Vertical Integration and Farm Gate Prices in the Coffee Industry in Côte d'Ivoire

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1. Introduction

Vertical integration is the process through which the different operations of a trading process ("upstream" and "downstream"), from acquisition (or production) of raw materials to marketing, are done by one firm. Thus, a given firm is said to be vertically integrated if it controls more than one of the successive stages in the production/acquisition of the product. It is not considered as integrated if it buys from other firms the production factors and the services that it needs to produce (acquire) or market the product.

Vertical integration is analysed with reference to three different approaches of economic theory: the transaction costs economics, the incomplete contracts theory and industrial economy. The transaction costs economics tackles the issue of the limitations of a firm, as raised by Coase (1937). The incomplete contracts theory deals with the existence of contracts for which all the possibilities were not taken into account due to the costs that would go with enumerating them and with drafting the clauses related to each. The modern industrial economy rests on the issue of production costs and market failure, that is, on the existence of a market power for certain firms. In this paper, the industrial economy will be used to determine whether vertical integration enables a firm operating at a given level of the production/marketing process to extend the market power that it can hold to a market that is available before or after this process.

With its model of successive monopolies, Spengler's (1950) study was the first to analyse, with enough clarity, vertically separated markets. Using the Spengler (1950) study as an analogy, and with reference to the behaviour of firms when they buy products (for example, the agricultural raw material), this study showed that when an industry relies on two successive monopsonies (one upstream and the other downstream), each monopsony adds its margin (the difference between the price and the marginal cost) such that the producer of the raw material (that is the farmer) gets a very low price. In such a situation, the vertical integration of the two successive monopsonies has the effect of increasing not only the farm gate price but also the profits of the industry (that is, the sum of the profits of the two). In this way, vertical integration improves the situations of both the integrated firm and the farmer.

However, successive monopolies/monopsonies are a very special case of successive markets. For example, using a model of successive oligopolies, Salinger (1988) concluded that the impact of vertical integration on the price of the end product was indeterminate. This result indicated that Spengler's (1950) finding cannot be generalized. According to Avenel (1999) this finding is highly dependent upon the structure of the market and the nature of the competition.

It is such a theoretical finding that led us to raise questions about the facts of the coffee market in Côte d'Ivoire. Indeed, since it was liberalized in 1998, the domestic Ivorian coffee trade has known a number of successive markets, with different types of actors. Certain key actors (the processing firms in particular) are present at the different levels of the marketing chain. Based in Europe and the USA, these key firms have set up branches in Côte d'Ivoire to ensure a continuous supply of coffee. They buy the coffee at the farm gate in order to supply not only their production units based in Côte d'Ivoire but also, and especially, those based in their countries of origin.

In such a configuration of the domestic market, vertical integration of the processing firms has definitely had a significant impact on farm gate prices. Therefore, this study sought to understand the interaction between the different actors in the coffee industry (farmers, cooperatives and private firms) and to analyse the effects of the vertical integration of the processing firms on the farm gate price.

The remainder of this paper is organized as follows. Section 2 describes the domestic market for Ivorian coffee. Section 3 provides a review of the literature and Section 4 presents the various theoretical models. The analyses of the results of the model presented in Section 5 and the final section is the conclusion.

2. Description of the market

Côte d'Ivoire is the 11th biggest producer of coffee in the world, producing about 4% of the world's coffee, which corresponds to about 200,000 tonnes.[1] Green coffee is the country's third largest export commodity and generates about CFA francs 100 billion (US$ 200 million) per year (BNETD, 2005). In Côte d'Ivoire coffee is grown over a total area of close to 1.2 million hectares and by around 444,000 farmers and their families. It is essentially grown on small farms of between 1.5ha and 5ha and produces a yield of 350kg/ha.

Since the 1960s, the coffee industry was managed jointly with the cocoa industry by a state-owned corporation (commonly known as Caistab), which controlled the marketing of coffee from production to export. Owing to the pressure exerted by the World Bank and the International Monetary Fund (IMF), Caistab was abolished and domestic marketing of coffee was liberalized in October 1998, while that of cocoa was liberalized in August 1999. As a result, big foreign groups specialized in coffee and cocoa bean grinding and in green coffee processing entered the Ivorian market and competed with less efficient local firms and little organized farmers. In the end, these multinationals supplanted the national operators and dominated the coffee and cocoa industries, from farm production to export, through to processing (Losch, 2001).

