned above, oil palm is heavily consumed locally. This situation has led to the proliferation of uncoordinated installation of small-scale processing factories after the market liberalisation. This profoundly altered the incentives of agro-processing companies to provide agricultural inputs and services to farmers as it was the case before liberalisation. This justifies our interest in studying research question 5.

1.3 Objectives

Our study aims at analysing the impact of market reform on producer price dynamics, supply and agricultural input and service provision in some specific Ivorian cash crop sub-sectors. Specifically this study intends to :

Objective 1 : Analyse the rubber world price transmission to Ivorian producer price after liberalisation and investigate asymmetry in the transmission process. This objective contributes to research questions 1 and 2.

Objective 2 : Analyse the cocoa price and supply responses to world price shocks after liberalisation in Côte d'Ivoire, and compare them to Ghana. This objective contributes to research questions 3 and 4.

Objective 3 : Conduct a theoretical assessment of the impact of competition between processing companies on the supply of inputs and services to farmers. This objective contributes

to research question 5.

Objective 4 : Analyse transversally the implication of the study's findings for the sector's competitiveness.

1.4 Main methodology

In this study, we use two distinct approaches. In Chapter 2 and 3, we use time series data econometrics and, in Chapter 4 we use a theoretical modelling approach using game theory. In chapter 2, we use a multivariate Threshold Vector Error Correction Model (TVECM) to investigate the price transmission mechanism between the world price and the Ivorian producer price, and test for non-linearity in the transmission process. For this time series technique, we use recent tests for non-stationarity and cointegration of the prices which take into account the potential presence of structural breaks in the data. We rely on the Johansen et al. (2000) cointegration approach which includes dummy to account for structural breaks. The objective of the error correction model is to search for the real link between the variables by removing the common cointegrating relationship between them and, doing so, avoid spurious regression. It is both a static and dynamic model which allows obtaining unbiased short-run effects and displaying long-run equilibrium between variables. In this approach used in chapter 2, the break date is unknown *a priori* and, thus determined endogenously.
In Chapter 3, we make use of the Impulse Response Function (IRF) to summarise the dynamic effect of world price shock on producer price, supply, and export. An IRF describes the evolution of the variable of interest along a specified time horizon after a shock in a given time period. We use a recent method developed by Jordà (2005). This method has the advantage of estimating regressions for each time horizon. Instead of extrapolating the parameters to increasingly distant horizons, Local Projections (LP) estimate the parameters sequentially at each horizon. With local projections the estimation of IRF with an exogenous shock is possible and the method allows the estimation of a multi-regime model. Unlike Chapter 2, in which structural change is determined endogenously, we consider in Chapter 3 the date of policy reform as the break-

ing point and, therefore the date is fixed *a priori*. While, the rubber price data examined in Chapter 2 covers only the post-reform period and the price spikes, data on the cocoa sub-sector examined in Chapter 3 covers both the pre- and post-reform periods.
Finally in Chapter 4, we use a theoretical model based on game theory to analyse the strategic decisions of both the agro-processing company and the small-scale processing factory in terms of service provision. This model allows us to illustrate the competition between an agro-processing company and a small-scale processing unit. We then analyse the results concerning the farmer's decision on which processor to supply, the price offered by the processor, and the provision of inputs and services to farmers by the processors.

1.5 Contribution of the study

This thesis contributes to untangle the impact of liberalisation on producer prices, supply and service provision in the cash crops sector. In the context of market reforms and persistent decline in agricultural commodity prices, our analysis makes a significant contribution. The nature of price transmission is particularly insightful to assess the market power exercised by private and intermediate actors. Moreover, most of the studies undertaken in SSA to evaluate the impact of market reforms are concentrated at macroeconomic and sector levels. This thesis goes down to the micro level, because it is also necessary to assess how competition among private processors affects smallholder farmers, who constitute the majority of producers in SSA economies. It is important to understand how they are adapting their strategic decisions to respond to the current liberalisation context.
Such an assessment provides valuable information to policy makers on the constraints that prevent farmers from fully benefiting from the effects of liberalisation and, hence helps clarify the direction agricultural development policy should take. It also provides insight into the importance of both adopting market reforms and strengthening market institutions and physical infrastructure. It is hoped that this contribute to the formulation of policies aimed at improving the conditions of small-scale

producers while addressing the emerging issue of defining the roles of the various institutions and their relevance to the overall goal of poverty reduction.

1.6 Overview

This doctoral thesis is the collection of three main chapters that can be read independently. Chapter 2 examines the link between world and producer prices for rubbber in Côte d'Ivoire using monthly data from August 2006 to December 2016. Recent unit root and co-integration tests allowing for multiple structural breaks are used. A vector error correction model (VECM) is used to test for asymmetry in price transmission process. Chapter 3 examines both cocoa supply and producer price responses to liberalisation reforms in Côte d'Ivoire and Ghana. Annual data from 1979 to 2017 are used. The estimation of impulse responses by local projections of Jordà (2005) gives a clear view of both producer price and supply responses to world price shock. Chapter 4 examines the competition between an agro-processing company and a small-scale processing factory, for the specific case of the Ivorian palm oil sector. The strategic decisions of both the agro-processing company and the small-scale processing factory in terms of provision of agricultural inputs and services are analysed based on the Hotelling model (Hotelling, 1929). This chapter explores the case of oil palm in Côte d'Ivoire. Indeed, local processing is more important for this product, so it is a sector in which competition has increased rapidly after the liberalisation of markets. Finally, chapter 5 summarizes our key research findings. It also gathers some policy implications of the results, limitations of the study, and perspectives for further research.
Chapter 2 has been published as "Ahoba, M., & Gaspart, F. (2019). Rubber world price transmission to Ivorian producer prices: an analysis in the presence of structural breaks. Agricultural and Food Economics, 7(1), 1-14."

CHAPTER 2

Rubber world price transmission to Ivorian producer price: an analysis in presence of structural breaks

This article analyzes the link between world prices and producer prices of rubber in Côte d'Ivoire. Using monthly data from 2006 to 2016, we gave special attention to structural breaks in the data and asymmetry in the transmission process. Empirical results validate the presence of two breaks in the data series, both in 2008 and 2011 corresponding to a general surge in commodity prices. A multivariate threshold vector error correction model (TVECM) allows us to test the presence of asymmetry. The results strongly support the linearity hypothesis against k-regime TVECM. From there, a linear VECM reveals that changes in rubber world prices are strongly transmitted to Ivorian producer prices. In case of a world price permanent decrease, this will be devastating for small producer incomes, since financial markets are essentially missing in those rural areas and switching costs for perennial crops are huge. Some recommendations are given to prevent such a crisis

Keywords Price transmission, Rubber, Threshold cointegration Côte d'Ivoire, Structural breaks.

2.1 Introduction

As many developing countries, Côte d'Ivoire experienced early in the 1990s the privatization of its export crops market. As part of the structural adjustment programs, this measure aimed at increasing the competitiveness of the export sector and offering to producers more incentive prices (Shepherd and Farolfi, 1999b). Before the 1990s, the export crop sector in Côte d'Ivoire was heavily regulated, with the involvement of the State at all levels of the production chain. The government was also in charge of regulating prices through the marketing boards. During the liberalisation, price stabilization schemes and the marketing boards were removed. One of the advantages of liberalisation has been to allow producers to benefit from increases in world prices, contrary to the stabilized prices under the former setting. On the other hand, liberalisation also implies the entry of few big private processors (multinational companies). In fact, the sudden withdrawal of the government led to a more commercial system for which producers were not prepared. Thus, in most export crop sectors, the entry of these big private firms simply replaced a State monopoly by a private monopoly, leading to asymmetry in the world price transmission to producers (Subervie, 2011a).
More than two decades after the liberalisation reform, there is a need for detailed research about the dynamics of producer prices. How are variations in world prices transmitted to the domestic market in Côte d'Ivoire ? Is there asymmetry in the transmission process ? How do price spikes, such as those experienced in 2008 and 2011 in agricultural commodity prices, influence the relationship between the world price and the price received by farmers ? All these are questions to be answered to help policy makers to be more effective in designing suitable policies to improve the welfare of small scale farmers, living in rural areas and who mainly depend on export crops revenue.
It is important to mention that more than 50% of the whole Côte d'Ivoire rubber production comes from small producers (Ruf, 2012; Kouame, 2015). From less than 100 tons in 1961, the national rubber production reached 119,000 tons in 2002 and 270,000 tons in 2013. Figure 2.1.1 depicts the evolution of both Ivorian rubber production and exports from 1980 to 2013.

The Ivorian rubber sector experienced significant changes after liberalisation. From a State oriented sector, the rubber sector now includes on one side, individual farmers who sell their raw product to agro-processing companies. On the other side, agro-processing companies which buy the farmers' production and ensure the conditioning, before exporting the rubber mainly to East Asia and Europe. In order to face these large agro-processing companies, small producers found it suitable to create one professional association to defend their mutual interests and counterbalance the potential market power of agro-processing companies. Like rubber farmers, agro-processing companies organized themselves into a professional association. Subsequently, all the professional associations came together into an interprofesionnal association: the Association of Natural Rubber Professionals in Côte d'Ivoire (APROMAC). Within APROMAC, the different stakeholders set up several professional agreements for regulating the sector, without government involvement. One of the objectives of these agreements was to ensure a fair remuneration for all actors. As a consequence of these agreements between the various actors (farmers and agro-processing companies), a high elasticity is expected for rubber world price transmission to producer prices, with no asymmetry in the transmission process, contrary to other Ivorian liberalized sectors. In fact, despite operational challenges, the Ivorian rubber sector has been able to stand out from the other cash crop sectors thanks to a well-organised structure (especially through APROMAC). In return, several taxes are paid by farmers to ensure a good management of their professional associations. This could eventually raise a financial barrier to world price transmission, since these taxes are deducted from the producer price.

Moreover, given that the country only holds a marginal share of the world market, we do not expect Ivorian producer price to influence the world price. While the country share in the whole African production is around 50 percent, it is still a marginal producer worldwide with a contribution around 2 percent of the world production. Most of the production is provided by South-East Asia (e.g., Thailand, Indonesia, Vietnam etc.) (MINADER, 2016).

Agricultural price transmission from the world market to domestic markets has received much attention in the literature. However, studies

focusing especially on world price transmission to producer prices for export crops in developing countries have received relatively scant attention, due partly to the lack of reliable data on producer prices in these countries. The results of studies on world price transmission to domestic prices in developing countries are generally mixed.

An earlier empirical paper of Mundlak and Larson (1992) investigated the relationship between the world and domestic prices for 58 countries and for the period 1961-1987. Using a linear regression to analyse world price transmission, they found that most variations in world prices are transmitted and are dominant component in of domestic prices changes. Subervie (2007) repeated a similar analysis for a post-liberalisation period. Results are heterogeneous. The elasticity is not significantly different from zero in 16 out of 48 countries, and lies between 0.18 and 1.4 for the countries where it is non-zero. However, for some products such as coffee and cocoa, elasticities are reasonably higher.

Beside the studies mentioned above, others tried to analyse price transmission using cointegration techniques (Quiroz and Soto, 1995; Minot, 2010; Hazell et al., 1990; Baffes and Gardner, 2003; Sharma, 2003; Cramon-Taubadel, 2017). In the vast majority of them, the tests do not systematically indicate the presence of a cointegration relationship between the producer price and the international price. For example, Minot (2010) found that less than a third of the 62 African prices tested showed a statistically significant link to international prices and reported a median elasticity of 0.54. The low values found for the elasticity in most of developing countries are attributed to State policies, unfavorable market conditions such as weak infrastructures, and market power which are the major barriers to price transmission.

Another interest is to examine the presence of asymmetry in the transmission process (Abdulai, 2000; Subervie, 2011b; Badolo, 2011). In his study, Badolo (2011) analyses the transmission of international price shocks to domestic prices of imported rice in Burkina Faso. The asymmetric response found in the study, is explained partly by the commercial intermediaries who form an oligopolistic system and try to more quickly transmit international price increases to domestic prices than international price decreases.

World price transmission to domestic markets in Côte d'Ivoire has not

been widely studied. Existing studies are either not recent or focus mainly on cocoa and coffee or some staple food (Lloyd et al., 1999; Jutting, 2005; Soumahoro, 2017). To the best of our knowledge, no evidence has been found on how rubber world prices are transmitted to the Ivorian domestic market. Hence, the purpose of this study is to investigate the link between the rubber world price and the producer price in Côte d'Ivoire. In addition to focusing on the rubber sector, another contribution of this paper is to analyse the consequences of world price spikes in the relationship between domestic and international prices. In fact, the rise in commodity prices of 2008 and 2011 renewed the debate on the transmission of international price shocks to domestic markets. Moreover, the increasing importance of rubber in the Ivorian economy and the dependence of thousands of farmers on rubber income make this concern relevant to focus on.
The remainder of the paper is organized as follows. Section 2 gives details about the data used for empirical analysis. Section 3 presents the methodology and all the models used for empirical evidence. Section 4 presents the arguments for the choice of models and the empirical results. Finally, Section 5 concludes with some remarks and policy recommendations.

2.2 Data

Monthly rubber world prices (P^w) and producer prices in Côte d'Ivoire (P^d) from August 2006 to December 2016 were used in the analysis. World prices were extracted from the World Bank database. These time series are sourced from Singapore Commodity Exchange (SICOM) which is an international reference for rubber market. The use of an international reference price from Eastern Asia is relevant, as Malaysia is one of the top export partners of Côte d'Ivoire [1].
Domestic prices considered are monthly prices paid to farmers. We did not use the export price here because the purpose is to analyse the link between the world price and the price received by farmers. In fact, producers do not export directly, they sell their product to agroindustrial

[1] https://wits.worldbank.org

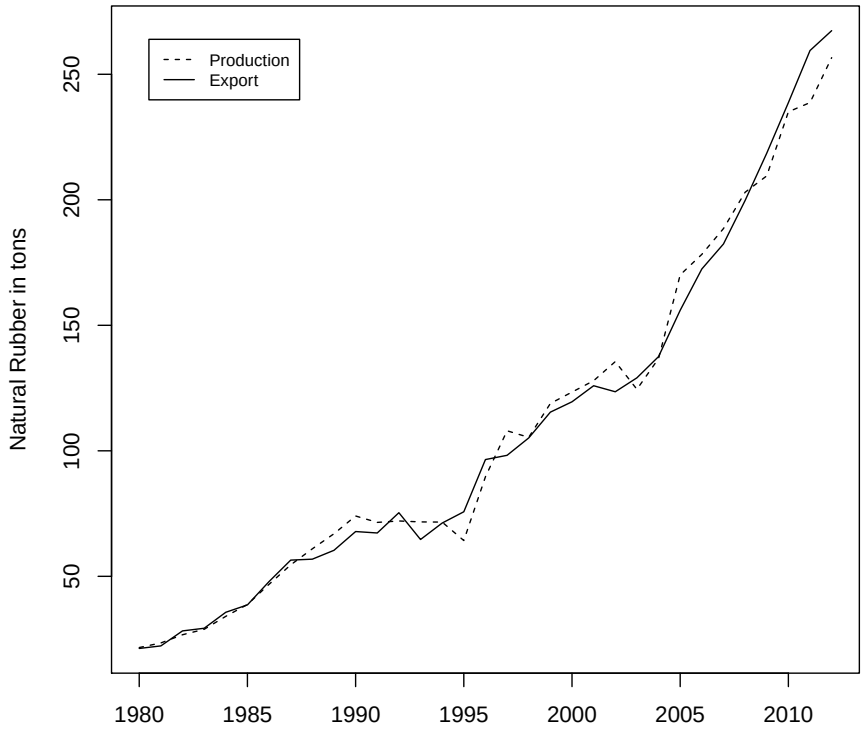


Figure 2.1.1 – Côte d'Ivoire natural rubber annual production and export from 1980 to 2012 (Source : FAOSTAT)

firms. Information on producer prices was provided by the interprofesionnal association of rubber sector in Côte d'Ivoire (APROMAC). Both prices are expressed in US Dollar per kilogram. Producer prices initially in local currency [2] is converted into USD using exchange rates from the Central Bank of West African States (BCEAO) [3]. Figure 2.2.1 shows both international and producer prices of rubber from August 2006 to December 2016. One can see that both prices co-move during this period. Moreover, the graph shows an important gap between both prices which is partially explained by the humidity rate of the domestic rubber compared to the international rubber. In fact, rubber sold on international market is dry while the rubber sold on the domestic market is wet, the former being estimated to worth 60 percent of the latter. The most striking feature of both series is that they are characterized by two important price spikes.

In fact, rubber prices maintain a growing trend between 2006 and 2008. This rise actually started in 2002 to reach a peak in 2008. However, rubber prices saw a significant price decrease of more than 50 percent between 2008 and 2009. Then both prices recovered again to reach a historical peak in the beginning of 2011, more than 6 US Dollar per kilogram for the world price. From there, both prices experienced a continuous decline. Increase in agricultural prices are not uncommon, but based on historical data, it is not usual for two important price spikes to occur within 3 years.

The study is conducted using the logarithm of rubber prices. Logarithmic transformation of price series is very common in economic analysis. It allows a simple interpretation of the resulting coefficients as elasticities. Table 2.2.1 provides descriptive statistics of non-logged rubber price series.

2.3 Methods

A multivariate Threshold Vector Error Correction Model (TVECM) is used in the analysis to investigate the rubber price transmission mech-

[2] Local currency in Côte d'Ivoire is the XOF which has a fix parity with Euro of 1 Euro = 655,957 XOF

[3] Available at http://edenpub.bceao.int/rapport.php

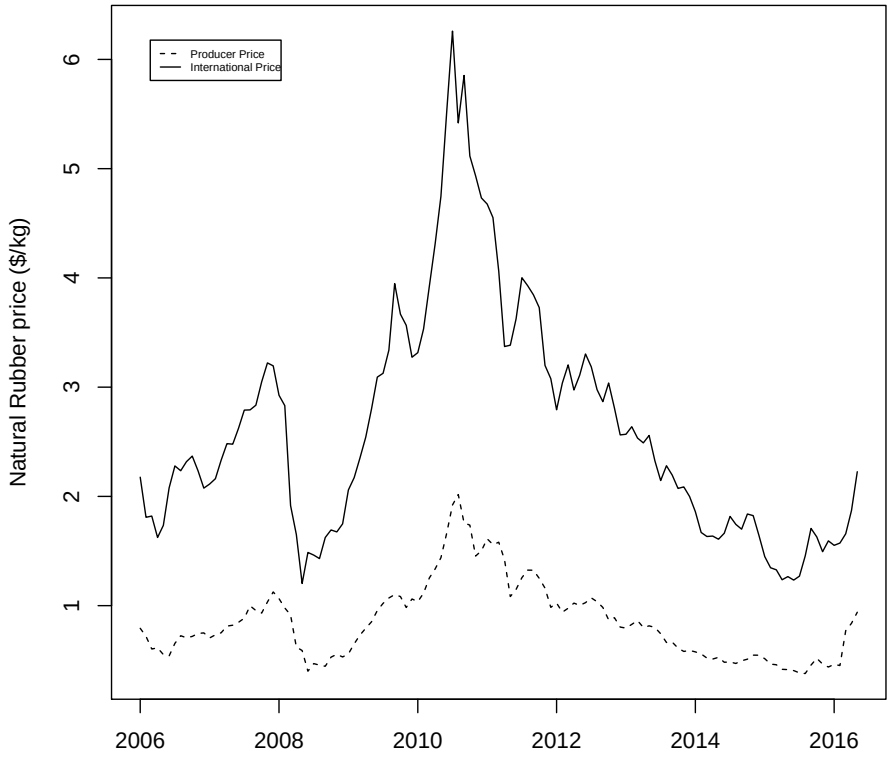


Figure 2.2.1 – Rubber monthly price from August 2006 to December 2016 (Source : APROMAC, World Bank)

Table 2.2.1 – Descriptive statistics for rubber prices in US Dollar per kilogram

	World price (P^w)	Producer price (P^d)
Mean	2.623	0.852
Minimum	1.203	0.379
Maximum	6.259	2.017
Standard Deviation	1.076	0.357
No. of observations	125	125

anism between the world price and the Ivorian producer price and test for non-linearity in the transmission process. Non-stationarity and co-movements of the prices are important time series properties to analyse beforehand. Since the sample covers a period with important shifts in the prices, tests allowing for structural breaks are needed.

2.3.1 Unit root test in the presence of breaks

Conventional unit root tests (e.g. Augmented Dickey-Fuller (ADF), Kwiatkowski-Phillips-Schmidt-Shin (KPSS), Phillips-Perron (PP), etc.) ignore the existence of level shifts and are no longer valid in the presence of structural breaks in the data (Perron, 1989). They might fail to reject the null hypothesis of a unit root while the data are actually stationary with the presence of breaks. Thus, when the variables considered are likely to contain breaks, it is more appropriate to use a unit root test allowing for breaks in the data. To this end, the test of Carrion-i Silvestre et al. (2009) hereafter (CKP) is implemented in the study. The model uses the M-tests introduced in Stock (1999) and analysed in Ng and Perron (2001). This test has several desirable properties: (a) it allows for multiple structural breaks both under the null and the alternative hypothesis; (b) it endogenously determines the break dates; (c) it uses Generalized Least Square (GLS) detrending procedures. `Gauss10` software is used for implementation. As for unit root tests, the presence of structural breaks tends also to affect standard cointegration tests and

may result in biased estimators.

Co-integration test in the presence of breaks

In this paper, Johansen et al. (2000) (JMN) specification that includes dummy variables to account for structural breaks in the data was used. Giles and Godwin (2012) gave detailed explanations about Hl(r) and Hc(r) (respectively with a linear trend and a constant level) tests for cointegration built by Johansen et al. (2000), with r standing for the cointegrating rank. Breakpoints are denoted by $v_j = (T_j/T)$, where T is the full sample size and T_j is the last observation of the j-th sub-sample, $j = 1, 2, .., q$. Including dummy variables to account for the different breaks, the Vector AutoRegressive model (VAR) becomes :

$$\Delta Y_t = \alpha \begin{pmatrix} \beta \\ \gamma \end{pmatrix}' \begin{pmatrix} Y_{t-1} \\ tD_{t-k} \end{pmatrix} + \mu D_{t-k} + \sum_{i=1}^{k-1} \Gamma_i \Delta Y_{t-i} + \sum_{i=0}^{k-1} \sum_{j=2}^{q} K_{j,i} I_{j,t-i} + \epsilon_t \tag{2.3.1}$$

Δ is the first difference operator, α and β are coefficients matrix of dimension ($p \times r$), γ is a ($q \times r$) coefficients matrix, Y_t is a p-vector process, μ is a p-vector, ϵ_t is assumed purely random and D_t a dummy variable. A detailed explanation of the specification of the dummy variables is provided by Joyeux (2007). The dummy variables are defined as follow:

$$D_{j,t} = \begin{cases} 1 \quad \text{for} \quad T_{j-1} + 1 \leq t \leq T_j, \quad \text{for} \quad j = 2, ...q \\ 0 \text{ otherwise,} \end{cases}$$

$$D_{j,t-k} = \begin{cases} 1 \quad \text{for} \quad T_{j-1} + k + 1 \leq t \leq T_j + k, \quad \text{for} \quad j = 2, ...q \\ 0 \text{ otherwise,} \end{cases}$$

$$I_{j,t} = \begin{cases} 1 \quad \text{for} \quad t = T_{j-1} + 1, \quad \text{for} \quad j = 2, ...q \\ 0 \text{ otherwise,} \end{cases}$$

The cointegration hypothesis can be tested with the following Likelihood Ratio (LR) statistic:

$$LR_{JMN} = -T \sum_{i=r+1}^{p} \ln(1 - \hat{\lambda}_i) \tag{2.3.2}$$

2.3.2 Price transmission and structural breaks

To capture the potential impact of structural breaks on the transmission process, dummy variables to account for the two price spikes observed in 2008 and 2011 is included in a linear VECM specification.

$$\begin{cases} \Delta P_t^d = \alpha(ECT_{-1}) + \omega_1 \Delta P_{t-1}^w + \omega_2 \Delta P_{t-1}^d + \delta_1 \Delta D_t^{08} + \delta_1 \Delta D_t^{11} + \nu_t \\ \Delta P_t^w = \alpha(ECT_{-1}) + \omega_1 \Delta P_{t-1}^d + \omega_2 \Delta P_{t-1}^w + \delta_1 \Delta D_t^{08} + \delta_1 \Delta D_t^{11} + \nu_t \end{cases} \tag{2.3.3}$$

with $ECT_{-1} = P_{t-1}^d - \beta P_{t-1}^w - \gamma_1 D_{t-1}^{08} - \gamma_2 D_{t-1}^{11}$.
P^d and P^w stand respectively for the Ivorian rubber producer price and the rubber world price, α is the speed of adjustment parameter, ω_1 the short run world price elasticity. The step dummy variables D^{08} and D^{11} are part of the cointegrating vector. Differentiated variable ΔD^{08} and ΔD^{11} are impulse dummies included in the equation in order to capture the possible short run effects of the structural changes in the data.

2.3.3 Test for linearity against multivariate threshold cointegration

Since the early proposal of Balke and Fomby (1997) to combine nonlinearity and cointegration by the introduction of threshold cointegration, the model has generated significant interest. While Balke and Fomby (1997) tested for threshold cointegration in a univariate setting, Lo and Zivot (2001) extended their approach to a multivariate threshold cointegration with a known cointegrating vector using the tests of Tsay (1998) and multivariate extensions of Hansen (1996). Lo and Zivot (2001), proposed to test a 3-regimes TVECM against a linear VECM, a 2-regimes TVECM against a linear VECM, and a 3-regimes against a 2-regimes TVECM. Another significant contribution has been the paper of Hansen and Seo (2002) which extended the work of Lo and Zivot (2001) by allowing an estimation of a multivariate TVECM for an unknown cointegrating vector. This approach considers a VECM with one cointegrating vector and the Error Correction Term (ECT) as a threshold variable. However, they proposed only a test for linear cointegration against a 2-regimes threshold cointegration. In our analysis, the null

hypothesis of linear cointegration against multivariate threshold cointegration is tested by following both approaches of Lo and Zivot (2001) and Hansen and Seo (2002). A 3-regimes threshold cointegration model takes the following form:

$$\Delta y_t = \begin{cases} A_1' X_{t-1}(\beta) + \mu_t & if \quad w_{t-1} < \gamma_1 \\ A_2' X_{t-1}(\beta) + \mu_t & if \quad \gamma_1 \leq w_{t-1} \leq \gamma_2 \\ A_3' X_{t-1}(\beta) + \mu_t & if \quad w_{t-1} > \gamma_2 \end{cases} \tag{2.3.4}$$

where γ_1 and γ_2 are the threshold parameters, y_t is a p-dimensional $I(1)$ time series which is cointegrated with one p-vector β such as $w_t(\beta) = \beta' y_t$ denotes the Error Correction Term (ECT) and

$$X_{t-1}(\beta) = \begin{pmatrix} 1 \\ w_{t-1}(\beta) \\ \Delta y_{t-1} \end{pmatrix}.$$

If a threshold cointegration is not detected, then the simple linear VECM is considered.

2.3.4 Impulse response function

Impulse response functions are computed to get a better picture of the short run dynamics between the variables. Impulse response functions are of interest in this empirical work as they represent marginal responses of the endogenous variables of the system to an impulse in one of them. For a stationary $VAR(p)$ process y_t the impulse response is basically derived from the moving average representation:

$$y_t = \Phi_0 u_t + \Phi_1 u_{t-1} + \Phi_2 u_{t-2} + \ldots, \tag{2.3.5}$$

where $\Phi_0 = I_k$, k being the number of endogenous variables, and p the number of lags of the VAR process y_t. Φ_s can be computed recursively as

$$\Phi_s = \sum_{j=1}^{s} \Phi_{s-j} A_j, \quad s = 1, 2, \ldots,$$

with $\Phi_0 = I_k$ and $A_j = 0$ for $j > p$. The coefficients of this representation may be interpreted as reflecting the response to impulses hitting the system. The (i, j)-th elements of the matrices Φ_s, regarded as a function

of s, trace out the expected response of $y_{i,t+s}$ to a unit change in $y_{j,t}$ holding constant all past values of y_t. The elements of Φ_s represent the impulse response of the components of y_t with respect to the u_t innovations (see Lütkepohl (2005) for further discussion). For non-stationary processes, the impulse response matrices Φ_s can be computed in the same way. The response of variable to a unit shock in another variable is depicted graphically for a visual impression of the dynamic interrelationships within the system. The impulse responses computed from the estimated VECM coefficients and bootstrap methods to construct confidence intervals were implemented in `JMulTi`.

2.4 Results and Discussion

2.4.1 Preliminary analysis

Results from the CKP test support the presence of unit roots meaning that the series are non-stationary. As shown in Table 2.4.1, the results reveal that both P^d and P^w series are non-stationary with the presence of two structural breaks. The break dates which are determined endogenously are reported in Table 2.4.1. They correspond to huge increases in rubber prices. Given that the dates slightly differ for both series, we considered the largest interval between the two breaks, i.e. the first break occurring in August 2008 and the second break in March 2011.
As previous unit root tests suggested that both series are $I(1)$, the cointegrating relationship between them has been analysed. Applying the JMN test which allows for breaks in the data, we cannot reject the hypothesis that both series are cointegrated. The results are summarized in Table 2.4.2. MZ_{α}^{GLS}, MSB^{GLS} and MZ_{t}^{GLS} are the M-test statistics described in Ng and Perron (2001).

2.4.2 Linear Vector Error Correction Model estimation

Results of the estimated linear VECM is reported in Table 2.4.3. This table also include estimated parameters of the co-integration relationship as well as misspecification tests. The long run elasticity is not

Table 2.4.1 – Model with linear time trend and possible breaks in the intercept and slope

	Break 1	Break 2	DF-GLS	MZ_{α}^{GLS}	MSB^{GLS}	MZ_{t}^{GLS}
P^{w}	09-2008	02-2011	-2.731	-20.589	0.142	-2.924
Critical values (5%)			-3.858	-30.164	0.128	-3.858
P^{d}	08-2008	03-2011	-1.728	-8.267	0.201	-1.665
Critical values (5%)			-3.861	-30.209	0.128	-3.861

Note: We cannot reject the null hypothesis of unit root with presence of breaks

Table 2.4.2 – Results of Johansen cointegration test

r	LR	10% Critical value	5% Critical Value	1% Critical Value
$r = 0$	66.13***	42.41	45.76	52.48
$r \geq 1$	10.07	21.13	23.71	29.06

Notes: Lag length for the test was chosen by Schwarz information criterion (SIC) and VAR residuals analysis; *** denote rejection of the null hypothesis at 1% significance level. r stands for the cointegrating rank.

statistically different from 1, meaning that world prices are perfectly transmitted to the domestic market in the long run. The positive link between both prices is not surprising, since the analysis is conducted in the post-liberalisation period when producer prices started moving closely to international prices. The estimated value of the short run elasticity between the rubber world price and the domestic price is statistically significant and about 0.75. This elasticity value denotes a high rubber world price transmission to the Ivorian producer price in the short run. Recall that the data used are monthly. Greb et al. (2016) also find roughly 75 percent of changes in international prices is transmitted to domestic markets, for cereals. However, we do not find perfect price transmission in the short run. As argued earlier in the introduction, taxes paid by farmers to their professional association and for agricultural services received, could eventually constitute a barrier to the world price transmission, as it is a variable component of the producer price. This is a potential explanation for finding incomplete price transmission between the international rubber price and producer prices in Côte d'Ivoire in the short run. As pointed by Kornher et al.

(2013), price transmission appears to be rather incomplete, especially for African countries. Rapsomanikis and Mugera (2011) explained the incomplete price transmission as due to a large portion of transaction costs and agricultural policies. The estimated coefficient of the error correction term is -0.20. This value represents the speed of adjustment. It suggests that 20 percent of the deviations from the equilibrium are corrected in a month. The negativity of this value confirms the return to the long-term equilibrium. Short run dynamics are further discussed below with the help of the impulse-response analysis. The dummy variables D^{08} (August 2008) and D^{11} (March 2011) have been included in the estimation of the linear VECM as specified in (2.3.3). Table 2.4.4 presents estimated values of δ_1 and δ_2 which represent the short run effect of the first and the second break respectively. The non-significance of these parameters shows that the two structural breaks do not have any short run impact on the price transmission process. As a consequence, important peaks in the price of natural rubber on the world market are also transmitted to the producer price in Côte d'Ivoire.

Table 2.4.3 – Results of the linear VECM

	ECT	ΔP^d_{-1}	ΔP^w_{-1}
P^d	-0.196(0.0743)**	0.031(0.0611)	0.739(0.0937)***
P^w	0.169(0.0983).	0.125(0.0808)	0.365(0.1239)**
Cointegrating relationship : P^d= 1.20+1.08***P^w			
LM test for autocorrelation		14.071	
p-value		0.296	
Multivariate ARCH-LM test		9.548	
p-value		0.388	

Note: ** and *** denote rejection of the null hypothesis respectively at 5% and 1% significance level.

2.4.3 Testing for linearity against threshold cointegration

The results reported in Table 2.4.5 confirm our hypothesis. In fact, the null hypothesis of linear cointegration cannot be rejected at 5% level of significance. Our empirical results are in line with the Ivorian rubber sector organization. In fact, being a member of interprofessional association gives farmers some power in the market which countervails the

Table 2.4.4 – Results of the VECM estimation with dummy variables

	Estimate	t-value	p-value
α	-0.194 (0.076)	-2.585	0.010 **
ω_1	0.742 (0.098)	7.654	0.000 ***
ω_2	0.03 (0.061)	0.534	0.594
δ_1	0.002 (0.067)	0.028	0.978
δ_2	0.004 (0.096)	0.036	0.971

Notes: ** and *** denote rejection of the null hypothesis respectively at 5% and 1% significance level. Standard errors in parenthesis.

power of agro-processing company. After the liberalisation of the agricultural sectors in Sub-Saharan Africa, the problem of declining market power of the farmers has been raised. The entry of large private actors prevent farmers from taking full advantage of the benefits of price liberalisation. This resulted in a low rate of elasticity of the producer price to the world price found in early studies, for most of the developing countries. The high elasticity and symmetric transmission found in this analysis show that the presence of a well-organized farmers' association can help to address the issue. We did not focus on the transmission from domestic to world prices since the country only holds a marginal share of the market. As stated in the introduction, Côte d'Ivoire's production is only about 2 percent of the world production, which is not enough to influence world prices. This is confirmed by the second line of Table 2.4.3, which shows a weak and insignificant transmission of the domestic price to the world price.

Table 2.4.5 – Summary of linearity tests

Estimates	Hansen and Seo test	Lo and Zivot test	
	linear vs threshold cointegration	linear vs 2-regimes	linear vs 3-regimes
supLM test value	11.97	13.69	39.83
p-value	0.66	0.43	0.11
Critical Value 95%	18.20	23.21	43.83

2.4.4 Impulse response function

The Impulse response function depicted in Figure 2.4.1 illustrates the result of simulating a rubber producer price response to a permanent 1-standard-deviation shock to the world price. A positive shock to rubber world prices leads to a new equilibrium characterized also by a higher producer price. The producer price increase is unexpectedly quick, since it requires only 5 months to complete. During the first 2 months, price increases are very large and quick and progressively slow down thereafter. After the 3rd month following the rubber world price shock, the price is very close to its new equilibrium and further increases are very small. However as expected, a shock in the domestic price has a statistically non-significant impact on the international price, since zero lies in the confidence interval of the corresponding impulse response (see Figure 2.4.2).

2.5 Conclusion

This paper aimed at examining the link between the rubber world price and the producer prices in Côte d'Ivoire. Two questions sustained this study. The first one was to analyse asymmetry in the transmission of rubber world prices to producer prices in Côte d'Ivoire. The second one was to analyse the impact of important price spikes on the relationship between both prices. Monthly data from August 2006 to December 2016 were used for the study. To account for the shifts in the data, recent unit root and co-integration tests allowing for multiple structural breaks in the data were used. Our results suggest that the world price and the producer price move together in the long run and the transmission process does not present asymmetry. In the long run world prices are perfectly transmitted to domestic prices and the short run elasticity is about 0.75, which also means that changes in rubber world prices are highly transmitted to producer prices in the short run. Our results also provide evidence of structural breaks. These structural breaks have a non-significant short run effect on the price transmission process. The results found are somehow surprising compared to the general trend of the other post-liberalized sectors, for which the studies highlight the

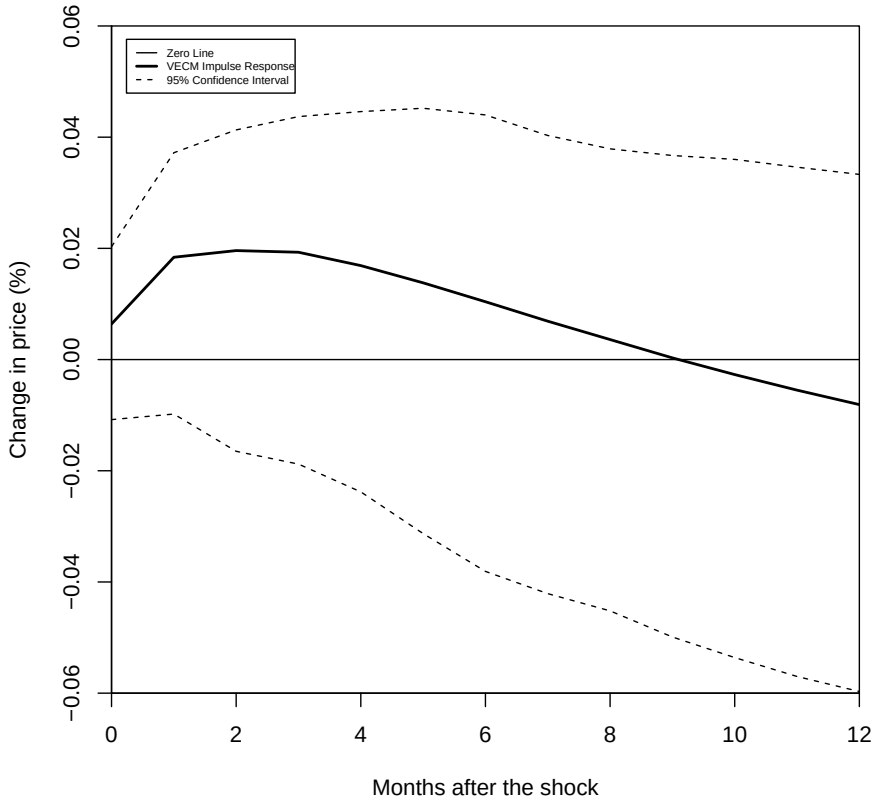


Figure 2.4.1 – Producer price response to a + 1 standard deviation shock to the world price

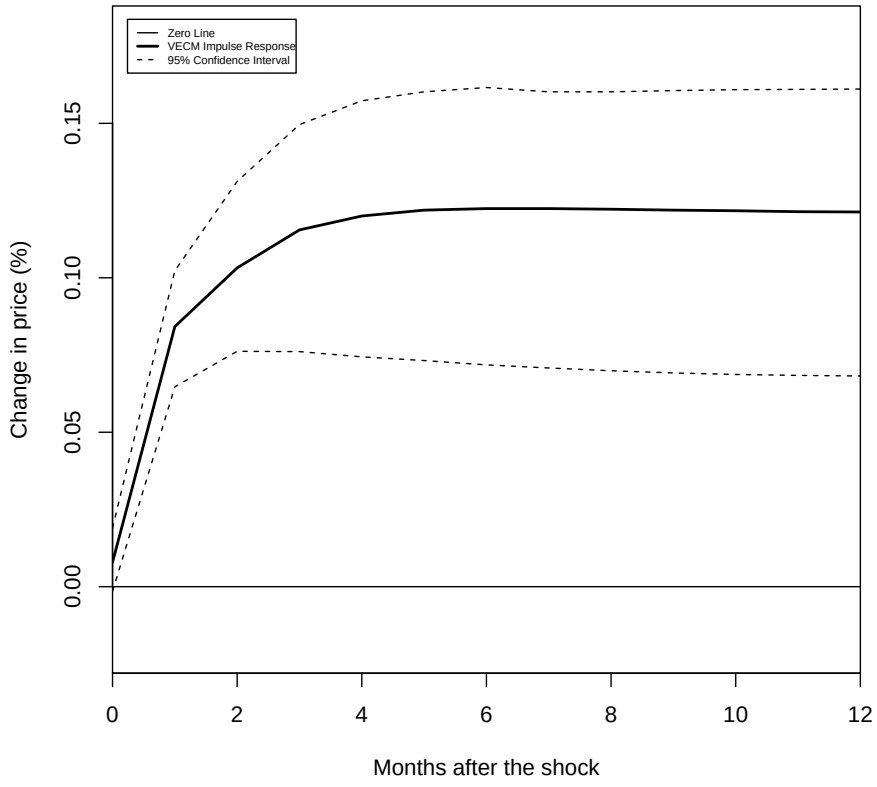


Figure 2.4.2 – World price response to a + 1standard deviation shock to the domestic price

presence of asymmetry in the transmission of world prices (Subervie (2011b), Badolo (2011)). However, when putting in parallel with the characteristics of the rubber industry, these results can be explained. The presence of an interprofesionnal association APROMAC within the rubber sector, that brings together all the stakeholder and advocates for fair remuneration for the various players, has been able to somehow reduce the potential market power of agro-processing company, which results in a symmetric price response even in the presence of world spikes. However, the positive relationship between the two prices suggests that producers are also directly exposed to huge decreases in prices. This constitutes a threat for their revenue and needs to be addressed. Huge decreases in prices would not be a problem if the institutional context was favourable. However, rural areas are essentially characterized by missing financial markets, and this reduces producers' ability to deal with the consequences of such price fluctuations. When credit or savings are constrained, smoothing consumption over time is obviously difficult. In addition, switching costs for perennial crops are huge. In this context a State intervention could be justified. A more general conclusion of this analysis is that increasing the farmers' market power by improving the viability of professional agricultural organizations can help the farmers to take more advantage of the benefits of the liberalisation. However, policy makers should be aware that the results also suggest that Ivorian producers are heavily exposed to world price fluctuations. This could be harmful in case of a sharp decrease in prices since financial markets are mostly missing in rural areas in developing countries. Thus, a price compensation mechanism should be introduced in this case. All these aspects and results above are to be taken into account in the implementation of the ongoing reform in the rubber sector in Côte d'Ivoire.
Since this topic has not been yet widely studied for export crops, this study serves as a starting point for future research into whether and to what extent world prices influence other export crops in Côte d'Ivoire.