At the end of 2001, in the face of the negative effects of this liberalization, the Government of Côte d'Ivoire responded by setting up three regulatory organs: the Coffee and Cocoa Regulatory Authority (ARCC), the Coffee and Cocoa Bourse (BCC) and the Regulation and Control Fund (FRC). These institutions had well specified roles in relation to the management of the coffee and cocoa industries. ARCC was charged with the administrative regulation of the two industries; BCC was responsible for their commercial regulation; and FRC was charged with their financial regulation. This new regulation structure gave rise to a special marketing chain of successive markets and intermediary firms between farmers and exporters.

Even though the stakes are different for coffee and cocoa, whether for the Ivorian economy or for the big foreign groups that are vertically integrated, the two industries are organized in the same manner: upstream there are farmers who grow coffee, cocoa or both, intermediaries comprising "dealers" (who numbered 188 in 2006/07) and non-export cooperatives (close to 600 in 2006/07); and downstream there are the exporters (who numbered 101 in 2006/07). With regard to exporters, for the 2006/07 harvest, 43 were foreigners, 38 were cooperatives (known as Coopex), and 20 were small and medium-scale exporters (known as pmex, which are local enterprises).

In this configuration, the market share of all the cooperatives put together and the small and medium-scale exporters remains very small. This is because of existing barriers to

entering the export market. First, engaging in the export business requires huge financial capital which local banks often refuse to give to local firms. Yet, a financial guarantee is a necessary requirement for being issued an export licence by the relevant authority. Second, the export business requires an efficient marketing network in the importing countries. These two requirements explain why the export sector is dominated by foreign firms that are backed by powerful financial groups.

Since the aim of the Government of Côte d'Ivoire was to process a significant portion of its coffee and cocoa production locally, it offered special benefits to coffee processing firms. Thus, in addition to being given a significant reduction in the single exit duties, these transformers were allowed to buy the green coffee and cocoa directly from the farm gate, unlike the exporters of these raw products who had to buy them from intermediary firms. So, the particular characteristic of the big firms in the industry lies in the fact that they operate processing factories, which enables them to export both green coffee and its by-products processed in these factories. This in turn entitles them to two distinct licences: one to export raw products and the other to export processed by-products. It is this particular configuration of the marketing of Ivorian coffee on the local market that inspired this paper, whose aim is to study the behaviour of firms when they buy coffee and, in particular, the impact of the vertical integration of coffee processing firms on the farm gate price paid to coffee farmers.

3. Literature review

Agricultural economists have produced substantial literature on imperfect competition and the behaviour of agricultural firms. Some of this literature is summarized in Sexton and Lavoie (2001), who show that these studies focused on testing market power from the selling point of view. This is surprising since the focus on agricultural markets seems to be stronger on the part of buyers. Rogers and Sexton (1994) examined the relative shortage of studies on the behaviour of oligopsonies on agricultural markets and noted that "this dismissive treatment of buyer market power is not reasonable for economists interested in agriculture and agricultural markets" (p. 1143).

However, there are notable exceptions: the pioneer work conducted by Just and Chem (1980) on the behaviour of an oligopsony on the tomato market is one of the first studies based on the New Empirical Industrial Organization (NEIO). These authors based their paper on the theory of monopsony and oligopsony so as to develop an empirical test of the presence, in the market under consideration, of a market power that arose from an exogenous shock. This test was then applied to the tomato processing industry, where the exogenous shock was created by the mechanization of the harvest. The statistical tests they carried out rejected the null hypothesis of competition.

The analyses of the buyer's market power in studies such as Durham and Sexton (1992), which focused on the tomato processing industry, and others on the market power on beef markets (Muth and Wohlgenant, 1999; Crespi and Sexton 2004) used this same methodology. These studies, except that by Muth and Wohlgenant (1999), have all brought to light the oligopsony power over markets. However, the number of buyer behaviour studies is insignificant compared with that of seller behaviour ones. One reason for that is that, unlike the empirical research on seller behaviour, the research on oligopsonies has been made difficult by the lack of the right data, especially with regard to the firms' cost of inputs.

Whether one is studying the buyer's market power or the seller's, game theory models are increasingly being used. The punishment (reprisal) strategies are necessary to maintain a collusive oligopsony in a context of repeated game where demand is uncertain and only the market variables can be observed. Timothy, Patterson and Acharya (2001) proposed a test of tacit collusion between the potato processing firms in the Washington area, which uses a dynamic model of regime change. The results of their research corroborate the existence of punishment and collusion regimes and show that the well-being losses caused by anticompetitive behaviours are significant.