CHAPTER 3

Ivorian and Ghanaian cocoa sub-sector responses to market reforms

Liberalisation reforms have been implemented in developing countries with the expectation of promoting competitive markets and offering better prices to farmers and consumers. However, their effects are yet elusive. This paper aims at examining the cocoa supply and producer price responses to liberalisation reforms in Côte d'Ivoire and Ghana, taking into account the different levels of implementation in the two countries. By using impulse response functions under local projection, the producer price and the cocoa supply responses to shock in the world price are analysed, before and after the policy reform. Empirical findings show that producer prices in both countries are more responsive to shock in world prices following the reform, but the response is greater for producer price in Côte d'Ivoire than in Ghana. Conversely, no significant impact of the reform are found on the supply response to world price shocks neither in Côte d'Ivoire nor in Ghana.

Keywords Local projections, impulse response, cocoa, liberalisation, Côte d'Ivoire, Ghana.

3.1 Introduction

World cocoa production has increased significantly over the last decades. From 1.2 million tons in 1960, it rose to 2.7 million tons in 1990 and 5.5 million tons in 2019. While America was historically the largest producer of cocoa, Africa took the lead around 1921 with nearly 200,000 tons and its supremacy remained unchallenged until now. Most of the world's cocoa production today is precisely located in West Africa. Côte d'Ivoire is currently the world's largest cocoa producer, with its neighbour Ghana being the second largest. Together, they account for 54 percent of the world's total production in 2019 according to FAOStat (2020).

The cocoa sub-sector represents a key sector for both Côte d'Ivoire and Ghana. It has been subject to special attention and various public policies in these two countries. One of the main policies was the liberalisation of the cash crop markets in the 1990s. Liberalisation was part of the structural adjustment programmes initiated by the World Bank (WB) and the International Monetary Fund (IMF), in sub-Saharan countries, to restore financial stability and stimulate economic growth. By removing the state monopoly, these programmes intended to reduce state failures as well as to provide competitive prices to farmers.

As pointed out by Ruf (2009), under the same word of liberalisation, economic reforms of a very different, almost opposite nature, were implemented in the two leading cocoa producing countries. In the case of Ghana, market liberalisation is partial, being limited to free up the domestic market, while maintaining the state-fixed purchase price. In the case of Côte d'Ivoire, market liberalisation is complete. The Ivorian market was even opened to private buyers before liberalisation.

Several decades after its progressive implementation, the debate about whether these reforms have lived up to their promises is still ongoing. A large literature attempts to analyse the effects of policy reforms in developing countries but its outcomes remain mixed. The effects of these reforms have been analysed, inter alia, on producer price level (Akiyama, 2001; Varangis and Schreiber, 2001), price volatility (McIntire and Varangis, 1999; Hazell, 1994), imput provision (Baffes, 2002; Lundbæk, 2002; Larsen, 2002), and supply response (Baffes, 2001; Amin,

1999; Varangis and Schreiber, 2001). In these studies, effects of liberalisation reforms vary both in terms of direction and magnitude. However, most argue that liberalisation has led to better market integration and that liberalisation impact has varied depending on the sector under consideration, the speed and degree of implementation, the accompanying measures, and some other specific factors.

For the specific case of the cocoa sub-sector in West Africa, the available studies mostly focus on the supply response; few have taken an interest in the dynamics of producer prices following these reforms. However, investigating the extent to which producer prices respond to global price shocks is crucial for the fight against poverty, rural income dynamics, and sustainable exports. The purpose of this study is to shed light on the market liberalisation effects in the specific context of cocoa and to analyse further, not only the supply response but also the producer price response to price shocks in the world market. Another contribution of this study is to compare both the Ivorian and Ghanaian sector responses, taking into account the degree in implementing liberalisation measures in these two countries. This paper investigates whether the reform of the marketing and pricing system in the cocoa sub-sector in Côte d'Ivoire and Ghana has made producer prices and supplies more responsive to global price shocks.

In the literature, domestic price responses to world price shocks are mostly analysed using Vector AutoRegession (VAR) and Vector Error Correction Model (VECM). Baffes and Gardner (2003) use the error-correction model to estimate the responsiveness of the domestic prices to fluctuations on the world market. The authors analyse price transmissions for 10 commodities and 8 countries for the period from mid 1970s to mid 1990s and find that Chile, Mexico, and Argentina are the only countries whose domestic commodity markets were integrated with world market. Ahoba and Gaspart (2019) make use of a VECM to show that changes in rubber world prices are strongly transmitted to Ivorian producer prices. Some of the previous studies also employed impulse response functions (IRF) calculated by a VAR to illustrate the dynamic interrelationships between world market and domestic producer prices (Beag and Singla, 2014; Ahoba and Gaspart, 2019). However Jordà (2005) argues that, the estimation of impulse response function by the

mean of Local projections (LP) offer three main advantages over the traditional structural vector autoregressive (SVAR) approach. First, LP are easier to estimate since they rely solely on simple linear regressions; second, the point or joint-wise inference is easily conducted; and third, impulse responses that are estimated using LP are more robust to misspecifications. Hence, in this analysis, the producer price and cocoa supply responses before and after the liberalisation reform are analysed using Impulse Response Function (IRF) estimated by the Local Projections (LP) method. This analysis uses annual price series mainly from the International Cocoa Organization (ICCO) and the World Bank from 1979 to 2017. First, this study highlights the differences in the implementation of this reform in the two cocoa producing countries. Second, the producer price and cocoa supply responses before and after the liberalisation reform are analysed, using Impulse Response (IR) functions estimated by LP.

On one hand, the findings confirm that the reforms brought producer prices to be more responsive to global price shocks. However, such impact is more significant in Côte d'Ivoire than in Ghana. These results are attributed to the fact that liberalisation is still partial in Ghana while complete in Côte d'Ivoire. On the other hand, we find no significant impact of the reform on the supply response to world price shocks in both Côte d'Ivoire and Ghana. Actually, cocoa production being a perennial crop, supply response can be delayed. In addition, the removal of input provision schemes with the liberalisation of the sector has certainly not been an incentive for farmers to engage more in cocoa production. Especially in a sector that is characterised by the unavailability of input and credit markets for farmers.

The remaining of this paper is organized as follows. Section 2 gives an overview of policy reform in both the Ivorian and Ghanaian cocoa subsectors. Section 3 and section 4 present respectively the data used in this study and the method to analyse the contribution of liberalisation reform on the cocoa sub-sector exposure to shocks in world price. Section 4 reports and discusses the empirical results. Section 5 concludes.

3.2 Price and supply responses to market reforms

Price and supply response have been studied to some extent in the literature. In many cases, for the post-liberalisation period, the share of the producer price in the Free On board (FOB) price seems to have increased (Varangis and Schreiber, 2001; Larsen, 2002). In contrast, the interventionist approach to agricultural markets of the pre-liberalisation period contributed to shift producer prices away from world export prices. It was even seen as a diversion of producers' incomes to other beneficiaries. As pointed by Akiyama et al. (2003), it is therefore expected that in the post-liberalisation period, producer price share of FOB price increases as a result of effective reforms, due to lower taxes and competition between traders. Kherallah et al. (2002) report that producers' share of export prices are higher in countries where reforms are completed when compared to countries where reforms are slow or do not take place. Varangis and Schreiber (2001) report that prices received by cocoa producers in Nigeria and Cameroon increased to over 70 percent of the FOB price, compared to 20 and 40 percent respectively, prior to reforms. They also report that market liberalisation exposes cocoa farmers to price volatility due to fluctuations in the world market, with seasonal variations in producer prices rising from almost zero before the reforms to international levels. In other words, the welfare gained from increasing the producers' share of export prices may be offset by increased price volatility. Larsen (2002) reports a rise of producer price shares in Zimbabwe from 42 percent to 53 percent. Studies examining at the response of domestic price to world price shocks are still rare.

With regard to the supply response, proponents of liberalisation reforms argue that a competitive market combined with a higher producer price should encourage farmers to produce more. However, the response regarding supply has been mixed. Identifying the impact of reforms on agricultural supply is not a simple issue due to the number of intervening factors such as international price, cultivated area, climatic changes. Akiyama (2001) reports that Uganda's coffee production increased sharply following the reform. Baffes (2001) reports similar results for cotton in Uganda and Zimbabwe. However, Subervie (2007)

shows that the response to instability depends on macroeconomic factors that influence framers' ability to manage price risk. This study also shows that the effect of price instability on supply is accentuated by high inflation, poor infrastructure and a weak financial system. These imply that vulnerability to global price instability can be reduced by improving the macroeconomic environment.
The nature of pre-reform agricultural policies has been also identified as a key determinant of supply response (Delpeuch and Leblois, 2014). There is therefore reason to believe that the impact of reforms in SSA is country specific and varies according to the degree of implementation. Hence the choice in this paper to investigate the impacts of market liberalisation and to compare the price and supply responses to the degree of implementation of reform in Côte d'Ivoire and Ghana.

3.3 Institutional changes in the Ivorian and Ghanaian cocoa sub-sectors

We cannot talk about cocoa without mentioning Côte d'Ivoire and Ghana being the world's leading producers since the beginning of the 20th century. Introduced in Côte d'Ivoire at the end of the 19th century, cocoa production increased sharply after the country's independence in 1960. In addition to the favourable climatic conditions, the government at that time promoted cocoa expansion to support family farming and generate export revenue. Domestic production increased from 550,000 tons in 1980 to 900,000 tons in 1995, then 1.5 million tons in 2015 (see Figure 3.3.1), and finally more than 2.1 millions tons in 2019. Nowadays, Côte d'Ivoire accounts for about 40 percent of the world cocoa production. According to AFDB (2018), the cocoa sub-sector accounted for 10percent of Côte d'Ivoire's Gross Domestic Product (GDP) and 40percent of export earnings in 2016.
The cocoa sub-sector in Ghana had and continues to play an important role in the country's economy. The domestic production in Ghana was about 800,000 tons in 2019 according to ICCO (2021), less than half of the production in Côte d'Ivoire. The cocoa sub-sector accounted for 7 percent to GDP in 2016 and contributes to about 25 percent of Ghana's

total export and foreign earnings in the same year (WorldBank, 2018). World leader in cocoa until the early 1960s, Ghana experienced a sharp decline in production from the mid-1960s and early 1980s. Officially recorded production of cocoa beans declined by 60percent (Varangis and Schreiber, 2001; Wessel and Quist-Wessel, 2015). Ghana's official production, which was five times that of Côte d'Ivoire in 1960, fell to a third of Côte d'Ivoire's production by the early 1980s (Bulir, 2002). However, a period of strong recovery followed this decline (see Figure 3.3.1). Some authors attributed this recovery to liberalisation (Ruf, 2007).

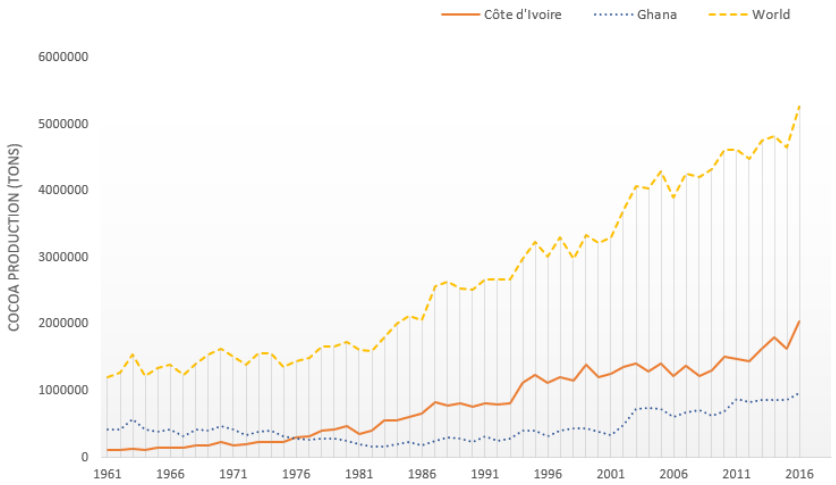


Figure 3.3.1 – Cocoa production in Côte d'Ivoire, Ghana and the world between 1960 and 2018 (Source : FAOSTAT)

Agricultural policy in the Ivorian and Ghanaian cocoa sub-sectors went through several phases. Until the early 1990s, the cocoa sub-sector in both countries was organising in a system where a public agency controlled producer prices and the various stages of the supply chain. In Côte d'Ivoire, the cocoa sub-sector was under the strict control of a stabilisation agency ("Caisse de stabilisation - CAISTAB"). The CAISTAB allowed farmers to benefit from stable prices thanks to an inter-annual price stabilization scheme. Each year, a producer price was set. While CAISTAB controlled the cocoa exports under a system of licensing ex-

port quotas, it left the cocoa collection to a network of private buyers (Losch, 2001).

In Ghana, the marketing board known as "COCOBOD" controlled every aspect of the cocoa supply chain. Its mission was not only to set producer prices and avoid instability in domestic prices, but also to play a strategic role in monitoring every operations in cocoa trade from farmgate to the exit port.

In both countries, the price stability system played a major contribution in increasing production. Farmers benefited not only from input subsidies but also from a stable source of revenue over time. However, the fall in world commodity prices and the rise in interest rates in the early 1980s plunged into recession several countries in the region, including Côte d'Ivoire and Ghana. In Côte d'Ivoire, the persistence in maintaining high producer prices against declining world prices in the late 1980s bankrupted the CAISTAB (McIntire and Varangis, 1999). Between July 1987 and October 1989, Côte d'Ivoire adopted an export retention strategy with the aim of accumulating stocks and influencing world prices up, but this strategy failed. The consequences for the country were disastrous: the collapse of the guaranteed price system as a result of internal problems, the failure to pay farmers, and an economy in recession. In Ghana, COCOBOD operations became also dysfunctional. By the early 1980s, cocoa production falled, from 591,000 tons in 1964 to 159,000 in 1983 and producer share in the FOB price was as low as 21 percent (Kolavalli et al., 2012).

Nevertheless, the cocoa sub-sector in both countries remained under the control of the state until early 1990s. Under the pressure of international institutions, both countries adopted structural and sectoral reforms, including the liberalisation of the cocoa sub-sector. Côte d'Ivoire entered into a progressive phase of liberalisation process with the introduction of a semi-liberal agricultural policy from 1990. This process resulted in the liquidation of the CAISTAB and the full liberalisation of the internal supply chain in 1999. Côte d'Ivoire also removed the export quota system as well as the indicative producer price. Instead of CAISTAB, a new structure called "New CAISTAB" was set up in 1999 with the aim of establishing effective competition between operators within the supply chain. The New CAISTAB became a regulatory agency, not a

marketing board anymore. On the other hand, Ghana liberalized the sector by removing the COCOBOD purchasing monopoly and introducing competition in the supply chain. Liberalisation in Ghana is limited in the extent to which private buyers continue to sell their cocoa purchased from farmers to the COCOBOD (Ruf, 2007).
Liberalisation in both countries came as a means of reducing marketing costs, promoting competition in the cocoa marketing channels, and raising farmers' share in the FOB price (Gilbert and Varangis, 2004). Indeed, in the system of stabilized prices that prevailed before liberalisation, producer prices deviated significantly over time, down from price trends on world markets. It is therefore expected with liberalisation that producer prices would be higher with a greater pass-through of global price shocks to producer price. As pointed by Tsowou and Gayi (2019), the atomized structure of farmers compared with global agricultural commodity markets reduces them to price takers. With regard to the supply response to a world price shock, it is expected that it would not be fast if there is any, because of the perennial nature of cocoa. It takes three to five years after planting to harvest the first crops. In addition, the abandonment of input provision programmes along with liberalisation tends to discourage farmers from investing in cocoa production. The extent to which cocoa prices and supply have responded to the reforms is still an open question. This study contributes to this debate.

3.4 Data and sources

Covering the period from 1979 to 2017, data consist in annual time series of cocoa world prices, cocoa producer prices, cocoa supply, and harvested area in both Côte d'Ivoire and Ghana. Rainfall data is only available for Côte d'Ivoire.
Data on real world prices of cocoa ($Price^W$) and real crude oil price ($Price^{CO}$) are obtained from the World Bank database (basis year 2010). Nominal producer prices of cocoa in both Côte d'ivoire and Ghana are announced by the respective governments and recorded by the International Cocoa Organization (ICCO). The Ivorian producer price is pro-

vided in "Franc de la Communauté Française Africaine - FCFA" and the Ghanaian producer price in Ghanaian Cedi. Both Ivorian and Ghanaian nominal producer prices are then deflated, using respectively the Ivorian and Ghanaian Consumer Price Index (CPI). The Ivorian and Ghanaian CPI (same basis year of 2010) come from the World Bank (2020b). Producer prices are converted into US Dollar, using the corresponding foreign exchange rate. Figure 3.4.1 shows the annual producer prices in Côte d'Ivoire and Ghana in parallel to the annual world prices. This figure shows that producer prices both in Côte d'Ivoire and Ghana began to track more closely the world price from 1990 and even earlier for Côte d'Ivoire.

For Côte d'Ivoire, because a semi-liberal policy was adopted as early as 1990 (Kipré and Ngbo, 2011), we consider the period before 1990 as the pre-reform period and the period after 1990 as the post-reform period. For Ghana, because the partial liberalisation officially took place in 1992, we consider the period before 1992 as the pre-reform period and the period after 1992 as the post-reform period.

Data on annual harvested area for Côte d'Ivoire ($Area^{CI}$) and Ghana ($Area^{GH}$) are sourced from the Food and Agriculture Organisation (FAO) database. Weather variables are limited to available rainfall records in the Ivorian cocoa production area, provided by the meteorological stations of the Soil, Water and Plants Central Laboratory (LCSEP) of the Ivorian National Center of Agronomic Research (CNRA). However, because the cocoa-producing areas in Côte d'Ivoire and Ghana have adjacent sides and share the same isobares, we use this available rainfall records as a proxy for Ghana. Rainfall data consist in yearly averages of rainfall during the flowering period of cocoa tree, from April to July (Akmel, 2017). These four months are therefore the most decisive for the success of the main cocoa harvest, beginning in October.

Table 3.4.1 gives the descriptive statistics of productions, prices and areas. A logarithmic transformation of the price series is used in the empirical analysis.

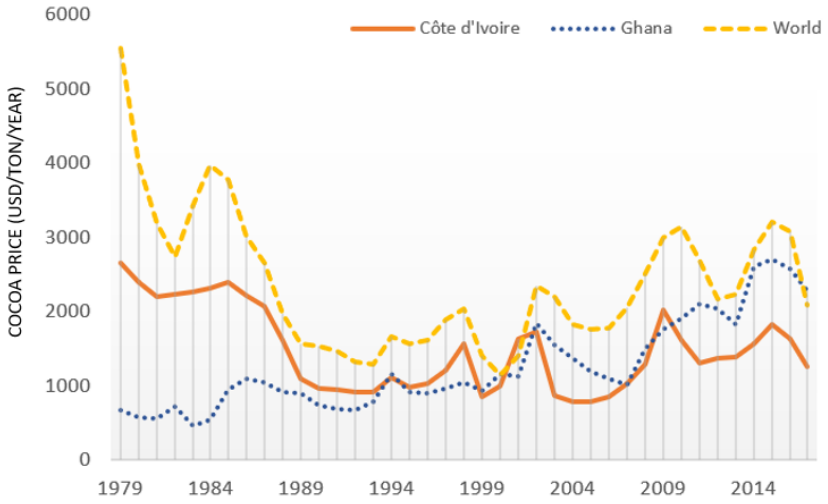


Figure 3.4.1 – Annual real producer prices in Côte d'Ivoire and Ghana, and the annual real world prices between 1979 and 2017 (Sources: World Bank, ICCO)

Table 3.4.1 – Descriptive statistics of original non-logged variables

	$Prod^{CI}$	$Prod^{GH}$	$Price^{W}$	$Price^{CI}$	$Price^{GH}$	$Price^{CO}$	$Area^{CI}$	$Area^{GH}$	$Rain^{CI}$
Mean	1,094,538	483,180	2,384.96	1,482.29	1,253.13	46.294	1,895,691	1,248,018	606.693
Minimum	360,000	159,000	1,138.51	778.48	455.44	15.9	784,700	686,531	449.367
Maximum	2,020,000	1,013,000	5,552.97	2,658.02	2,700.41	95.27	4,075,017	2,000,000	797.667
Standard Deviation	454,140	261,916	940.46	553.60	616.28	25.050	757,822	411,228	87.762

CI = Côte d'Ivoire; GH=Ghana; W= World; CO= Crude Oil

Production in tons; Real Cocoa Price in USD/ton; $Price^{CO}$ in USD/bbl ; Area in ha; Rain in mm

Sources: FAOstat, World Bank, ICCO and CNRA

3.5 The impulse response function

Impulse Response Functions (IRF) are a key statistical tool that is used to summarize the dynamic effects of structural shocks on time series. An impulse-response function describes the evolution of the variable of interest along a specified time horizon after a shock in a given time period. Jordà (2005) developed the Local Projections (LP) method to estimate these IRF. This method provides a statistical framework that accounts for the relationship between an exogenous variable and an endogenous variable, measured at different time points (Ramey, 2016). It requires the estimation of regressions for each time horizon because, instead of extrapolating the parameters into increasingly distant horizons, it estimates the parameters sequentially at each point of interest. The LP method also allows to estimate IRF for exogenous shocks. As mentioned in Jordà (2005), the LP method offers three main advantages over the traditional Structural Vector AutoRegressive (SVAR) approach:

1. Joint or point-wise analytic inference is simpler;
2. The LP method can be estimated by simpler regression techniques;
3. The LP method are more robust to misspecification.

The Jorda's LP method is used in this study. The following motivates our choice for the LP method. The LP method offers more flexibility in the estimation of the impulse response function compared to direct estimation through the SVAR model. Actually, the SVAR constraints the impulse response function to be equal to the successive power of the same given set of parameters calibrated at time horizon 0. By adopting such an approach in the SVAR model, one can see that any estimation error or misspecification is easily propagated and accumulated to future time horizons. On the other side, the LP method adopts a different approach by iteratively estimating the impulse response function at each future time horizon, which in turn helps reducing the estimation error and to provide more flexibility to model the impulse response functions. Since our objective is to analyse cocoa producer price and supply responses to a shock in world price, we use the specification with an identified shock. Moreover, we consider a one-regime framework using the whole data set,

and then a two-regimes model to split the effects for periods before and after the liberalisation reform.
The LP method has been successfully applied in the literature especially to tackle various issues. Kuiper and Lansink (2013) use the LP method to compute price-reaction functions to show how the prices of the different stages in a food supply chain dynamically respond to each other and whether these responses reveal any asymmetric patterns. Empirical applications for the U.S. pork-meat and broiler-composite chains illustrate the convenience of the method and reveal an asymmetric price transmission in the pork chain. It is also worth mentioning Kapelko et al. (2017) who analyse the impact of the 2008 financial crisis on the dynamic productivity growth and its components using a firm-level data set of Spanish meat processing, dairy processing, and oils and fats firms. The impulse response analysis shows that the impact of the crisis on dynamic productivity growth is negative and persistent in the oils and fats industry, initially positive but then negative in the meat processing industry, and positive in the dairy processing industry. More recently, Francis and Restrepo-Ángel (2018) use the LP approach to analyse the impact of a shock to international oil prices on agriculture, mining and industry sectors in Colombia. Their results show that agriculture's Foreign Direct Investment (FDI), production and Producer Price Index (PPI) are unaffected by a shock on international oil prices. Industry's production falls between the second and fifth quarters after the shock, with no significant responses in its FDI and PPI. The FDI and PPI respond positively in the mining sector.

3.5.1 Estimation of the exogenous shock

To isolate the shock in world prices, we estimate an Auto-Regressive (AR) model of the cocoa world price. Since Côte d'Ivoire holds a large share of world production, we additionally assume that the Ivorian supply is very likely to influence world price. In this respect, we include the Ivorian supply as a control variable into the AR specification. We also control for crude oil price, because the movement of crude oil prices on the world market also determines the prices of cocoa on the world market (Ewing and Malik, 2013). This leads to the following preliminary

regression.

$$\begin{aligned} Price_t^W = \alpha_1 + \beta_1 Price_{t-1}^W + \cdots + \beta_p Price_{t-p}^W + \gamma_0 Prod_{t-1}^{CI} + \ldots \\ + \gamma_p Prod_{t-p}^{CI} + \delta_0 Price_{t-1}^{CO} + \cdots + \delta_p Price_{t-p}^{CO} + \nu_t \end{aligned} \tag{3.5.1}$$

where

- $Price_t^W$ is the real world price of cocoa at time t,
- $Prod_t^{CI}$ is the Ivorian production of cocoa at time t,
- $Price^{CO}$ is the real world price of crude oil at time t,
- ν_t is the error term at time t.

The optimal lag p of the regressor is selected using the Akaike Information Criterion (AIC). The error term ν_t can be viewed as the innovation at time t from the real world price of cocoa and is considered as an exogenous shock. We then estimate the impulse response functions to analyse the response of the real producer price of cocoa and the cocoa supply with respect to the shock ν_t.

3.5.2 Estimation of the impulse response function

The local projections method is used to estimate the impulse response functions of both cocoa producer price and supply in Côte d'Ivoire and Ghana as it allows to take into account an exogenous shock. A one-regime specification is first considered to examine how the cocoa producer price and supply respond over the whole period under analysis. In a second step, is introduced a two-regimes model to account for differences in responses in both periods before and after the liberalisation reform.

The one-regime specification

The general form of the one-regime model is described by the following expression:

$$y_{t+h} = \alpha_h + \beta_h \nu_t + \boldsymbol{\phi}_h^{'} \boldsymbol{x}_t + u_{h,t+h} \tag{3.5.2}$$

where:

- $h = 0, 1, ..., H-1$ is the forecast horizon (time period) for the impulse response,
- H is the maximum number of horizons set,
- y_t is the dependent variable,
- ν_t is the exogenous shock estimated in the AR regression (3.5.1),
- β_h captures the causal effect of the shock ν_t at horizon h. The numerical sequence of the $\{\beta_h\}_{h=1,2,...}$ forms the impulse response function in the one-regime specification.
- $\boldsymbol{x}_t$ is a vector of control variables which includes both the lags of the dependent variable and additional explanatory regressors,
- $\boldsymbol{\phi}_h$ is the vector of coefficients related to regressors,
- $u_{h,t+h}$ is a prediction error term. This term represents the moving average of the forecasted errors from t to $t+h$ and is therefore uncorrelated with the regressors. The $u_{h,t+h}$ terms are autocorrelated and heteroscedastic.

This model allows to capture the response of the dependent variable y at time $t+h$ to the shock variable ν_t at time t. The impulse response function consists in the sequence of all estimated parameters β_h, where $h = 0, 1, \cdots, H-1$.
Following the general form of the one-regime model, the analysis is performed using the cocoa producer price ($Price^C$) and production ($Prod^C$) separately for Côte d'Ivoire and Ghana as the dependent variable y_t^C. Depending on the selected dependent variable, relevant explanatory variables x_t are considered :

- In the case of the cocoa producer price, the vector of control variables is
$$\boldsymbol{x}_t^C = \left(Price_{t-1}^C, \ldots, Price_{t-p}^C, Prod_{t-1}^C\right)'$$
leading to the following model :
$$\begin{aligned} Price_{t+h}^C =& \alpha_h + \beta_h \nu_t + \phi_1 Price_{t-1}^C + \cdots + \phi_p Price_{t-p}^C + \\ & \phi_{p+1} Prod_{t-1}^C + u_{h,t+h} \end{aligned} \tag{3.5.3}$$

where C is either CI or GH for Côte d'Ivoire and Ghana respectively.

- In the case of the cocoa supply, the vector of control variables is

$$\boldsymbol{x}_t = \left(Prod_t^C, Prod_{t-1}^C, \ldots, Prod_{t-p}^C, Price_{t-1}^C, Area_t^C, Rain_t^C\right)'$$

leading to the following model :

$$\begin{aligned} Prod_{t+h}^C = \alpha_h + \beta_h \nu_t + \phi_0 Prod_t^C + \phi_1 Prod_{t-1}^C + \cdots + \phi_p Prod_{t-p}^C \\ + \phi_{p+1} Price_{t-1}^C + \phi_{p+2} Area_t^C + \phi_{p+3} Rain_t^C + u_{h,t+h} \end{aligned} \tag{3.5.4}$$

where C is either CI or GH for Côte d'Ivoire and Ghana respectivel.

The two-regimes specification

The LP method is extensible to a two-regimes framework that is useful to analyse the impulse responses for two different periods, i.e., before and after the liberalisation reform. This extension consists in separating the dynamics y_{t+h} into two regimes R_1 (before the liberalisation reform) and R_2 (after the liberalisation reform) by means of a dichotomous variable. Observations for the two regimes are the product of an indicator function and the variables through the following expression:

$$\begin{aligned} y_{t+h} =& \alpha_h + (\beta_{h,R_1} \nu_t + \boldsymbol{\phi}_{R_1}^{'} \boldsymbol{x}_t) \cdot (1 - \mathbb{1}(t \leq t^\star)) + \\ & (\beta_{h,R_2} \nu_t + \boldsymbol{\phi}_{R_2}^{'} \boldsymbol{x}_t) \cdot \mathbb{1}(t \leq t^\star) + w_{h,t+h} \end{aligned} \tag{3.5.5}$$

where

- β_{h,R_i} captures the causal effect of the shock ν_t under regime $R_i (i = 1, 2)$ at horizon h. The numerical sequence of the $\{\beta_{h,R_i}\}_{i=1,2 \text{ and } h=1,2,\ldots}$ forms the impulse response function in the two-regime specification,
- $\boldsymbol{\phi}_{R_i}$ captures the vector of coefficients related to the explanatory regressors under both regimes $R_i (i = 1, 2)$,
- $t^\star$ is the year of the reform,

- $\mathbb{1}(t \leq t^{\star}) = \begin{cases} 1 & \text{if } t \leq t^{\star} \\ 0 & \text{otherwise,} \end{cases}$

- $w_{h,t+h}$ is a prediction error term. This term represents the moving average of the forecasted errors from t to $t + h$ and is therefore uncorrelated with the regressors. The $w_{h,t+h}$ terms are autocorrelated and heteroscedastic.

- $\boldsymbol{x}_t$ and ν_t are exactly the same control variables and exogenous shock as previously defined for the one-regime model.

In a similar way as for the one-regime model, the general form for the two-regimes model is also specified for cocoa producer price and supply for both Côte d'Ivoire and Ghana.

3.6 Estimation Results

Following the LP method presented in the previous section, we investigate whether the reform of the marketing and pricing system in the cocoa sub-sector in Côte d'Ivoire and Ghana has made cocoa producer prices and supply more responsive to world price shocks. Models 3.5.2 and 3.5.5 are implemented using the `R` package `lpirfs` (Adämmer, 2019). The results are presented firstly for the world price shock, secondly for the local projections of the producer prices, and third for the local projections of the cocoa supply.

3.6.1 The world price shock

We first perform a regression based on the model 3.5.1 to capture the shock in the cocoa world price. Table 3.6.1 summarizes its estimation. This preliminary estimation shows a positive and significant effect of the lagged world price on the current world price with a corresponding p-value lower than 5%. The lagged crude oil price also has a significant effect. In contrast, the lagged Ivorian production level has a non significant effect.
Figure 3.6.1 depicts the world price shocks between 1979 and 2017. This figure highlights the volatile nature of the cocoa world price with numer-

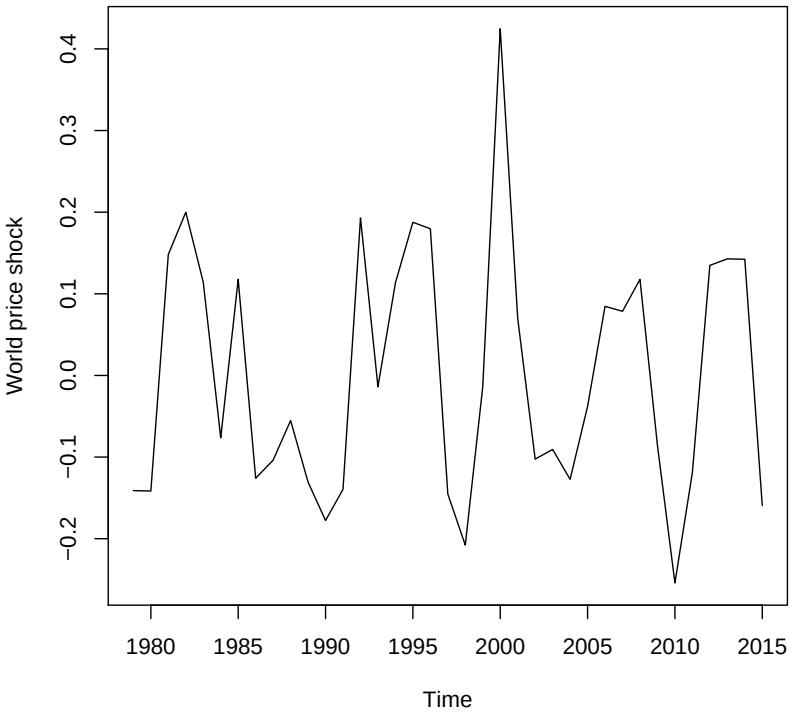


Figure 3.6.1 – Estimated cocoa world price shock ν_t

Table 3.6.1 – Estimation results of the AR model 3.5.1 for cocoa world price

	Estimate	Std. Error	t-Statistic	p-value	Significance
(Intercept)	4.317	1.466	2.944	0.006	**
$Price^{W}_{t-1}$	0.560	0.110	5.115	0.000	***
$Prod^{CI}_{t-1}$	-0.132	0.199	-0.667	0.510	
$Prod^{CI}_{t-2}$	0.001	0.209	0.004	0.997	
$Crude_{t-1}$	0.236	0.067	3.524	0.001	**
LM test for autocorrelation			2.05	0.09	
ARCH-LM test			0.75	0.39	
Adjusted R-squared : 0.765					

Notes: ** (resp. ***) denote rejection of the null hypothesis at 1% (resp. 0.1%) significance level.

ous peaks of volatility, with the highest peak in 2000 and the highest drop in 2010. There is also a large drop in 1999 followed by a sharp recovery in 2001 and 2002. This drop coincides with the achievement of the liberalisation process in Côte d'Ivoire. For Gilbert and Varangis (2004), this world price fall was rather due to lack of growth in the world cocoa consumption and was unrelated to the liberalisation process.
Table 3.6.1 also presents diagnostic tests of the residuals from model 3.5.1. The Lagrange Multiplier (LM) test and the AutoRegressive Conditional Heteroskedasticity (ARCH) test indicate no evidence of autocorrelation or ARCH effects in the residuals.

3.6.2 Estimation results of the impulse response function for the producer prices

We use the estimated innovation of the world price as a shock for the estimation of the impulse response functions. We first estimate the producer price response for both countries under a one-regime model and, then, under a two-regimes model. We also provide confidence interval at 95 percent significance level.

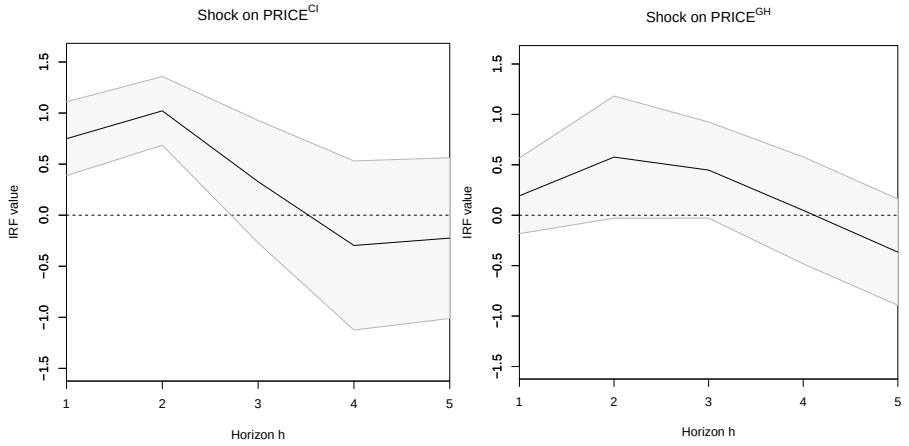
The one-regime model

The one-regime IRF is estimated for the Ivorian and Ghanaian producer prices following the Jordà's (2005) LP method. In statistics, for every decision rule in statistical hypothesis testing, there is an equivalent statement about whether the hypothesized parameter value is included in a confidence interval. With some algebra, it can be seen that the null hypothesis of null IRF (i.e IRF not significant) is rejected if and only if the value 0 is not in the confidence interval. In this respect, to conclude that the shock causes a significant effect on the variable of interest, it is sufficient to observe the periods for which the confidence band of the impulse responses does not contain zero. Figure 3.6.2 shows the one-regime impulse responses of the Ivorian and Ghanaian producer prices to a world price shock.

Results from the one-regime model indicate that Ivorian producer prices are more responsive to world price shocks than Ghanaian producer prices. Shocks on world price are fully transmitted to Ivorian producer prices in two years as the IRF corresponding value is around 1. The response of the Ivorian producer prices to world price shocks is significant and remains so for almost three years thereafter. Shocks on world price are almost significantly transmitted to Ghanaian producer prices. However, around 50 percent of shocks on world price is transmitted to Ghanain producer price after two years as the IRF value is around 0.5. This can be explained by the fact that contrary to Ghana, the Ivorian cocoa sub-sector internal marketing was already operated by private actors before complete liberalisation.

The two-regimes model

We recall that the period before 1990 (respectively 1992) is considered as pre-reform and the period after it as post-reform for Côte d'Ivoire (respectively Ghana). The estimation results of the two-regimes IRF for Côte d'Ivoire and Ghana are respectively depicted in Figures 3.6.3 and 3.6.4. As mentioned above, to conclude that the shock causes a significant effect on the variable of interest, it is sufficient to observe the periods for which the confidence band of the impulse responses does not contain zero. For Côte d'Ivoire, the pre-reform producer price response



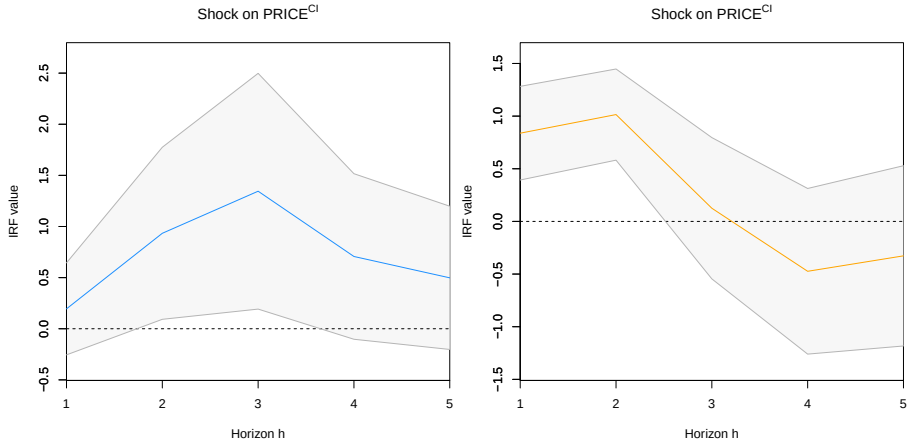
(a) (b)

Figure 3.6.2 – Impulse response functions of the Ivorian (3.6.2a) and Ghanaian (3.6.2b) producer prices to a world price shock.

to world price shock is significant with a lag of two years. For Ghana, this response is not significant. Not surprisingly, the post-reform impulse response of producer prices is significant in both countries but to a different degree that is important to highlight. The producer price response in Côte d'Ivoire is more persistent than the Ghanaian producer price response. Moreover, while in Côte d'Ivoire the world price shock is fully transmitted to the Ivorian producer price, in Ghana approximately the IRF value does not reach 1, so that the shock is not fully transmitted to Ghanaian producer prices. This is true both for the period before and after liberalisation. It can be concluded that reforms have improved the Ivoirian and Ghanaian cocoa sub-sector linkage with the world market in different degree.