Sexton (1990) used the neoclassical theory to develop a model of spatial competition in agricultural markets. The model derives price-output equilibria for investor-oriented firms (IOF) and cooperative processors in oligopsonistic, spatial markets, focusing on

the pro-competitive effects of cooperatives. Sexton computes and compares equilibrium processor-farm price spreads under alternative market structures and modes of firm behaviour by means of the conjectural variations approach. He formally established the conditions and the magnitude of the cooperatives' pro-competitive effect on oligopsonistic markets.

Roger and Bhuyan (1995) proposed a neoclassical analysis of the incentives for and impacts of forward integration into downstream processing stages in the marketing chain by both an IOF and an agricultural marketing cooperative. They developed a three-stage model of a vertical market structure consisting of farmers, an assembler and a processor, with two behavioural assumptions for the cooperative assembler: active versus passive cooperative. The active cooperative is able to control raw product supply (possibly by restricting membership), whereas the passive cooperative takes the quantity of raw product delivered by members as given. The authors compared equilibrium post-integration price-output solutions for the IOF and for the active and the passive cooperative. In doing so, the article complements and supports the Sexton (1990) results.

Albaek and Schultz (1998) used the standard theory of industrial organization to develop a competition model between a cooperative and an IOF in a Cournot duopoly game. The authors determined the conditions under which a cooperative could increase its market share and supplant the IOF on the market. The authors also showed that the members of the cooperative would earn more than the vertically integrated profit per farmer generated in the IOF. Their paper enables us to better understand the fact that cooperatives are more dynamic when they are in competition with profit-maximizing firms.

Karantininis and Zago (2001) developed a game theory model to study the effects of endogenous membership and heterogeneity on the behaviour of members and cooperatives. In their model, an IOF and a cooperative are in competition in the Cournot way. The authors determined the conditions under which a farmer would join the cooperative in a mixed duopsony setting. They equally determined the optimal membership size of the cooperative and the impact of the member heterogeneity on this optimal membership size. In this way, the authors contributed to our better understanding of the way in which farmers choose between alternative marketing channels.

Hoffmann (2005) examined how the structure of ownership (private firm or farming cooperative) affected the endogenous choice of quality and the results of equilibrium in a two-level game. The author showed that if the cost of quality at the first level is fixed and varies with non-constant returns to scale, the firm could gain a structural cost advantage from its very structure of ownership in addition to its advantage in terms of quality. In the case of a fixed quality cost at the first level, he showed that even if the private firm set higher prices, it would still generate a consumer surplus that was greater than that which the cooperative would get by selling good quality products.

According to Bates (1997), the coffee market is one of the few world markets subject to effective political regulation. The author explored the origins, the operations and the failure of the International Coffee Organization, created in 1960, which he referred to as the international "government" for coffee. He tackled the key issues of international economic policy and comparative policies as well as the creation of political institutions and their impact on markets. Focusing his research on East Africa, Colombia and Brazil,

the author explored the domestic sources of international policies within the confines of a unique theoretical framework combining theoretical games and other approaches.

These theoretical and empirical studies are useful. However, none was really concerned with modelling the behaviour of actors on the coffee market of a particular country. Therefore, none used models of sequential games involving more than three stages. The contribution of this study will, therefore, be to expand the analysis of the behaviour of firms when they are buying their essential raw materials on the domestic coffee market in Côte d'Ivoire using models of four-stage sequential games.

4. The models

This study develops two formalized models based on the theory of sequential games. These models describe the interaction and the vertical relationship between the various actors in the local coffee marketing chain. The first model is a very simplified representation of the marketing chain, which enables the processing firms to get supplies of green coffee directly from the farmers—which is the current organization. The second model proposes that the processing firms should get supplies of coffee from local intermediary firms—which is the alternative organization. The study first expounds on the two models before comparing the results of each model.

Before presenting the two models, the paper presents a simple model of successive monopsonies which will give us an insight into the effects of vertical integration on the farm gate price.

A simple model of successive monopsonies

Let us suppose that farmers, after the harvest, sell their production to a firm, M1, in a situation of monopsony. Let us further suppose that the quantity of agricultural products bought by this monopsony is resold without undergoing any processing to another firm, M2, which, too, is in a situation of monopsony. M2 then processes the products to sell the end product on the end market. It is assumed that the production costs in these two monopsonies are nil, with the exception of the costs of buying the agricultural inputs.

The separation scenario

Let us suppose that, given the costs they incur in production, farmers are assigned a supply function of the agricultural product of the form $w(X) = \alpha X$, where w is the farm gate price and X the produced quantity. Let us also assume that the monopsony M2 processes a unit of agricultural produce into a unit of end product. The problem that this monopsony seeks to solve can be summarized thus:

$$\underset{X_2}{Max}\ \pi_2 = p.X_2 - p_w(X_2).X_2, \qquad (1)$$

where p is the price of the end product, X_2 the demand for inputs by monopsony M2, and p_w the price of agricultural product on the intermediate markets. From the necessary maximization condition, the indirect demand function for inputs by the monopsony can be deduced as follows:

$$p_w(X_2) = p - \frac{dp_w}{dX_2} X_2. \tag{2}$$

Similarly, the problem of the monopsony M1 can be summarized in the following maximization program:

$$\underset{X_1}{Max}\ \pi_1 = p_w.X_1 - w(X_1).X_1, \tag{3}$$

where X_1 is the quantity of agricultural produce harvested and resold to the monopsony M2. The monopsony M1 then takes the price of the production on the intermediate market as given. Thus, since the two monopsonies are supposed to be identical, the farm gate price set by the monopsony M1 at the equilibrium is

$$w^{ni} = \frac{1}{3} p. \tag{4}$$

The quantity of production harvested and resold is $X^{ni} = \frac{1}{3\alpha} p$, and the monopsony M2 sets an intermediate price, $p_w = \frac{2}{3} p$. So, the industry's profit when the upstream and downstream activities are separated is $\pi^{ni} = \pi_1 + \pi_2 = \frac{2}{\alpha}\left(\frac{p}{3}\right)^2$.

The integration scenario

In this scenario, it is assumed that the two monopsonies are merged to form only one firm. In this way, the intermediate market ceases to exist and the integrated firm is in a situation of monopsony. Such a firm will thus find a solution to the following maximization program:

$$\underset{X}{Max}\ \pi = p.X - w(X).X. \tag{5}$$

This solution will in turn produce the farm gate price set by the integrated monopsony as follows:

$$w^I = \frac{1}{2} \quad p > w^{ni} . \tag{6}$$

The quantity of agricultural production required by the integrated monopsony will be $X^I = \frac{1}{2\alpha} \quad p > X^{ni}$, while the profit of the integrated firm and, hence, of the industry, will be:

$$\pi^I = \frac{1}{\alpha}\left(\frac{p}{2}\right)^2 > \pi^{ni} . \tag{7}$$

It can thus be concluded that vertical integration makes it possible to increase the farm gate price and equally enables an improvement in the situation of the integrated firm. This theoretical result agrees with that obtained by Spengler (1950). However, the structure of coffee marketing in Côte d'Ivoire is a little more complex than that presented in this model of successive monopsonies. Therefore, it is the models presented in the following paragraphs that will enable us to appreciate the real impact of vertical integration on the farm gate price of Ivorian coffee.

Model 1: Vertical integration of the processing firm

The actors and their roles

This study assumes a very simplified form of the domestic coffee marketing chain, which involves five types if actors: farmers, an exporter cooperative, a multinational, green coffee exporters, and the intermediaries.