The implication of these results requires attention, particularly in the case of negative shock in world prices, as farmers may lack access to resources to cope with price risks. Figures 3.6.3 and 3.6.4 confirm that the degree of implementation of the reform, complete in Côte d'Ivoire and partial in Ghana, has determined the sector's price responses. It is therefore possible that other potential domestic factors that impede

the linkage to the world market, may also help explain the difference between the responses of Côte d'Ivoire and Ghana. For example, the unfavourable monetary policy environment in Ghana, with high inflation and overvalued exchange rates, has a negative impact on producer prices and shifts them away from world price trends.

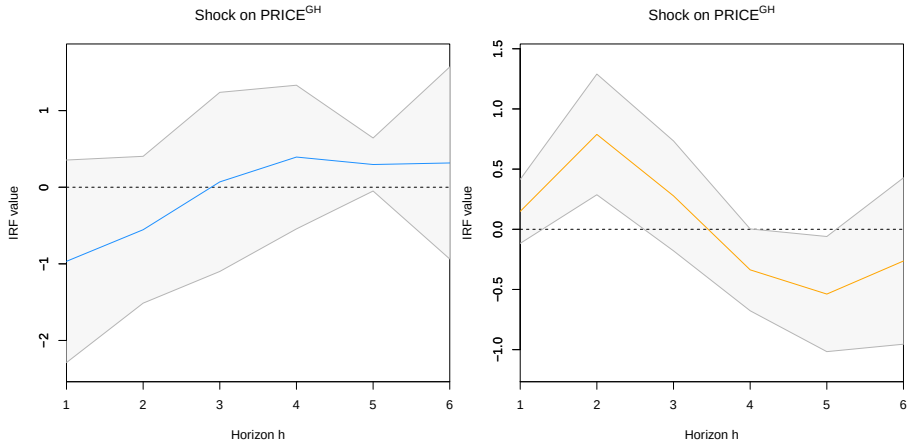


(a) (b)

Figure 3.6.3 – Impulse response functions of the Ivorian producer price to a world price shock for the period before liberalisation (3.6.3a) and after liberalisation (3.6.3b)

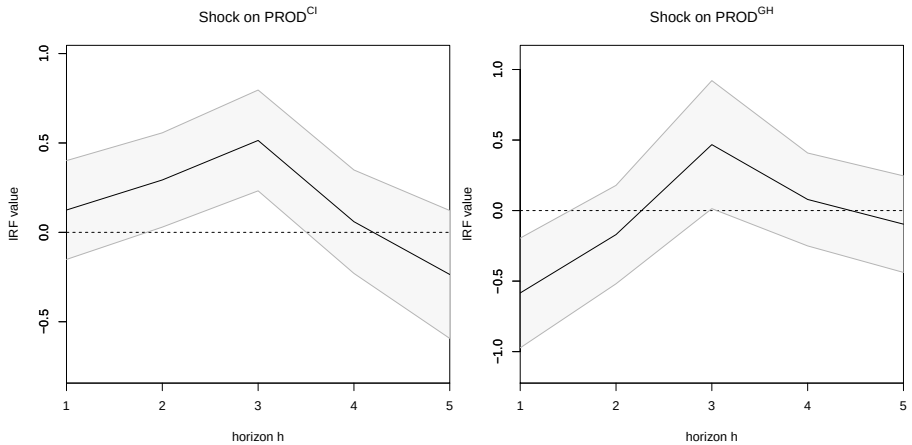
3.6.3 Estimation results of the impulse repoonse functions for the cocoa supply

Similar for the cocoa producer prices, the one-regime and two-regimes impulse responses are estimated for the cocoa supply in Côte d'Ivoire and Ghana. We also perform similar estimation for both the Ivorian and Ghanaian cocoa exports. Results are reported in section 3.8 as an appendix of this chapter.



(a) (b)

Figure 3.6.4 – Impulse response functions of the Ghanaian producer price to a world price shock for the period before liberalisation (3.6.4a) and after liberalisation (3.6.4b)



(a) (b)

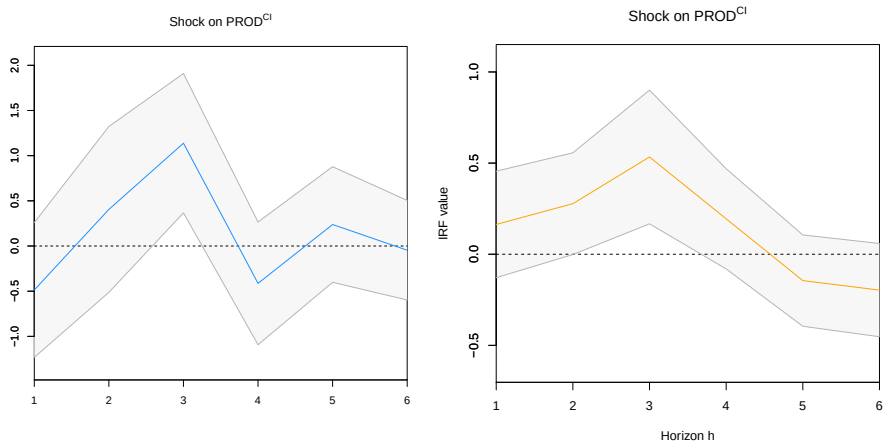
Figure 3.6.5 – Impulse response functions of the Ivorian (3.6.5a) and Ghanaian (3.6.5b) cocoa supply to a world price shock.

The one-regime model

The estimation results from the one-regime IRF depicted in Figure 3.6.5 indicate that the Ivorian cocoa supply is more responsive to world price shocks than the Ghanaian cocoa supply. The effect of a world price shock is significant in the case of Côte d'Ivoire but not for Ghana. In the case of Côte d'Ivoire this effect is significant for the period between two and three years. In addition, for both countries only 50 percent of the world price shock is transmitted after three years.

The two-regimes model

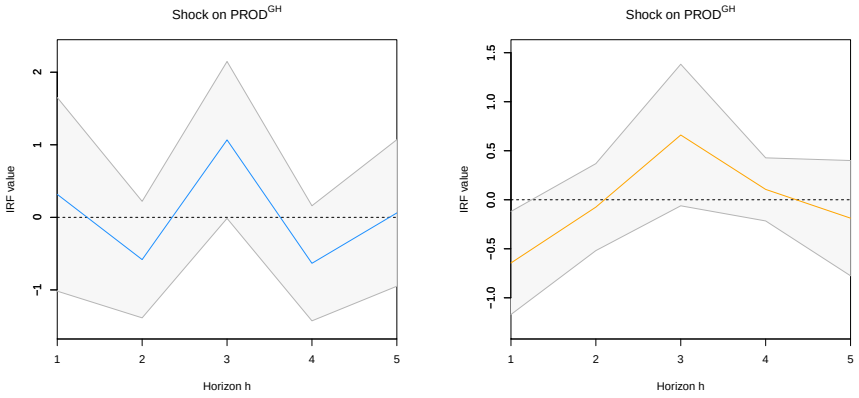
For the two-regimes IRF, the break date remains the same, i.e., we consider the period before 1990 (respectively 1992) as pre-reform and the period after as post-reform for Côte d'Ivoire (respectively Ghana). Figures 3.6.6 and 3.6.7 show the impulse response functions respectively for Côte d'Ivoire and Ghana.



(a) (b)

Figure 3.6.6 – Impulse response functions of the Ivorian cocoa supply to a world price shock for the period before liberalisation (3.6.6a) and after liberalisation (3.6.6b).

The response of the Ivorian cocoa supply to a shock in world price is



(a) (b)

Figure 3.6.7 – Impulse response functions of the Ghanaian cocoa supply to a world price shock for the period before liberalisation (3.6.7a) and after liberalisation (3.6.7b)

significant for the period between two and three years after the shock. On the other hand, the response of the Ghanaian cocoa supply to shock in world price is not significant for both periods, before and after liberalisation. It is not surprising that there is no strong and immediate cocoa supply response to a world price shock for both countries. Cocoa being a perennial crop, supply response can be only delayed. As pointed by Akiyama et al. (2003), supply response of tree crops is slow and often occurs with significant lags due to their biological nature. In some cases, a supply response never takes place because of lack of investment due to the uncertainty regarding economic and other government policies. Actually, the Ivorian supply response although significant, is not even significantly different for the periods before and after liberalisation. So the fact of having adopted a liberalisation reform does not lead to a better response of cocoa supply to a world price shock. As argued earlier, removing input provision schemes with liberalisation has certainly not been an incentive for farmers to invest more in cocoa production, especially in a sub-sector characterised by missing input and credit markets for farmers.

3.7 Conclusions

With the objective of reducing state failures and providing more competitive prices for farmers, policymakers promoted market reforms in the African cash crop sector. The effects yet ambiguous of these reforms require more studies. This paper investigates whether the reform of the marketing and pricing system in the cocoa sub-sector in Côte d'Ivoire and Ghana has made producer prices and supply more responsive to global price shocks, using impulse response functions estimated by local projections.

Estimation results indicate that world price shocks cause a stronger response of cocoa producer prices after than before the liberalisation period both in Côte d'Ivoire and Ghana. However, the effect varies according to the country. The price response is stronger in Côte d'Ivoire where the liberalisation has been more complete. While the transmission of the world price shock to Ivorian producer prices is full, about 50 percent of the shock is only transmitted to the Ghanaian cocoa producer prices. Moreover, a shock does not systematically lead to a cocoa supply response as supply of cocoa beans is price inelastic in the short term due to the perennial nature of the crop. The world price shock leads to a significant supply response between the second and third year after the shock for Côte d'Ivoire but a non-significant response for Ghana. However, the supply response to world price shocks is unchanged for the period before and after liberalisation for both countries. Liberalisation did not therefore lead to a better response of cocoa supply to a world price shock in both countries. It can be argued that market liberalisation, although partial in Ghana and complete in Côte d'Ivoire, has been effective in enhancing integration with world markets in both Côte d'Ivoire and Ghana.

These findings suggest that some key issues have to be addressed. In both countries the world price shock is transmitted and can represent a price risk to farmers in the case of negative shock as they may lack access to resources or insurance to cope with price risks. Both the Ivorian and Ghanaian governments need to work towards offering a favourable environment to farmers including offering a larger share of the world price to farmers to improve their income. It would also be useful to put

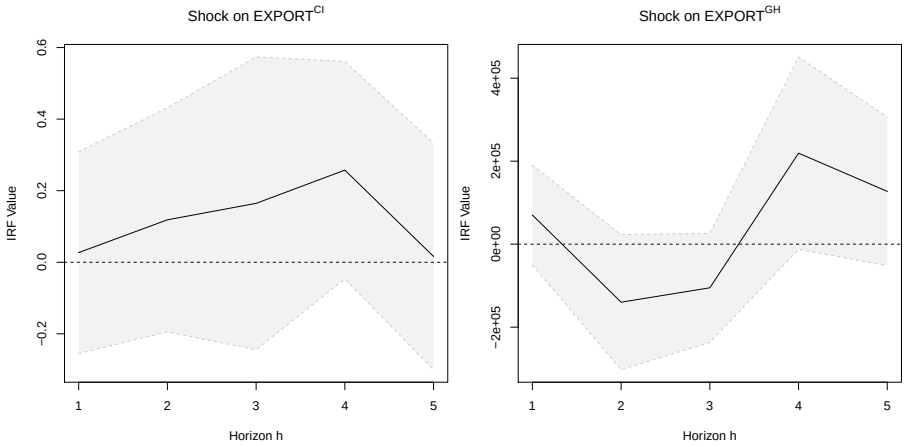
in place private alternatives to the input supply system that prevailed before liberalisation.

One of the limitations of the local projections method is that the exogenous variables must be identified beforehand. In addition, a local projection can sometimes provide an undulating impulse response function and a wide confidence interval (Ramey, 2016). One way to deal with that is to use a Bayesian local projection method as an alternative to estimate the IRF (see Tanaka 2020). Future studies could also look at splitting shocks into positive and negative shocks. Indeed, observing the difference in persistence of the response between negative and positive shocks is an important piece of information in the formulation of relevant policies.

3.8 Appendix : Estimation results of the local projections for the cocoa export

The estimation results from the one-regime model depicted in Figure 3.6.5 indicate that the Ivorian and Ghanaian cocoa export response to world price shocks are not significant.

The one-regime model

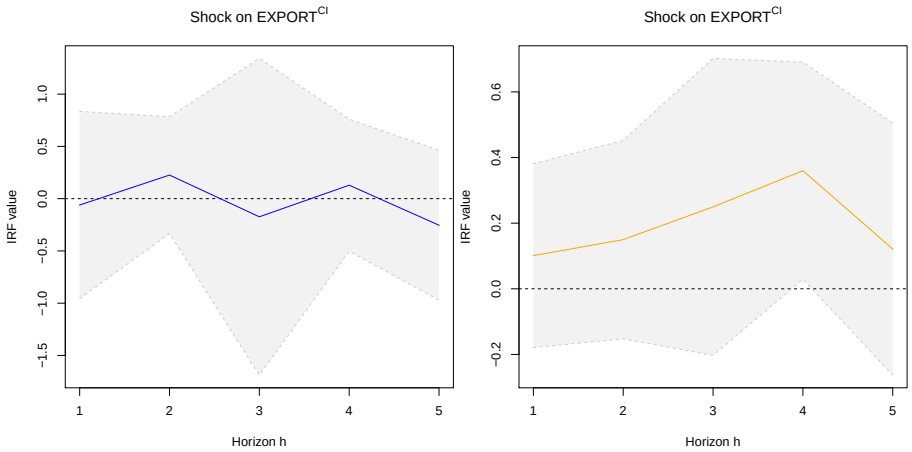


(a) (b)

Figure 3.8.1 – Impulse response functions of the Ivorian (3.8.1a) and Ghanaian (3.8.1b) export of cocoa to a world price shock.

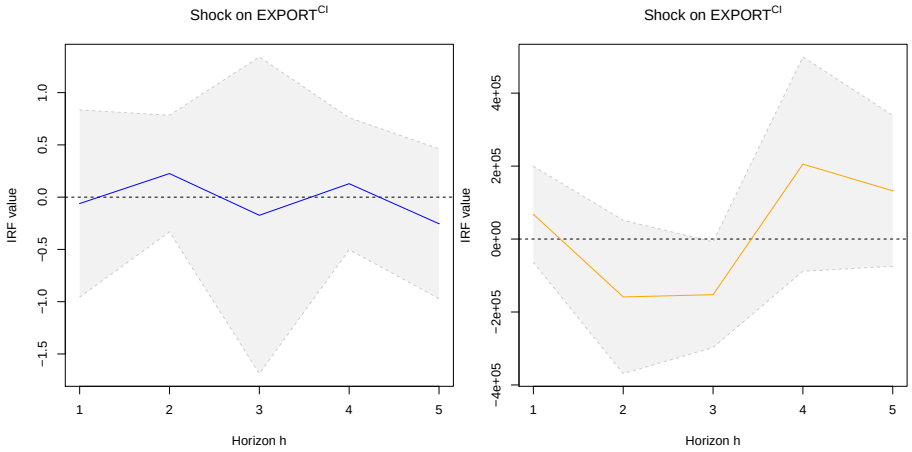
The two-regimes model

For the two-regimes LP model, the break date remains the same, i.e., we consider the period before 1990 (respectively 1992) is considered as pre-reform and the period after as post-reform for Côte d'Ivoire (respectively Ghana) Figure 3.8.2 and 3.8.3 show the impulse response functions respectively for Côte d'Ivoire and Ghana. For both period, before and after liberalization reform, the export responses to a world price shock are non significant either in Côte d'Ivoire nor in Ghana.



(a) (b)

Figure 3.8.2 – Impulse response functions of the Ivorian cocoa export, to a world price shock for the period before liberalisation (3.8.2a) and after liberalisation (3.8.2b).



(a) (b)

Figure 3.8.3 – Impulse response function of the Ghanaian cocoa export, to a world price shock for the period before liberalisation (3.8.3a) and after liberalisation (3.8.3b)

CHAPTER 4

Increasing competition in the Ivorian palm oil sector: implications for input and service provision

Following the liberalization reform in the 1990s, the Ivorian palm oil sector has been reshaped by the withdrawal of the state and the entry of agro-processing companies. Given the context of missing markets for input and credit supply to farmers, agro-processing companies engaged in providing agricultural inputs and services to farmers. However, the uncoordinated entry in the sector of several small-scale processing factories, offering to farmers some opportunities for side selling, negatively influenced the partnerships between farmers and agro-processing companies. Based on the Hotelling competition model, this chapter provides a theoretical representation of the competition between an agro-industrial company and a small-scale processing factory, as well as their decisions on input and services supply. Outcomes of the model suggest that in presence of the small-scale processing factory, the agro-industrial company has less incentive to provide inputs and services to its suppliers while it offers higher purchase prices to them. The model also shows that the small-scale processing factory has no equilibrium incentive to provide inputs and services to its suppliers. Greater competition is desired but only if market failures are removed. The second best solution in that institutional context requires the small-scale processing factories to provide similar inputs and services than the agro-processing companies.

Keywords Hotelling, Nash equilibrium, agro-processing company, small-scale processing factory, competition, oil palm, Côte d'Ivoire.

4.1 Introduction

By far the first source of lipids in Côte d'Ivoire, the oil palm is an important sub-sector in the country's consumption and economy. As pointed in the recent report of the Foundation for World Agriculture and Rurality (FARM, 2020), the oil palm sub-sector represents 2 percent of the Ivorian Gross Domestic Product (GDP), and directly or indirectly supports two million people or 10 percent of the population. Moreover, almost all palm fresh fruit bunches (FFB) are processed locally and the country exports about 45 percent of its production in the West-African region. This sub-sector also receives a particular attention in terms of public policy, because the oil produced comes mainly from the FFB of small-scale farms who provide about 60 percent of the national production.

Starting from the mid-1990's, the Ivorian oil palm sub-sector has been gradually liberalized as part of the structural adjustment programmes, initiated by the International Monetary Fund (IMF) and the World Bank in Sub-saharan African countries (Akiyama et al., 2003). One key objective of this reform was to strengthen the competitiveness of the sector and allow farmers to benefit from price increases in the world market (Shepherd and Farolfi, 1999a). This reform involved the withdrawal of the state from the sub-sector, and the liquidation of the public assets to three large private agro-processing companies, that nowadays operate in separate production areas (Naï et al., 2000; Jannot, 2010).

The liberalisation of the sub-sector has lead to regional monopsony by agro-processing companies, making them the only market for farmers' supply in their respective production areas. The ground left by the withdrawal of the state, in terms of provision of agricultural services, required for farmers and processors in the sub-sector to develop a regulatory framework on a contractual basis (Akindes and Kouame, 2001). This was particularly needed as the sub-sector is characterised by missing markets for input supply to farmers. The contract involved the agro-processing company providing a range of agricultural services (input provision, technical assistance, FFB collection, and infrastructure) to farmers and benefiting from their supplies in return. These services were temporarily provided by the few agro-processing companies, as the

long-term target was to gather farmers into cooperatives that would provide these services for their members.

With time, the sub-sector evolved from a monopsony to an oligopsony structure. Processors of FFB have been diversified with the entry of small-scale processing factories. These small-scale processors, by offering the opportunity of side selling to farmers at a competitive price, because of their lower fixed costs, reduced farmers' incentive to deliver their production to the agro-processing companies which provided them services. In this more competitive situation, farmers started to have more choice to sell their production. Both agro-processing companies and small-scale processing factories are adapting their strategic choices, especially in terms of price offer and service provision. In this context, this chapter provides a theoretical illustration of a competition between processors, their decisions about services provision. To avoid complexity, we reduce the theoretical illustration to a duopsony by considering one agro-processing company in competition with only one small-scale processing factory.