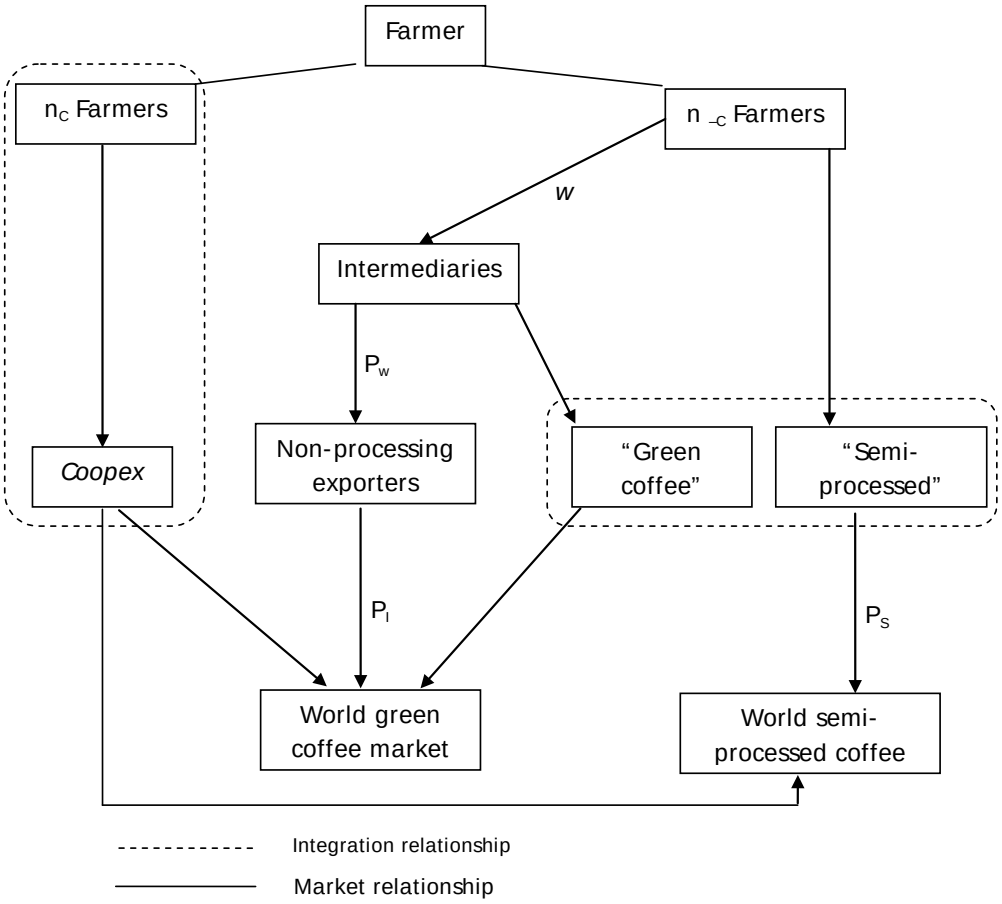
- **The farmers:** These are the people who supply green coffee at the farm gate.
- **An exporter cooperative (Coopex):** This is a coalition of farmers who have decided to integrate vertically in the marketing chain. It is responsible for collecting its members' coffee production at the farm gate. This production is divided into two parts: one undergoes the first stage of processing by Coopex and is sold as ground coffee on the world market for the semi-processed coffee. The other part is kept in its raw state and is sold directly on the world market for green coffee on behalf of the members of the cooperative.
- **A multinational:** This is a foreign firm with a strong financial capability. It has two divisions: "green coffee" and "coffee by-products". The green coffee division is in charge of buying the coffee beans on the local market (that is, from the local

intermediaries) and selling it on the world green coffee market. The coffee by-products division buys green coffee, has it undergo the first stage of processing locally, and then sells the by-product on the world market for the semi-processed coffee.

- **The green coffee exporters:** These are private firms which also buy green coffee on the local coffee market and later resell it on the world green coffee market. They comprise local firms and subsidiaries of international retail companies. These subsidiaries have the financial capability of a multinational, but, unlike multinationals, do not engage in coffee processing activities at any stage.
- **The intermediaries:** These comprise non-exporter cooperatives and "dealers". They buy coffee at the farm gate and resell it to green coffee exporters on the local green coffee market.

Figure 1 shows a very simplified chain of the domestic coffee market in Côte d'Ivoire.

Figure 1: Simplified coffee marketing chain (Model 1)



The functioning of markets

This paper assumes that coffee marketing in Côte d'Ivoire follows a chain comprising the following four steps:

Step 1: Farmer *Coopex* membership.
When farmers produce a certain quantity of green coffee, they have two distinct choices regarding how to sell it: either they decide to become members of *Coopex* or they decide not to.

Step 2: Members of *Coopex* supply their production to the cooperative at a profit (represented in our equation by π_c). Farmers who are not members of *Coopex* supply their production to private firms, that is, the intermediaries, or to the semi-processed coffee division of a multinational. They each (the farmers) get a profit (represented in our equation by π_{-c}.).

Step 3: Intermediaries buy green coffee from the farmers and resell it to private exporters of green coffee (that is, the non-processing firms and the green coffee division of a multinational).

Step 4: The exporters of green coffee sell it on the world green coffee market; *Coopex* does the same for the non-processed part of the coffee bought from its members. Both the semi-processed coffee division of a multinational and *Coopex* partially and locally process part of the coffee (that is, the remaining part in the case of *Coopex*) bought at the farm gate in order to resell the by-product on the world market for the semi-processed coffee.

The symbols used in the model

n_C: the number of farmers who are members of *Coopex*
n_{-C}: the number of farmers who are non-members of *Coopex*
$N = n_C + n_{-C}$: the total number of farmers in the coffee industry
N_E: the number of exporters not involved in coffee processing excluding *Coopex*
n_I: the total number of intermediaries
X_C: the total quantity of coffee supplied by members of *Coopex*
X_{-C}: the total quantity of coffee supplied by farmers to private firms
x_C: the quantity of green coffee supplied by a representative farmer member of *Coopex*
X_{-C}: the quantity of green coffee supplied by a representative farmer to private firms
X_E: the total supply of green coffee from all the exporters of green coffee, excluding *Coopex*
X_I: the total demand for green coffee from all the intermediaries
X_S: the total demand for green coffee from the semi-processed coffee division of the multinational

$X_S = X_{-C} - X_I$;

X_E : the demand for green coffee from a representative exporter

x_I : the demand for green coffee from a representative intermediary

w : the farm gate price for coffee

P_w : the price of green coffee on the local market

P_S : the price of semi-processed coffee on the international market

P_I : the price of green coffee on the international market

$\prod_C$: the profit made by *Coopex*

π_c : the profit made by a representative member of *Coopex*

π_{-c} : the profit made by a representative farmer supplier of coffee to private firms

$\prod_E$: the profit made by a representative exporter of green coffee (excluding *Coopex*)

$\prod_I$: the profit made by a representative intermediary

$\prod_S$: the profit made by the semi-processed coffee division of a multinational

The assumptions

It is assumed here that only *Coopex,* the intermediaries and the semi-processed coffee division of a multinational can get, at the farm gate (concerning the first model), supplies of green coffee that is supposed to be homogeneous. However, only the green coffee bought at the farm gate by the semi-processed coffee division of a multinational is processed locally.

It is also assumed that *Coopex* only accepts the supply from its members who are supposed to be identical. The intermediaries are also identical and get supplies from homogeneous farmers. These intermediaries are too many for any individual intermediary to be able to influence the price upstream or downstream.

It is assumed that the semi-processed coffee division of a multinational processes all the coffee bought at the farm gate and thus cannot supply green coffee to the green coffee division (in keeping with regulations). This means that the two divisions of the same multinational act independently of each other. That is one of the conditions set by the administrative authority in charge of licences. It can thus be assumed that each division maximizes its profit independently of the other.

Each farmer incurs the production cost that goes with its production technique and defined by the following function:

$$f(x) = \frac{1}{2}\alpha x^2, \alpha > 0 \qquad (1)$$

for every x quantity of green coffee produced (and delivered). This type of function for the costs that farmers incur is frequently used in the literature (see, for example, Albaek and Schultz, 1998; Karantininis and Zago, 2001).

Coopex incurs the total cost of the coffee production it buys, defined by the following function:

$$F_C(X_C) = t_C X_C,\ t_C > 0 \quad (2)$$

where t_C is the marginal cost of buying. *Coopex* also incurs a marginal cost of the processing $\mu > 0$ for processing the quantity γX_C of the green coffee ($0 \leq \gamma \leq 1$) in the quantity Q_C of by-products using the technology $Q_C = \lambda_C (\gamma X_C)$. The assumption made here is a simplifying one of the exogeneity of γ.

The semi-processed coffee division equally incurs a total cost of buying defined by the following function:

$$F_S(X_S) = t_S X_S,\ t_S > 0 \quad (3)$$

where t_S is the marginal cost. In addition to this cost, the division also incurs the constant marginal cost of processing $c > 0$ for processing the quantities X_S of green coffee in the quantities Q of by-products using the technology $Q = \lambda X_S$.

It is further assumed that a representative intermediary incurs an increasing marginal cost for the coffee production bought at the farm gate, a cost defined by the following function:

$$Cm_I = bx_I,\ b > 0 \quad (4)$$

Since a multinational is backed by big international financial groups, it has access to vast information and marketing networks and intangible assets (which rely on the collection and use of information on markets) that enable it to make economies of scale. Moreover, since the aim of the Ivorian Government is to have a significant proportion of its coffee production processed locally, it has given tax incentives to the semi-processed coffee division of the multinational. This incentive has thus given that division of the multinational a dominant position when buying green coffee, compared to its rivals. It will behave like a dominant firm, therefore, like a "price maker" and its rivals will constitute a competitive fringe. As for the green coffee division, it is a "price taker" on the intermediary market because it is in competition with other exporters (namely the branches of trading companies) of equal financial capability.

For the semi-processed coffee division to be viable, it will be assumed that $P_S > t_S + c$.

It is assumed that the residual demand for green coffee addressed to Côte d'Ivoire is expressed as follows:

$$P_I = a - X$$

where $a > X > 0$ and $X = (1 - \gamma) X_C + X_E$.

The ideal would be to use a general form for the demand, but this linear form will be used here because it will enable an easier description of the model. The solution to this specific equation requires insightful explanations for results that are less clear in a model with a general form.