This theoretical analysis serves the relevant debate on the restructuration of the post-liberalized African cash crop sub-sectors and the accompanying measures for a successful contract farming (Key and Runsten, 1999; Reardon et al., 2009; Sexton, 2013; Macchiavello and Morjaria, 2021). Actually, liberalisation reforms intended to improve competition within the sub-sector and strengthen price incentives to farmers, but examples of some inefficiencies observed in various liberalized sub-sectors raised awareness of decision makers. In most liberalized cash crop subsectors in developing countries, a greater competition between private actors has often been associated with a sharp decline in input use, as mentioned in Delpierre (2008) and Shepherd and Farolfi (1999a). On account of the possibility of side-selling, agro-processing companies face lower incentive to provide agricultural inputs and other services. The case for cotton in Zimbabwe or coffee in Tanzania discussed respectively by Gibbon (1999) and Winter-Nelson and Temu (2002) supports that intense competition is often associated with lower level of input uses, and research and development investments. These shortcomings have been mostly attributed to market failures such as the missing credit market. To address these inefficiencies, Badiane et al. (2002) suggest that com-

petition should be sustained while institutions for loan recovery should be created. Poulton et al. (2004) instead suggest that promoting coordination between players within the sector might be a way to achieve a higher level of input and service supply. Using a two-stages Cournot game, Delpierre (2008) shows that relaxing the liquidity constraint has ambiguous effects on input use and farmer income. He argues that relaxing the liquidity constraint entails a higher price elasticity of supply that results in a reduction of traders' profit margins. As a consequence, traders' incentives to contribute to input availability are weakened.

This chapter uses another approach to this question. Based on an Hotelling model (Hotelling, 1929), we examine the competition between an agro-processing company and a small-scale processing factory, for the specific case of the Ivorian oil palm sub-sector. The Hotelling model is one popular framework that is used in analysing spatial competition. The major advantage of using this model rests in allowing the explicit analysis of the selection of buyers, i.e., to which firm the farmer decides to sell his production (Matsumura and Matsushima, 2004). With this model, we analyse the strategic decisions of both the agro-processing company and the small-scale processing factory in terms of service provision.

To this end, we employ a three-stages duopsony game. Following the sequence of activities in the Ivorian oil palm sub-sector, in the first stage of the game both processors simultaneously select the amount of services to provide to farmers. In the second stage, they simultaneously set prices. In the third stage, farmers decide to which processor they deliver to. Since the long-term objective of the government is to organize farmers into cooperatives, the game is also solved considering the case where farmers are collectively organised into cooperatives. Results from this set-up show that in this competitive situation, farmers benefit from higher prices but processors reduce their provision of services. The small-scale processing factory has even no equilibrium incentive to provide services to farmers.

The remainder of the chapter is organised as follows. Section 2 provides background information about the Ivorian oil palm sub-sector. Section 3 structures the modelling of a duopsonistic industry where an agro-processing company competes with a small-scale processor for the

purchase of FFB sold by local farmers. Section 4 analyses the outcomes when farmers organise themselves into cooperatives. Section 5 concludes.

4.2 The oil palm sub-sector in Côte d'Ivoire

With more than 2 million tons of fresh fruit bunches (FFB) and 450,000 tons of crude oil produced in 2018, the country is the second African largest producer, just behind Nigeria (FAOStat, 2020). The oil palm growing area in Côte d'Ivoire extends from the Ghanaian border in the east to the Liberian border in the west at a depth of 100 km from the coastline as depicted in Figure 4.2.1. The oil palm sub-sector in Côte d'Ivoire is dominated by small-scale farms who supply around 60% of the total amount of FFB produced that are then processed by miling firms. The remaining production comes from large plantations owned by agro-processing companies. The oil palm sub-sector provides more than 200,000 direct jobs and supports millions of people in the country. The development of the plantation of oil palms in Côte d'Ivoire results from the government's strong motivation to diversify cash crops from cocoa and coffee, introducing other crops such as rubber, cotton and oil palm. For oil palm, the strategic vision of the government has been effective through two five-years subsidised projects called "Plan palmier" which started respectively in 1963 and 1985 (Naï et al., 2000; Sayam and Cheyns, 2015). This vision had been based on agro-industrial complex : palm oil mills and large plantations owned by a public company known as Palmindustrie. Through the projects, farmers receive special fund to expand their plantations, benefit from technical assistance, and provide inputs in exchange for the delivery of their production to the mills. The government succeeded in promoting the cultivation of oil palm, building several oil mills, and creating large plantations which have contributed in making palm oil an alternative cash crop for the country.

The oil palm sub-sector was liberalized in 1997. Assets of Palmindustrie were sold to three agro-processing companies (Palmci, Sipef-CI, and Palmafrique) that respectively took over the agro-industrial complexes of Palmindustrie located in the South-West and South-East (9 oil mills,

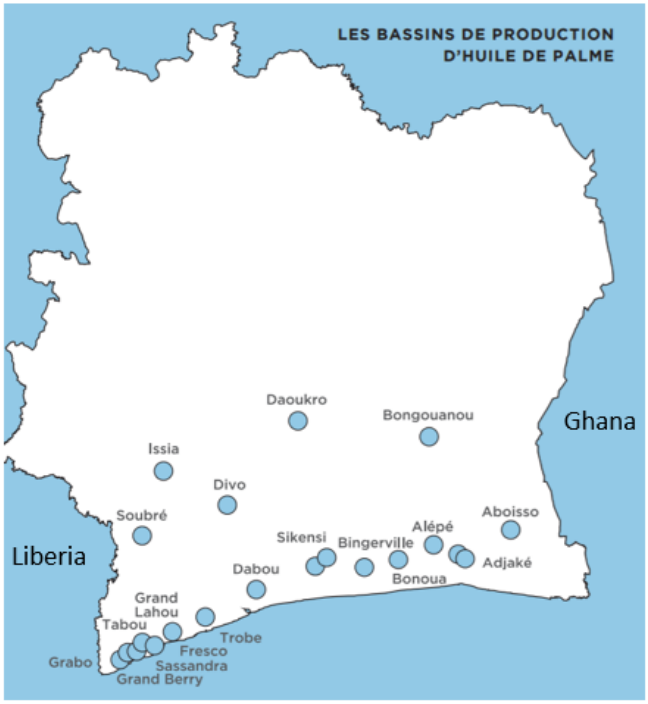


Figure 4.2.1 – Location of the major oil palm growing area in Côte d'Ivoire (Source : FARM)

35,000 ha of plantation), the Centre-West (2 oil mills, 12,700 ha of plantation), and the Centre-East (3 oil mills, 7,500 ha of plantation). These agribusiness companies are only involved in the first-level processing of FFB into crude palm oil.

The withdrawal of the state from technical assistance and input supply to farmers left a field in a sub-sector characterised by unavailability of input and credit market for farmers.[1] As a result, the government promoted the organisation of farmers' cooperatives that would provide to farmers, services previously offered by the public company. While waiting for cooperatives to be able to provide these services to their members, agro-processing companies temporarily agreed to do so. From four cooperatives established by the time of liberalisation, there are now more than 40 cooperatives in the sub-sector. These cooperatives still depend on agro-processing companies for the provision of services to their members.

The sub-sector is regulated by an inter-professional association, the AIPH (*Association Interprofessionnelle du Palmier à Huile*), created in 2003 and which brings together, through their professional associations, farmers and processing companies. The role of the professional associations is to defend the interests of their members. There is APROSAPCI [2] for the agro-processing companies, GITHP [3] for the second-level processing companies, and FENCOPAHCI [4] for farmers and their cooperatives. One of the roles of AIPH is to establish a consensual pricing mechanism to set the monthly price of palm oil and FFB. The current mechanism was adopted in 2009. It is mainly based on a mix of the Cost Insurance Freight (CIF) price of the Rotterdam Stock Exchange, the domestic ex-tank crude oil price, the domestic palm kernels price, the extraction rate for palm oil and palm kernel oil in Côte d'Ivoire, and the cost of services provided by agro-processing companies. However, studies are currently being carried out to revise this pricing mechanism.

[1] One can argue that farmers have access to inputs from the other sub-sectors. But there is a lack of input and credit markets in the other main sub-sectors.

[2] *Association Professionnelle des Sociétés Agricoles du Palmier en Côte d'Ivoire (APROSAPCI)*

[3] *Groupement des Industriels Transformateurs d'Huile de Palme(GITHP)*

[4] *Fédération Nationale des Coopératives et unions de coopératives de Planteurs de Palmier à huile (FENACOPAH-CI)*

Figure 4.2.2 describes the organisation of the different actors in the oil palm value chain in Côte d'Ivoire. In addition to the above-mentioned actors, CNRA[5], FIRCA[6] and FER[7], on the left side of Figure 4.2.2 are respectively responsible for agricultural research, technical assistance to farmers and financing the development of oil palm cultivation.
Particularly, the sector is experiencing a proliferation of small-scale processing factories in the South-East part of the country (see Figure 4.2.3). Between 2006 and 2016, more than 15 small-scale processing plants were created. This has pushed the total processing capacity to more than double the required capacity (1,120 tons/hour installed against a need of 650 tons/hour) according to MINADER (2016). By offering side selling to farmers, small-scale processing factories allow farmers to avoid paying their contribution to the professional associations and agro-processing companies for the inputs and services they receive.
In this new competitive configuration, agreements and mechanisms previously set up become obsolete. For instance, the indicative purchase price fixed by the AIPH is not enforced in areas where competition among the large and small processing factories is fierce as in the South-East area. There is also a reduction in service supply and, hence, farm plantation yields whereas farmers long-term interest is still to benefit from the provision of inputs and additional services. Different stakeholders wonder about the measures to take to secure this provision, while ensuring the competitiveness and the sustainability of the Ivorian oil palm sub-sector. In the following section, we use a theoretical model to analyse competition between an agro-processing firm and a small-scale processing factory, and their decisions on the provision of agricultural inputs and services.

4.3 The theoretical model

Previously dominated by large-scale processing companies, now the Ivorian palm oil supply chain also involves several small-scale processing

[5] *Centre National de Recherche Agronomique (CNRA)*
[6] *Fonds Interprofessionnel pour la Recherche et le conseil agricole (FIRCA)*
[7] *Fond d'Extension et de Renouvellement (FER)*

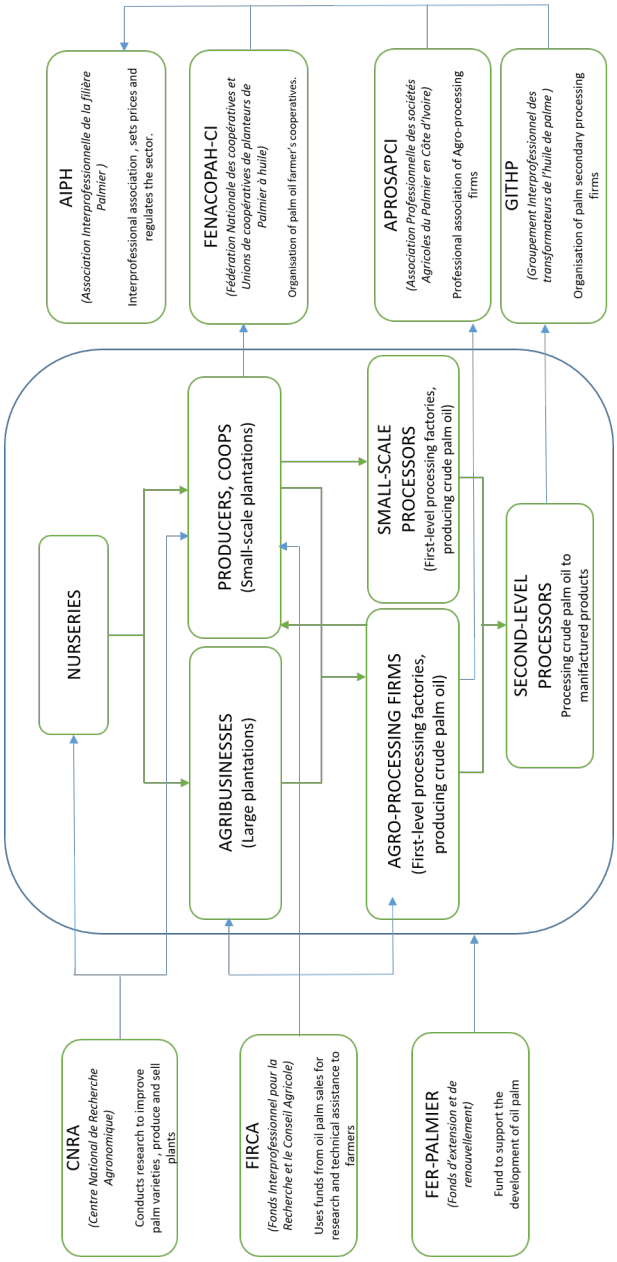


Figure 4.2.2 – Organisation of the Ivorian palm oil sector, (*Source*: Author)

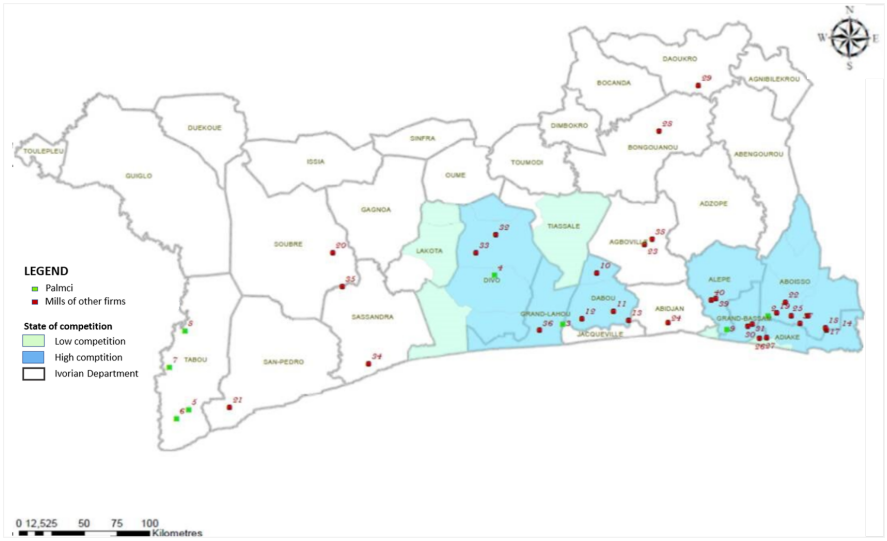


Figure 4.2.3 – Competition in the palm oil production areas of Côte d'Ivoire (Source: Palmci, 2015)

factories. We formulate a model based on the standard Hotelling model (Hotelling, 1929) to analyse the strategic decisions of processors and farmers in terms of input and service supply.

4.3.1 The general framework

We simplify the market structure as a duopsony in which a large-scale processing company and a small-scale processing factory compete to each other to purchase from farmers or farmer's cooperatives oil palm fresh fruit bunches (FFB) as an intermediate good for oil palm production. Farmers are assumed to supply FFB as an homogeneous intermediate good. We also consider that the two competitors are located at the opposing extremes of a line. We call the large processing company as Firm A and the small processing factory as Firm B (see Figure 4.3.1). Farmers depend on processors for the supply of services (input provision, technical assistance, crop collection, and infrastructure). As a result, the competitive game runs as followed. First, the processors decide the quantity of services to provide, then choose simultaneously the price

to offer for buying their supply and, finally, farmer X decides to which firm A or B deliver its production. The game is solved using backward induction. It implies to determine at each stage of the game the optimal strategy of the player who makes the last decision in the game. Then, the optimal action of the next-to-last moving player is determined, taking the last player's action as given. Concretely speaking, we solve for the decision of farmers in a first step, then prices in a second step, and services provision in a third step.

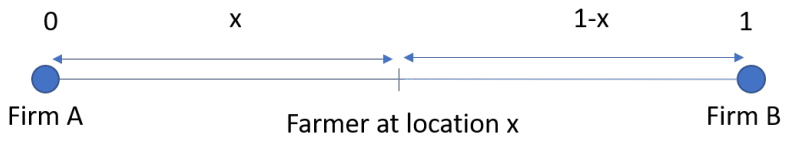


Figure 4.3.1 – The Hotelling competition setting

We now treat two different cases. The first case consists in the contract of processors with individual farmers and the second case in the exclusive contract of farmers' cooperatives with processors. Figures 4.3.2 and 4.3.3 consist in a visual as a of both cases.

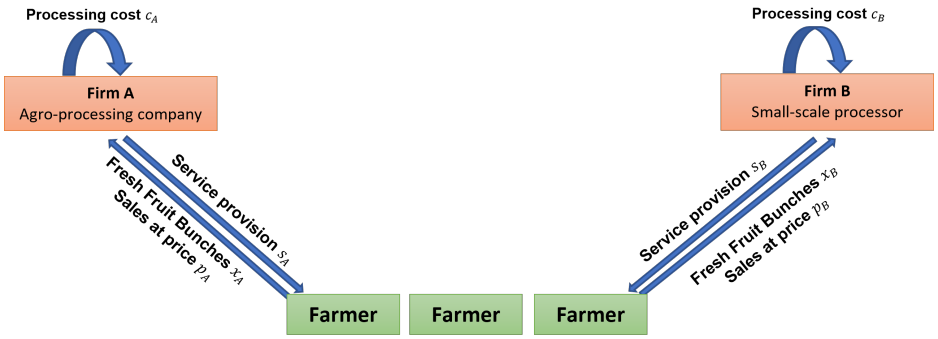


Figure 4.3.2 – Case 1 - Game with individual farmers

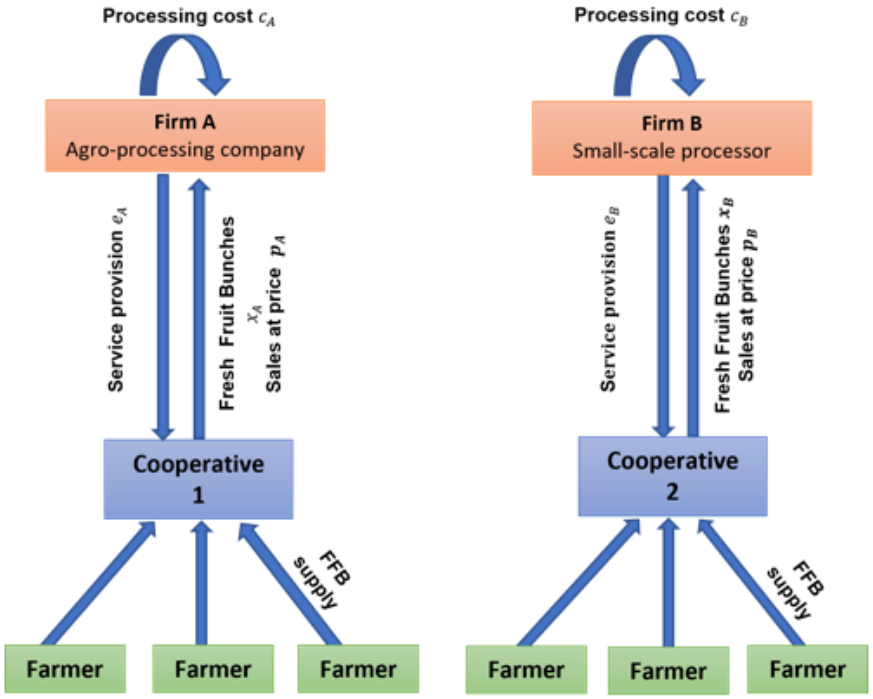


Figure 4.3.3 – Case 2 - Game with farmers' cooperatives

4.3.2 Case 1 : The game with individual farmers

This section considers the 3-stages game with individual farmers. The different stages consist in :

- **Stage 1 - Service provision** : Processors, represented by Firms A and B in Figure 4.3.2, decide first on services (input provision, technical assistance, crop collection, and infrastructure investment) to provide to farmers.
- **Stage 2 - Price offer** : Processors A and B set the price for their purchases from farmers.
- **Stage 3 - Buyer selection** : Farmers decide to which processor A or B to sell their production.

The specific assumptions for solving this game are first presented in the next section.

Assumptions

The game with individual farmers is subject to the following assumptions:

- The fresh fruit bunches (FFB) are sold either to firm A or B by individual farmers.
- Following the Hotelling model with transportation costs and full market coverage, farmers are uniformly distributed over the interval $[0; 1]$.
- Firm A, respectively B, is precisely located at 0, respectively 1 along the interval [0;1].
- The decision variable p_i represents the purchase price offered by firm i ($i \in \{A, B\}$).
- The parameter t represents the unit transport cost that farmers pay to ship their production to the firm A or B, which remains the same regardless the firm to which the farmer delivers.

- Farmers have a unit supply meaning that each farmer provides one or zero unit of production.
- The variable x is the location over the interval [0;1] of a farmer as shown in Figure 4.3.1. It is the distance between the farmer and firm A. Hence, the distance between the same farmer and firm B is $1 - x$.
- If the farmer located at distance x from A decides to sell its production to firm A, its profit is defined by $\pi_x^A = p_A - tx$. On the contrary, it is defined by $\pi_x^B = p_B - t(1 - x)$.
- if $\pi_x^A > \pi_x^B$, the same farmer located at distance x from firm A delivers at firm A. Otherwise, he delivers at firm B.

All proofs and detailed calculations to obtain the different formulas of the remaining sections are given in the Appendix.

The farmer's decision on buyer selection

To determine farmers who choose to deliver to a particular firm i ($i \in \{A, B\}$), we first have to find the location $x^\star$ of the farmer who is indifferent between the two firms. The indifferent farmer has the same profit delivering his production to the two firms. As a consequence, equalizing π_x^A and π_x^B.

$$x^\star = \frac{1}{2} + \frac{p_A - p_B}{2t}. \tag{4.3.1}$$

As farmers are uniformly distributed over the interval [0;1], the market share of firm i ($i \in \{A, B\}$) is therefore in this case equal to

$$x_i^\star = \begin{cases} x^\star & \text{if } i = A \\ 1 - x^\star & \text{if } i = B \end{cases} \tag{4.3.2}$$

which leads to

$$x_i^\star = \frac{1}{2} + \frac{p_i - p_j}{2t} \tag{4.3.3}$$

with i ($i \in \{A, B\}$ and $i \neq j$).
Recall that farmers have a unit supply meaning each farmer supplies one or zero units of output. This implies that market share $x_i^\star$, ($i \in \{A, B\}$) automatically gives the total quantity of production received by firm i. The farmers' inverse supply is then given by

$$p_i = p_j + 2t(x_i^\star - 1) \tag{4.3.4}$$

with i ($i \in \{A, B\}$). From equation 4.3.3, one can see that production sold to a firm i decreases in the unit transport cost t and depends on each other price. By offering a higher price than its competitor, one firm can thus increase its market share. However, this increase in price can not be infinite since it implies as well a drop in the marginal profit i.e., the profit generated by processing an additional unit of FFB. The firm can increase its price as long as its marginal profit is positive. The determination of the equilibrium price in this competitive game is discussed in the next section.

The firm's decision on price offer

The profit function π_i for firm i ($i \in \{A, B\}$ and $i \neq j$) is defined as :

$$\pi_i = (v - p_i - c_i)\ x_i\ q(s) - s_i \tag{4.3.5}$$

where

- The parameter v denotes the price at which the firms sell the crude palm oil. This price is assumed to be the same for both firms.
- The parameter c_i stands for the unit processing cost of firm i.
- The variable x_i is the total farmers' shipment to firm i.
- The function $q(\cdot)$ represents the supply function of one individual farm shipment to the firm i which depends on services s ($s = s_A + s_B$) provided by both firms A and B to farmers.
- The parameter s_i represents the total cost of services provided by firm i to farmers, since the farm input and service cost is normalized to 1.

Processing costs are assumed to be smaller for the large processing company A than for the small processing factory B, i.e., $c_A < c_B$, because the former benefits from economy of size for processing the FFB into crude palm oil. Given equation 4.3.3, the solution of the optimization problem for firm i's ($i \in \{A, B\}$ and $i \neq j$) profit with respect to price is:

$$p_i^\star = \underset{p_i}{\operatorname{argmax}} \left\{ (v - p_i - c_i)\ x_i^\star\ q(s) - s_i \right\}$$

The first order condition for firm i leads to the following reaction function:

$$p_i^\star = \frac{v - c_i + p_j - t}{2} \tag{4.3.6}$$

Substituting $p_j^\star$ into equation 4.3.6 we obtain the following competitive price:

$$p_i^\star = v - t - \frac{2}{3}c_i - \frac{1}{3}c_j \tag{4.3.7}$$

The solution of this duopsonistic model indicates that prices offered by both Firms A and B are different according to their unit processing costs of production. As a result, the market share $x_i^\star$ in this case is not systematically equal to $\frac{1}{2}$ as in the standard Hotelling model with duopsonistic firms located at the opposing extremes. The difference in market shares is proportional to the difference in unit processing costs. The next section determines the optimal provision of services offered by both firms.

The firm's decision on service provision

Farmers depend on processing firms for the supply of services (input provision, technical assistance, crop collection and infrastructure). In this section, we analyse the firm decisions in terms of service provision. The total supply function q_i to firm i ($i \in \{A, B\}$) is given by

$$q_i = x_i^\star\ q(s). \tag{4.3.8}$$

Recall that the function $q(s)$ represents the multiplicative factor of the farm supply depending on the use of agricultural inputs and additional

services. As shown by equation 4.3.8, the total farm supply depends on the total amount of services provided by both firm A and B. However, the costs of these services incurred by one firm are sunk if the farmer does not deliver this firm. Given that the small processing factory (firm B) is less efficient than the large processing company (firm A) and that service supply does not impact the market share $x_i^\star$ (see equation 4.3.3), firm B should have less incentive than firm A to provide services. Using equations 4.3.3 and 4.3.7, the total supply function to firm i can be rewritten as follows :

$$q_i = \frac{q(s)}{2}\left(1 + \frac{c_j - c_i}{3t}\right). \tag{4.3.9}$$

Both Firms A and B provide the quantity of services which maximizes their own profit. Given equation 4.3.9, the optimal total cost of input and service provision $s_i^\star$ for firm i is then the solution of the following optimization problem:

$$s_i^\star = \underset{s_i}{\operatorname{argmax}} \left\{ \left(v - p_i^\star - c_i\right) q_i - s_i \right\}$$

With $i \neq j$, the first order condition leads to

$$q'(s_i^\star + s_j) = \frac{2t}{\left(t + \frac{c_j - c_i}{3}\right)^2} \tag{4.3.10}$$

Since unit processing costs $c_A \neq c_B$, then one of the two equations has a corner solution at the equilibrium which is

$$\begin{cases} s_A^\star = q'^{-1}\left(\frac{2t}{\left(t + \frac{C_B - C_A}{3}\right)^2}\right) \\ s_B^\star = 0 \end{cases} \tag{4.3.11}$$

It results that competition between a large agro-processing company with economy of size and a small-scale processing factory is beneficial for individual farmers in terms of price. In this competitive framework, it is the price offered that actually determines the market share of both processors rather than their provision of inputs and additional services. To compensate for an increase in price, processors have an incentive to

reduce their potential sunk costs leading to provide fewer inputs and services to farmers. Figure 4.3.4 shows the best response curves in terms of input and service provision for both competitors. These curves represent the amount of services provided by a processor with respect to the amount provided by the other. The Nash equilibrium represents the optimal strategy for each processor when considering the decisions of the other. The Nash equilibrium in this game is reached with one corner solution ($s_B^\star = 0$). This suggests that the small-scale processing factory has no interest to provide inputs and services at the market share equilibrium.

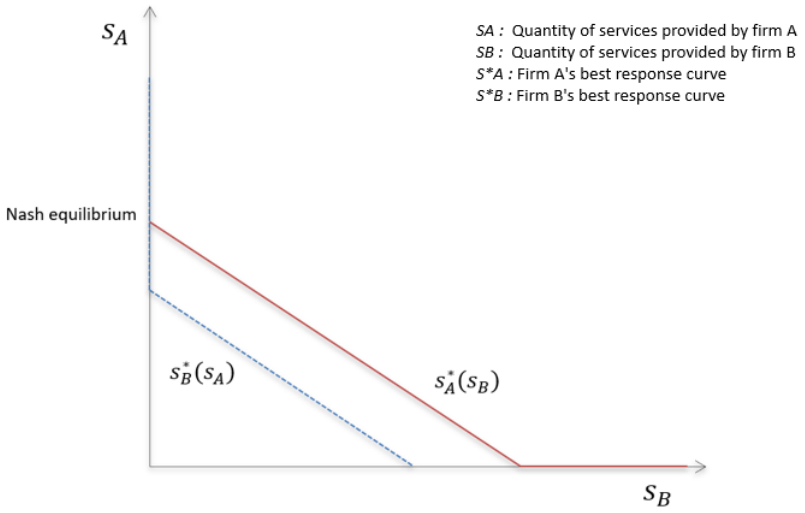


Figure 4.3.4 – Nash equilibrium for the services provision stage

4.3.3 Case 2 : The game with farmers organized in cooperatives

This section considers a three-stages game with individual farmers who are regrouped into cooperatives that have an exclusive contract with the processors. Farmers organized into cooperatives improve their bargaining position and can, therefore, countervail the processor market power.

Among the services that processors provided initially to farmers, we consider that input provision, technical assistance and collection of output are now negotiated between the farmer's cooperatives and the processor and can be implicitly considered as part of the purchase price offered by the processor. However, we assume that the remaining provision such as infrastructure investment, is not negotiated due to its public nature as it benefits to all farmers. Therefore, we focus in this case on the provision of this particular service. The principle of the overall game remains the same as in the previous case with slightly different stages which are :

- **Stage 1 - Infrastructure investment** : The processors (firm A or B) first make some infrastructure expenditures (e_A or e_B) that increase productivity for all farmers but which represent a sunk cost. In this game, the processors only supply inputs and services to the farmers who belong to the cooperative with which a contract is established.
- **Stage 2 - Buyer selection** : Then, each farmer decides to belong to a cooperative and therefore engages through this cooperative in delivering either at firm A or B or quits the market.
- **Stage 3 - Price negotiation** : Finally, each Firm i negotiates the purchase price with each cooperative.

Similarly to the previous game, this second game is solved using backward induction.

The price negotiation

The purchase price p_i still stands for the price offered by firm i ($i \in \{A, B\}$) but to the farmers' cooperative. We write the total profit function of firm i (with $i \neq j$) as

$$\pi_i = (v - p_i - c_i)\ x_i\ q(s) - s_i \tag{4.3.12}$$

In this case, for each farmer located at distance x who delivers to firm i through his cooperative, the individual farm profit function is given by :

$$\pi_i^x = (p_i - tx_i)\ q(s) \tag{4.3.13}$$

Aggregating individual farm profits gives the joint profit for the cooperative members who deliver at firm i.

$$\int_0^{x_i^\star} \pi_i^x \, \mathrm{d}x = x_i^\star \; q(s) \left(p_i - \frac{t x_i^\star}{2} \right) \tag{4.3.14}$$

Because the farmers' cooperative negotiates the price with the processor, the optimal transaction price is the one that maximizes the profit of the coalition, i.e., the cooperative and the processor. It is assumed that the total opportunity cost for a farmer's production is $Zq(s)$ while processor i loses s_i. $Zq(s)$ represents the total revenue the farmer can obtain from his production with an alternative solution, if he decides to quit the market. The joint optimization problem for both the cooperative and firm i is then

$$p_i^\star = \underset{p_i}{\operatorname{argmax}} \left\{ (\pi_i + s_i) \cdot \int_0^{x_i^\star} \left(\pi_i^x - Zq(s) \right) \mathrm{d}x \right\}. \tag{4.3.15}$$

This objective function is set as the product of both the firm i and the cooperative profits to constrain both profits to be positive. In the case that one of the two profits is null, there is no solution since the game is cooperative. This joint profit maximization leads to the solution $p_i^\star$ defined as:

$$p_i^\star = \frac{1}{2} \left(v - c_i + Z + t \frac{x_i^\star}{2} \right). \tag{4.3.16}$$

In this case, note that the bargaining power represented by the opportunity cost Z of the cooperative is a key parameter in the price negotiation.

The farmer's decision on buyer selection

Just like in the previous case where we determine which farmers choose to deliver to firm A or B, we have to find the farmer $x^\star$ who is indifferent between both firms A and B. By equalizing both π_x^A and π_x^B we found that

$$x^\star = \frac{1}{2} + \frac{c_B - c_A}{3t} \tag{4.3.17}$$

As farmers are uniformly distributed over the interval [0;1], market share of firm i ($i \in \{A, B\}$) is therefore in this case equal to

$$x_i^\star = \begin{cases} x^\star & \text{if } i = A \\ 1 - x^\star & \text{if } i = B \end{cases} \tag{4.3.18}$$

which leads to

$$x_i^\star = \frac{1}{2} + \frac{c_j - c_i}{3t} \tag{4.3.19}$$

with i ($i \in \{A, B\}$ and $i \neq j$).

Recall that farmers have a unit supply meaning each farmer supplies one or zero units of output. This implies that market share $x_i^\star$, ($i \in \{A, B\}$) automatically gives the total quantity of production received by firm i. One can see from 4.3.19 that while the firm's unit processing cost decreases, its market share increases.

The firm's decision on infrastructure investment

In this case, the provision of services only covers infrastructure investment, such as road maintenance, because the provision of other services negotiated within the coalition can implicitly be seen as an integral part of the negotiated price. The optimisation problem for firm i ($i \in \{A, B\}$) can be written as follows :

$$s_i^\star = \underset{s_i}{\operatorname{argmax}} \left\{ \left(v - p_i^\star - c_i \right) x_i^\star \; q(s) - s_i \right\}$$

leading to

$$q'(s_i^\star + s_j) = \frac{2}{\left(v - c_i - Z - \frac{1}{2} t x_i^\star \right) x_i^\star} \tag{4.3.20}$$

When $c_A \neq c_B$ one of the two equations indicates a corner solution at the Nash equilibrium, namely $s_B^\star = 0$ as in the case of individual farmers. The small-scale processing factory still has no incentive to invest in infrastructure. The main difference for this second case is that only infrastructure investment represents potential sunk cost. At least, the cooperatives thanks to their negotiations with processors, obtain the input supply, the crop collection and the technical assistance for their members. However, this scheme necessitates the presence of functional cooperatives that have exclusive contracts with processors.

4.3.4 Intermediate conclusions

The use of the Hotteling framework illustrates the competition between an agro-processing company and a small-scale processing factory with different unit processing costs, which caricaturizes to the current status of the oil palm sub-sector in Côte d'Ivoire. In the first case where the processors contract with individual farmers, we show that it is the price offered that actually determines the market share of both processors rather than their provision of inputs and additional services which lead to potential sunk costs. So processors provide fewer inputs and services to farmers but higher price to increase their market share. In the second case where the farmers' cooperatives contract exclusively with both processors, the reduction of service provision by the processors only concerns infrastructure investment. In both cases, we show that with competition, farmers gain in term of higher purchase price but this gain is countervailed by a reduction in the supply of inputs and services. In the Nash equilibrium, the small-scale processor has no incentive to provide services to farmers. The advantage for farmers of being organised in operational cooperatives is that the cooperative has greater bargaining power and can engage in exclusive contracts with processing firms. Similar results, where fierce competition is associated with lower input availability, have been observed for the cotton sector by Poulton et al. (2004) in Uganda and Gibbon (1999) in Tanzania. Moreover, field observations in Côte d'Ivoire confirm that the purchase price of FFB set up by AIPH is no longer enforced. There is also a decline in the technical assistance and the provision of services to farmers. Moreover, the FARM (2020) report notes that farmers' yields are around 4 to 5 tons of palm fruit bunches per ha, much less compared to 20 to 25 tons for industrial plantations using the same plant material.

4.4 Concluding remarks

The liberalisation of the Ivorian oil palm sub-sector has ended the public monopoly with the entry of private agro-pocessing companies. The lack of input and credit markets for farmers made necessary the involvement of agro-processing companies in the provision of agricultural inputs

and services to farmers, pending the organisation of farmer's cooperatives and the strengthening of their capacity in providing services to their members. The subsequent entry of small-scale processing factories which offer the possibility of side selling, led to a greater competition between processors and showed the limits of farmers' dependence on processors for input and service provision. The existence of competition among processing firms impacts on they behaviour in terms of input and service provision, price and market outcomes.

Thanks to the analytical results derived from the Hotelling model, competition between a large agro-processing company and a small-scale processing factory leads to a decline in the supply of inputs and services. The small-scale processing factory has even no incentive to provide inputs and services to farmers at the market share equilibrium.

The predictions of the model where the farmers are in cooperative and contract with the processor are somewhat different from those obtained for individual farmers in the same market. The difference in predictions can be attributed to the pricing rules. The cooperative tries to maximise the profits of the members and the processor, whereas in the case of individual farmers, the processor only maximises his own profits. These analytical results imply the attention of policy makers as no suitable alternatives exist for farmers in terms of input supplies and services. The withdrawal of the government from input and service provision has not been properly compensated for by involving processing firms. As pointed by Ponte (2001), would the withdrawal of the state in places where the private sector involvement is structurally limited have occurred too abruptly with still market failures ?

We argue that the second best solution in that institutional context calls for the entering factories to provide the same inputs and services than larger agro-processing companies. Ultimately, it would be necessary to strengthen the capacity of farmers' cooperatives to provide additional agricultural inputs and services to their members and to facilitate seasonal credits for farmers.

One of the main limitations of most microeconomics models is that results seem to heavily depend on strong assumptions made about the economic setting. In our case we only consider a linear production space in which farmers are uniformly distributed. It is reasonable to think

that such simplifying assumption is needed at an early stage of the theoretical framework. However, one should strive for more robust results. In this respect, it might be possible to extend the theoretical framework studied in this chapter. (Graubner et al., 2021) present the theoretical foundations of spatial pricing, competition, and location in terms of buyer power and discuss relevant concept for agricultural market, the paper provides some insights for future research and the challenges of spatial competition analysis in agricultural economics.

The distribution of farmers on the Hotelling line can be generalized beyond the uniform distribution. Neven (1986) examine an Hotelling competition game with an increasing densities of consumers towards the centre. The use of this assumption in the model will probably influence the market share of processing companies. It could also be interesting to better support the theoretical findings with empirical evidence. Finally, we can also introduce product quality differentiation by the processing companies. (Mérel et al., 2009) propose and illustrate appropriate modelling frameworks to study cooperatives' performance in differentiated-product market settings

The application of a spatial competition model to analyse the competition of agro-processing companies in an export crop market, demonstrates their potential to provide information on the strategic decisions of farmers, cooperatives and processing companies in this context of agricultural market liberalisation.

4.5 Appendix: Derivations of equations of section 4.3

Proof of Equation 4.3.3

$$\begin{aligned}\pi_x^A = \pi_x^B &\iff p_A - tx = p_B - t(1-x)\\ &\iff x^\star = \frac{1}{2} + \frac{p_A - p_B}{2t}.\end{aligned}$$

Proof of Equation 4.3.6

$$\begin{aligned}\frac{\partial \pi_i}{\partial p_i} = 0 &\iff -\frac{p_i - p_j + t}{2t} q(s) + (v - p_i - c_i)\frac{1}{2t} q(e) = 0\\ &\iff \frac{-p_i + p_j - t + v - p_i - c_j}{2t} = 0\\ &\iff \frac{-2p_i + p_j - t + v - c_i}{2t} = 0\\ &\iff -\frac{p_i^\star}{t} + \frac{v - c_i + p_j - t}{2t} = 0\\ &\iff -p_i + \frac{v - c_i + p_j - t}{2} = 0\\ &\iff p_i^\star = \frac{v - c_i + p_j - t}{2}\end{aligned}$$

Proof of Equation 4.3.7

$$\begin{aligned}p_i^\star &= \frac{v - c_i + p_j^\star - t}{2}\\ &= \frac{v - c_i + \frac{v - c_j + p_i^\star - t}{2} - t}{2}\\ &= \frac{2v - 2c_i + v - c_j + p_i^\star - t - 2t}{4}\\ p_i^\star &= \frac{3v - 2c_i - c_j + p_i^\star - 3t}{4}\\ &\iff p_i^\star - \frac{p_i^\star}{4} = \frac{3}{4} p_i^\star = \frac{3v - 2c_i - c_j}{4}\\ &\iff p_i^\star = v - t - \frac{2}{3} c_i - \frac{1}{3} c_j\end{aligned}$$

Proof of Equation 4.3.9

$$\begin{aligned}
q_i &= x_i^\star \; q(s) \\
&= \left(\frac{1}{2} + \frac{p_i^\star - p_j^\star}{2t}\right) q(s) \\
&= \left(\frac{1}{2} + \frac{\left(-\frac{2}{3}c_i - \frac{1}{3}c_j\right) - \left(-\frac{2}{3}c_j - \frac{1}{3}c_i\right)}{2t}\right) q(s) \\
&= \left(\frac{1}{2} + \frac{-\frac{1}{3}c_i + \frac{1}{3}c_j}{2t}\right) q(s) \\
&= \frac{q(s)}{2}\left(1 + \frac{c_j - c_i}{3t}\right)
\end{aligned}$$

Proof of Equation 4.3.19

Consider objective function O_1 defined as

$$O_1(s_i) = \left(v - p_i^\star - c_i\right) q_i - s_i$$

Then first order condition leads to

$$\begin{aligned}
\frac{\partial O_1}{\partial s_i} = (v - p_i^\star - c_i)\frac{q'(s_i^\star + s_j)}{2}\left(1 + \frac{c_j - c_i}{3t}\right) - 1 = 0 \\
\iff (v - p_i^\star - c_i)\frac{q'(e_i^\star + s_j)}{2}\left(1 + \frac{c_j - c_i}{3t}\right) = 1 \\
\iff q'(s_i^\star + s_j) = \frac{2}{(v - p_i^\star - c_i)\left(1 + \frac{c_j - c_i}{3t}\right)} \\
\iff q'(s_i^\star + s_j) = \frac{2t}{(v - p_i^\star - c_i)\left(t + \frac{c_j - c_i}{3}\right)}
\end{aligned}$$

As

$$\begin{aligned}
v - p_i^\star - c_i &= v - (v - t - \frac{2}{3}c_i - \frac{1}{3}c_j) - c_i \\
&= t + \frac{2}{3}c_i + \frac{1}{3}c_j - c_i \\
&= t + \frac{1}{3}c_j - \frac{1}{3}c_i \\
&= t + \frac{c_j - c_i}{3}
\end{aligned}$$

Finally

$$q'(s_i^\star + s_j) = \frac{2t}{\left(t + \frac{c_j - c_i}{3}\right)^2}$$

Proof of equation 4.3.14

$$\int_0^{x^\star} \pi_A^x \, dx = \int_0^{x^\star} (p_A - tx) q(e) \, dx$$

Let consider

$$\begin{cases} u(x) = (p_A - tx) \; q(e) \\ v'(x) = 1 \end{cases} \Longrightarrow \begin{cases} u'(x) = -tq(e) \\ v(x) = x \end{cases}$$

Using integration by parts, we have

$$\begin{aligned} \int_0^{x^\star} \pi_A^x dx &= \Big[(p_A - tx) \; x \; q(e)\Big]_0^{x^\star} + \int_0^{x^\star} t \; x \; q(e) dx \\ &= (p_A - tx^\star) \; x^\star \; q(e) + \Big[t \; q(e) \; \frac{x^{\star 2}}{2}\Big]_0^{x^\star} \\ &= (p_A - tx^\star) \; x^\star \; q(e) + t \; q(e) \; \frac{x^{\star 2}}{2} \\ &= p_A \; x^\star \; q(e) - t \; q(e) \; x^{\star 2} + t \; q(e) \; \frac{x^{\star 2}}{2} \\ &= p_A \; x^\star \; q(e) - t \; q(e) \; \frac{x^{\star 2}}{2} \\ &= x^\star \; q(e)\Big(p_A - t \; \frac{x^\star}{2}\Big) \end{aligned}$$

By a change of variable $y = 1 - x$, we can show that

$$\int_{x^\star}^1 \pi_B^x \, dx = \int_0^{1-x^\star} \pi_B^x \, dy$$

implying a result of a same kind than previously. That ends the proofs.