Finally, to make the solution of the equation in the model easier, the buyer's illusion hypothesis will have to be assumed. In this assumption, for each given price, the buyer has the illusion that he or she has bought all the green coffee that he or she wants at this price. However, there is a problem underlying such an assumption. This indeed suggests that it is possible for the dominant firm to buy a quantity of coffee higher than the supply available, which would be impossible in reality. Nevertheless, this problem can be solved by imposing constraints on the parameters of the model. In this way, we will limit ourselves to a definition domain where the problem does not arise. The buyer's illusion hypothesis is recurrent in the economic literature on successive markets, for example in Salinger (1988), but it has not yet been resolved. However, the assumption is not a problem in itself at the equilibrium level.

Model resolution

The process of the game in this model will be done by using backward induction argument. Thus, we start by solving stage 4, then stages 3 and 2, and finally, the first stage. This resolution will result in the setting of the farm gate equilibrium price and the optimum distribution of farmers.

Stage 4

Coopex

In a given space, farmers in Côte d'Ivoire have two distinct choices about selling their green coffee: they can deliver it to private firms, or they can join *Coopex*. When they choose the latter, they each decide on what quantity to deliver to the cooperative. The *Coopex* offer is thus exogenous and the management of the cooperative has no control over the quantities produced by its members. Thus, each member of the *Coopex* decides on the output level that maximises his profit, given the deliveries of all the other members.

The *Coopex's* profit $\prod_C$ is expressed as follows:

$$\prod_C = P_I (1 - \gamma) X_C + P_S \lambda_C (\gamma X_C) - F_C (X_C) - wX_C - \mu(\gamma X_C) \quad (5a)$$

If we let λ_C, then we get:

$$\prod_C = P_I (1 - \gamma) X_C + P_S (\gamma X_C) - F_C (X_C) - wX_C - \mu(\gamma X_C) \quad (5b)$$

and,

$$\prod_C = 0 \Rightarrow w = w_M = P_I (1 - \gamma) + \gamma P_S - F_C (X_C) / X_C - \gamma\mu,\ w_M \geq 0 \quad (6)$$

where w_M is the farm gate price, which a representative member of *Coopex* gets. Thus, this member's profit is expressed as follows:

$$\pi_C = w_M .x_C - f\left(x_C\right) + \left[\left(1 - \gamma\right) P_I + \gamma P_S - \gamma\mu\right] x_C - F_C\left(X_C\right) \frac{x_C}{X_C} - \frac{1}{2}\ \alpha x_C^{\,2} \tag{7a}$$

It transpires from this expression that each member incurs the cost of supplying his or her production to the exporter cooperative. For each farmer, the maximization program is thus the following:

$$\max_{x_C} \pi_C = \left[\left(\ 1 - \gamma\right) P_I + \gamma P_S - \gamma\mu\right] x_C - F_C\left(X_C\right) \frac{x_C}{x_C + X_{C\text{-}i}} - \frac{1}{2}\ \alpha x_C^{\,2} \tag{7b}$$

Or the following:

$$\max_{x_C} \pi_C = \left\{ \begin{array}{l} \left[\left(1 - \gamma\right)\left(a - \left(1\text{-}\ \gamma\right)\left(x_C + X_{C\text{-}i}\right) - X_E\right) + \gamma P_S - \gamma\mu\right] x_C \\ - F_C\left(x_C + X_{C\text{-}i}\right) \frac{x_C}{x_C + X_{C\text{-}i}} - \frac{1}{2}\ \alpha x_C^{\,2} \end{array} \right\} \tag{7c}$$

where $X_C = x_C + X_{C\text{-}i}$.

First-order condition:

$$\frac{\partial \pi_C}{\partial x_C} = 0 \Rightarrow$$

$$\left[\left(1 - \gamma\right)\left(a - \left(1\text{-}\ \gamma\right)\left(x_C + X_{C\text{-}i}\right) - X_E\right) + \gamma P_S - \gamma\mu\right]$$

$$- \left(1 - \gamma\right)^2 x_C - t_C\left(\frac{x_C}{x_C + X_{C\text{-}i}} + \frac{x_{C\text{-}i}}{x_C + X_{C\text{-}i}}\right) - \alpha x_C = 0$$

Since the members of the exporter cooperative are supposed to be identical, we get:

$X_{C\text{-}i} = (n_C - 1)x_C$. As a result, we get:

$$x_C = r(X_E) = \left(\alpha + (1 - \gamma)^2 (1 + n_C)\right)^{-1} \left((1 - \gamma)\ (a - X_E) + \gamma P_S - t_C - \gamma\mu\right) \tag{8a}$$

This function represents each member's response to the exports of all the private exporters of green coffee.