Proof of Equation 4.3.16

Consider objective function O_2 becomes

$$\begin{aligned} O_2(p_i) &= \Big(\pi_i + e_i\Big) \int_0^{x_i^\star} \Big(\pi_x^i - Zq(e)\Big)dx \\ &= \Big((v - p_i - c_i)x_i^\star q(e)\Big) \times \Big(\int_0^{x_i^\star} \pi_x^i dx - x_i^\star Zq(e)\Big) \\ &= \Big((v - p_i - c_i)x_i^\star q(e)\Big) \times \Big(x_i^\star q(e)\Big(p_i - t\frac{x_i^\star}{2}\Big) - x_i^\star Zq(e)\Big) \end{aligned}$$

First order condition leads to

$$\begin{aligned} \frac{\partial O_2}{\partial p_i} &= -x_i^\star q(e)\Big[x_i^\star q(e)\ \Big(p_i - t\frac{x_i^\star}{2}\Big) - x_i^\star Zq(e)\Big] + \Big[(v - p_i - c_i)x_i^\star q(e)\Big]\ x_i^\star q(e) = 0 \\ &\iff -\Big(\Big(p_i - t\frac{x_i^\star}{2}\Big) - Z\Big) + \Big(v - p_i - c_i\Big) = 0 \\ &\iff \Big(-p_i + t\frac{x_i^\star}{2} + Z\Big) + \big(v - p_i - c_i\Big) = 0 \\ &\iff -2p_i + t\frac{x_i^\star}{2} + Z + v - c_i = 0 \\ &\iff p_i^\star = \frac{1}{2}\Big(v - c_i + Z + t\frac{x_i^\star}{2}\Big) \end{aligned}$$

Proof of Equation 4.3.17

We have,

$$\begin{aligned} \pi_i^x &= (p_i^\star - tx_i^\star)\ q(e) \\ &= \Big(\frac{1}{2}(v - c_i + Z + t\frac{x_i^\star}{2}) - tx_i^\star\Big)q(e) \\ &= \frac{1}{2}\Big(v - c_i + Z + t\frac{x_i^\star}{2} - 2tx_i^\star\Big)q(e) \\ &= \frac{1}{2}\Big(v - c_i + Z - \frac{3}{2}tx_i^\star\Big)q(e) \end{aligned}$$

Then,

$$\begin{aligned}
\pi_A^x = \pi_B^x &\iff v - c_A + Z - \frac{3}{2}tx_A^\star = v - c_B + Z - \frac{3}{2}tx_B^\star \\
&\iff v - c_A + Z - \frac{3}{2}tx^\star = v - c_B + Z - \frac{3}{2}t(1 - x^\star) \\
&\iff c_B - c_A = \frac{3}{2}tx^\star - \frac{3}{2}t(1 - x^\star) \\
&\iff c_B - c_A = 3tx^\star - \frac{3}{2}t \\
&\iff \frac{3t}{2} + c_B - c_A = 3tx^\star \\
&\iff x^\star = \frac{1}{2} + \frac{c_B - c_A}{3t}
\end{aligned}$$

Proof of Equation 4.3.20

Consider objective function O_3 defined as

$$O_3 = (v - p_i^\star - c_i)\ x_i^\star\ q(e) - e_i$$

First order condition leads to

$$\begin{aligned}
\frac{\partial O_3}{\partial e_i} &= (v - p_i^\star - c_i)\ x_i^\star\ q'(e) - 1 = 0 \\
&\iff q'(e) = \frac{1}{(v - p_i^\star - c_i)x_i^\star} \\
&\iff q'(e) = \frac{1}{\left(v - \frac{1}{2}\left(v - c_i + Z + t\frac{x_i^\star}{2}\right) - c_i\right)x_i^\star} \\
&\iff q'(e) = \frac{1}{\left(\frac{1}{2}v - \frac{1}{2}c_i - \frac{1}{2}Z - t\frac{x_i^\star}{4}\right)x_i^\star} \\
&\iff q'(e) = \frac{1}{\frac{1}{2}\left(v - c_i - Z - t\frac{x_i^\star}{2}\right)x_i^\star} \\
&\iff q'(e) = \frac{2}{\left(v - c_i - Z - t\frac{x_i^\star}{2}\right)x_i^\star}
\end{aligned}$$

CHAPTER 5

Conclusions

Because of their agricultural potential and the relative importance of agricultural sector, the vast majority of sub-Saharan African (SSA) countries decided to base their economies on the agricultural sector, after independence. Given the strategic importance of this sector, most of these countries adopted an interventionist approach, involving the public sector at all levels of the value chain. This approach was characterised by the presence of state-owned companies around which farmers were supplied with inputs and services, and guaranteed prices. However, poor public management, coupled with unfavourable international economic conditions, plunged most countries into crisis and diverted them from their commitment to provide better living conditions for farmers. To restore financial stability and stimulate economic growth, SSA countries engaged in the World Bank's structural adjustment programmes which led to a gradual liberalisation of their agricultural export market, from the 1990s. The aim of these reforms was to improve the competitiveness of the sector and to offer competitive prices to farmers. Consequently, the agricultural sector witnessed a progressive loss of public control over the export crop marketing chain, replaced by the entry of private actors. By the end of the 1990s, all mechanisms in place to

stabilise prices were also removed. Evaluation of structural adjustment programmes in SSA have been inconclusive and highly controversial. There is however a general consensus that reforms did not met expectation. Agricultural reforms in SSA have so far been disappointing. The sector has not delivered substantial economic growth to significantly reduce poverty. As a result, SSA is lagging behind other regions in terms of development and poverty reduction. Relevant evaluations of the reforms are needed to frame future policies to significantly reduce poverty and reverse the trend in the future.
In this context, the objective of this study is set to analyse the impact of liberalisation reform on the dynamics of producer prices, supply and provision of agricultural inputs and services in the Ivorian export crop sector whilst focusing on the rubber, palm oil and cocoa sub-sectors in Côte d'Ivoire. The selection of these sub-sectors rests on their importance for the economy of Côte d'Ivoire. The key results and their main contributions are presented below.

5.1 Key results

First, we conclude that liberalisation reforms have increased the transmission of the rubber world price to domestic prices. Results from chapter 2 suggest that world prices are perfectly transmitted to domestic prices. There is also no asymmetry in the transmission process, even during world price spikes. This is an interesting result since one would expect an asymmetric price transmission, given the presence of large private actors in the sector. Results of previous studies on post-liberalized sectors such as Subervie (2007) and Badolo (2011) report the presence of asymmetry in the transmission of the world price to domestic market. The well-structured internal organisation of the rubber sub-sector, with the presence of an inter-professional association that brings together all the stakeholders and advocates for fair remuneration, has reduced the potential market power of agro-processing companies.
Secondly, liberalisation reforms brought Ivorian cocoa producer prices to better response to world price shocks as suggest by results from chap-

ter 3. Compared to those of Ghana, the results show in Côte d'Ivoire a more significant impact than in Ghana which is explained by the fact that the process of liberalisation is more advanced in Côte d'Ivoire than in Ghana. However, liberalisation has not a significant impact on the supply response to world price shocks in both Côte d'Ivoire and Ghana. That is, cocoa supply response to world price shock is not systematic in any case, probably because cocoa production is a perennial crop. As a consequence, supply response to world price shock can be delayed.

The above results suggest that Ivorian farmers are highly exposed to fluctuations in world prices, which constitutes a threat for them especially in the case of negative shocks. Important decreases in world prices would not be a problem in the case of a favourable institutional context. However, rural areas are characterised by a lack of credit and insurance markets for farmers. This reduces the ability of producers to cope with the consequences of such price fluctuations. When credit or savings are limited, smoothing consumption over time is obviously challenging.

Thirdly, liberalisation reforms have led to a multiplicity of processing companies in the oil palm sub-sector. Chapter 4 analyses the impact of this market structure based on the Hotelling model. It shows analytically that competition between an agro-processing company and a small-scale processing factory leads to a decline in the supply of agricultural inputs and services. At the market share equilibrium, the small-scale processing factory lacks the incentive to provide inputs and services to farmers. Actually, the withdrawal of the government from input and service provision is not properly compensated for by involvement of processing companies. In this market structure, the small-scale processing factory just like the agro-processing companies should provide agricultural inputs and services to farmers. As argued in the chapter, greater competition is desired but at the condition that market failures be removed.

From an overall perspective, adjustment programmes have clearly brought some improvements but did not answer some of the main Ivorian cash crop sub-sector fundamental development questions. The challenge is to make this liberalized export crop marketing system sustainable and responsive to the needs and expectations of farmers. It could therefore be relevant to strengthen the capacity of farmers' cooperatives to pro-

vide additional agricultural inputs and services to their members and to facilitate seasonal credit market for farmers. As Worako et al. (2008) posit, we need to move from '*getting prices right*' to '*getting institutions right*', so as to address market failures, insufficient provision of public goods to improve farmers' income and reduce rural poverty.

5.2 Main contributions

Along the way, extensive discussions with experts (*Centre Nationale de Recherches Agronomiques - CNRA*, International Cocoa Organisation - ICCO, Ivorian Ministry of Finance, *Société Africaine de Plantations d'Hévéa - SAPH, PALMCI*) on the field help shaping and challenging the choice of the issues tackled in this thesis. Such approach guarantees the relevance of the issues addressed in this thesis and also the interest of both policy-makers and academics.

To study those issues, this doctoral thesis adopts a unique multidisciplinary and methodological approach that rigorously goes from basic and advanced time series analysis to game theory. More specifically, this thesis emphasizes the need for addressing the spurious regression issue in the case of non-stationary data and pleads for the use of more adapted method such as the Error Correction Model (ECM). This model requires testing for cointegration and the tests generally used fail when the data additionally presents some breaks. That is the reason why the thesis goes beyond these traditional tests and uses more recent one which efficiently deals with the presence of breaks in the data. A refined version of the Threshold Vector Error Correction Model (TVECM) is also used, allowing to account for structural breaks in the data. This is an important contribution in the sense that the presence of breaks is often ignored in non-stationary data analysis. The ECM also shows that the use of cointegration is especially useful for the distinction between the short and long run dynamics which may differ to each other.

Another methodological contribution of the thesis is the use of the local projections methodology. The LP method offers more flexibility in the estimation of the impulse response function compared to direct estimation through the traditional Structural Vector AutoRegressive (SVAR)

model frequently used in the literature. Actually the SVAR model constraints the impulse response function to be equal to the successive power of the same given set of parameters calibrated at time horizon 0. By adopting such an approach in the SVAR model, one can see that any estimation error or misspecification is easily propagated and accumulated to future time horizons. On the other side, the LP method adopts a different approach by iteratively estimating the impulse response function at each future time horizon, which in turn helps reducing the estimation error and to provide more flexibility to estimate the impulse response function.
In addition, one original contribution of the thesis is the use of the Hotelling model, stemming from game theory, to study competition in Ivorian the palm oil sector. This is a particular novel approach in the agricultural economics research field. This model provides a mathematical framework to formally understand the response of the main actors of the oil palm sector to increasing competition.
Finally, apart from its methodological diversity, the quality of the thesis also lies in the diversity of the products and locations considered through it. Actually, the main Ivorian export crops namely cocoa, rubber and oil palm are considered. These are very strategic products for the Ivorian economy as they have a significant impact in both the country and farmer revenues. In addition, two countries, Côte d'Ivoire and Ghana, are carefully studied which is interesting to compare policy reform response between them. The aforementioned points summarised the main contributions of the thesis. This is surely a non-exhaustive list as the reader may discover other significant contributions in this thesis.

5.3 Limitations and perspectives

At this point, it is important to highlight some limitations of this study and propose perspectives for further research. Concerning chapter 2, the difference in the periodicity of the price series before and after liberalisation made it impossible to carry out analyses over the entire period in order to better appreciate the differences in terms of price transmission for the two periods. Concerning chapter 3, when using a local projection,

the exogenous variable must be identified beforehand. In addition, a local projection can sometimes provide a wiggly impulse response function and wide confidence intervals (Ramey, 2016). A Bayesian local projections approach can then be considered as an alternative. Bayesian local projections is a very recent method proposed by Miranda-Agrippino et al. (2021). They propose a robust framework to estimate IRF. Even if local projections are semi-parametric in nature and do not assume any specific model, this flexibility however leads to high variance and some estimator inefficiency. Actually, the autocorrelation of the residuals stemming from the local projection iterative regressions causes an underestimation of the true variance of the estimator of the impulse response function. In other words, the Gaussian likelihood function with independent and identically distributed errors assumed for the different time horizons in the classical local projections approach, is misspecified. This in turn may harm the confidence interval of the impulse response function and, as a consequence, the conclusions one can draw from them. To solve the issue, Miranda-Agrippino et al. (2021) propose instead to use a quasi-maximum likelihood approach in which a Gaussian likelihood with a sandwich estimator for the variance is used in conjunction with different specifications for the priors. By using this Bayesian approach, one can still preserve the flexibility of the local projections, better capture the properties of the data, and regularize the impulse response forecast.

The small number of annual observations in this chapter 3 could be another limitation of the study. However, this can be mitigated by the fact that the considered time range is wide enough. Cross-border trade activities designed to avoid taxes, customs delay or currency restrictions can distort statistics. Because of this, it would be interesting to include as a control variable in the equations, a smuggling variable. A smuggling variable is defined by Bulir (2002) as the ratio of real Ghanaian cocoa producer prices to real Ivorian cocoa producer prices. Indeed, inspired by the presence of a symmetry between the Ivorian and Ghanaian cocoa sector performance, some researchers model Ghanaian production as a function of the price incentive to smuggle and find a significant impact. Every year, there is a high level of cocoa beans smuggled between Côte d'Ivoire and Ghana. Despite the common interests of these countries,

a sharing border, a potentially homogeneous pressure of international cocoa price fluctuations, and their weight in the cocoa global production, both countries have been notable for their sluggishness in creating a framework for cooperation, to restrict cross-country competition, and improve the welfare of cocoa farmers in both countries. In fact, domestic prices in Côte d'Ivoire have often been different than in neighboring Ghana, creating incentive for smuggling cocoa across border and artificially impacting production in both countries. Between 1970s and early 1980s, it is estimated that as much as 20 percent of Ghana's cocoa harvest was smuggled into Côte d'Ivoire (Bulir, 2002). A further research can be investigated the effect of this practice on Ivorian and Ghanian cocoa supply.
Concerning chapter 4, the core assumptions of the theoretical model such as linear production space and uniform distribution, can be viewed as strong. Further research can attempt to generalize the Hotelling model framework by considering other types of production space and probabilistic distributions. Moreover, one can consider the case with several small-scale processing factories. Dynamic evolution of the equilibrium can be investigated as well. It could also be wise to support the theoretical findings with empirical evidence. These findings also motivate further research on how to strengthen the capacity of cooperatives to provide agricultural inputs and services that fit their members needs in the current sector context, recalling that the goal is to achieve a significant reduction in rural poverty. This thesis is a contribution attempt to achieve this goal.

In the end, all the analysis performed in this thesis can be replicated for other sub-sectors. Cashew and cotton are two potential candidates to begin with, as they both present many similarities with the sub-sectors previously studied. Actually, cashew began to be a popular crop in the north of Côte d'Ivoire since the 2000s. According to Ruf et al. (2019), in two decades, the country takes the position of the world's leading producer of cashew. From 8,500 tons in 1989, Ivorian cashew production surpassed 70,000 tons in 1999 and then jumped to 350,000 tons in 2010. Despite the 2016 drought and clandestine sales to Ghana, the 700,000 tons bar was officially crossed in 2017. As one can see in Figure 5.3.1,

the price of cashew has also been subject to large fluctuations in recent years. As a consequence, the study of the transmission of the world

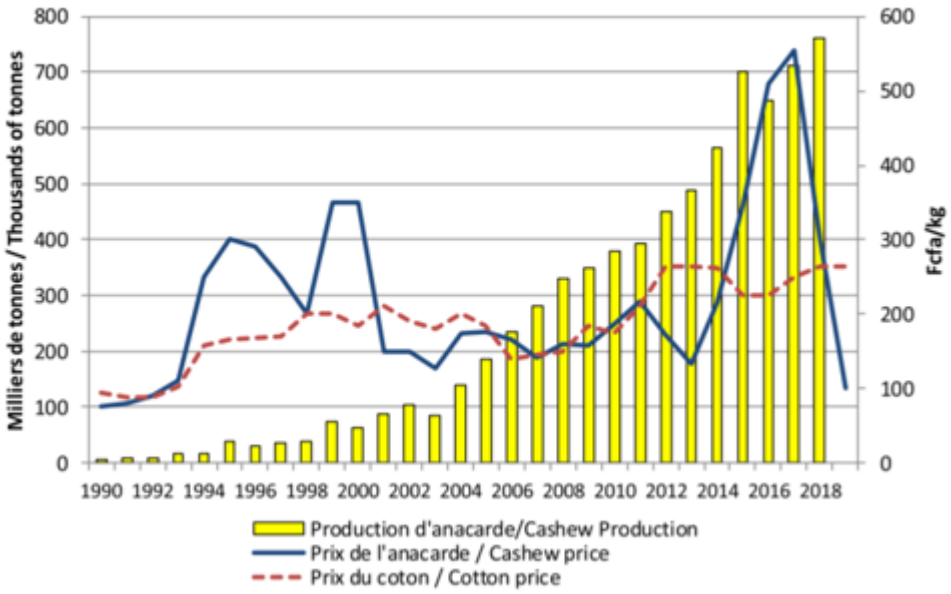


Figure 5.3.1 – National production of cashew, nominal prices of cashew and cotton paid to producers from 1990 to 2018. Source : Ruf et al. (2019)

price to the producer price similar to the one performed in chapter 2 for rubber, could be replicated for the case of cashew. As also mentioned, Ivorian cashew is sold clandestinely in Ghana. A study of this smuggling effect on Ivorian production could also be of interest. Concerning coton, it is among the top five most exported crops in Côte d'Ivoire (see Figure 1.1.3). According to Gergely (2010), this sub-sector has also been subject to market liberalization with the privatization of the *Compagnie Ivoirienne de Développement des Fibres Textiles (CIDT)*, a state-owned firm which historically had a monopoly on the purchase of cotton seed and the marketing of the fiber and seed until 1998. In addition, as Côte d'Ivoire borders both Burkina Faso and Mali, two major African cotton producers, a comparison of the organisation of this sub-sector for

all three countries, as well as their respective responses of the producer price to the world price, as carried out in chapter 3, will be worth to investigate.

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