The second-order condition gives the following:

$$\frac{\partial^2 \pi_C}{\partial x_C^{\,2}} = -\left(2(1-\gamma)^2 + \alpha\right) < 0.$$

The *Coopex's* reaction function is thus:

$$X_C = R\left(X_E\right) = \frac{n_C}{\alpha + \left(1-\gamma\right)^2\left(1+n_C\right)}\left((1-\gamma)\,(a - X_E) + \gamma\, P_S - t_C - \gamma\mu\right) \tag{8b}$$

The private exporters

Let us assume that exporters of green coffee, except *Coopex*, are all identical and compete with each other in the Cournot way. Each determines the quantity of green coffee that it exports, considering as given the quantities exported by its direct competitors and the exporter cooperative.

The buyer's illusion hypothesis is assumed here. This means that for a given price, the buyer has the illusion that he or she has bought the quantity of green coffee that he or she wants. We have $1 + n_E$ private exporters of green coffee. If $\prod_E$ is the profit of a representative private exporter, the problem that this exporter wants to resolve is expressed in the following equation:

$$\max_{x_C} \prod_E = \left(P_I - P_w\right)\; x_E = \left[a - \left((1-\gamma)\,X_C + X_{E\text{-}i} + x_E\right) - P_w\right] x_E \tag{9}$$

where $X_E = x_E + X_{E\text{-}i}$.

The necessary maximization condition is given by:

$$\frac{\partial \prod_E}{\partial x_E} = 0 \Rightarrow a - \left((1-\gamma)\,X_C + X_{E\text{-}i} + x_E\right) - P_w - x_E = 0$$

Since the private exporters are supposed to be identical, we get the following:

$$x_E = \frac{1}{2+n_E}\left(a - P_w - (1-\gamma)\,X_C\right) \tag{10a}$$

The sufficient maximization condition gives the following:

$$\frac{\partial^2 \prod_E}{\partial x_E} = -2 < 0$$

Thus, we get:

$$X_E = R\left((1-\gamma)X_C\right) = \frac{1+n_E}{2+n_E}\left(a - P_w - (1-\gamma)X_C\right) \tag{10b}$$

This is the expression of the reaction function of all the private exporters faced by green coffee exports of the exporting cooperative.

The different quantities of green coffee, namely $(1-\gamma)X_C$ and X_E, exported by the exporter cooperative and all the private exporters of green coffee, based on P_w, are obtained through solving the system of equations in (8b) and (10b). Through the method of substitution, we get:

$$X_E = \frac{1+n_E}{2+n_E}\left(1 - \frac{1+n_E}{2+n_E} \times \frac{(1-\gamma)^2 n_C}{\alpha + (1-\gamma)^2(1+n_C)}\right)^1 \left(\times (a - P_w) = \frac{(1-\gamma)^2 n_C}{\alpha + (1-\gamma)^2(1+n_C)} \left((1-\gamma)a + \gamma P_S - t_C) - \gamma\mu\right)\right) \tag{10c}$$

and,

$$X_C = \frac{n_C}{\alpha + (1-\gamma)^2(1+n_C)} \Big/ \left(1 - \frac{1+n_E}{2+n_E} \times \frac{(1-\gamma)^2 n_C}{\alpha + (1-\gamma)^2(1+n_C)}\right) \times \left[(1-\gamma)\left(a - \frac{1+n_E}{2+n_E}(a - P_w)\right) + \gamma P_S - t_C - \gamma\mu)\right] \tag{11}$$

Stage 3

Determining the intermediate price

The intermediate price P_w on the domestic green coffee market is determined by confronting the supply made by all the intermediaries and the demand from the private exporters. Thus, for a given farm gate price *w*, we first have to determine the optimal offer made by all the intermediaries. And since P_w is given for each firm on the domestic market, the problem that each intermediary seeks to solve is the following:

$$\max_{x_I} \prod_I = P_w x_I - w x_I - CT_I(x_I) \tag{12}$$

where $CT_I(x_I)$ is the total cost incurred by each intermediary, x_I is the quantity that he or she offers, and $\prod_I$ is the profit that he or she gets in return.

The necessary maximization condition is expressed in the following formula:

$$\frac{\partial \prod_I}{\partial x_I} = 0 \Rightarrow P_w - w - C_{mI} = P_w - w - b x_I = 0$$

hence,

$$x_I = \frac{1}{b}\left(P_w - w\right) \tag{13a}$$

The sufficient maximization condition gives the following:

$$\frac{\partial^2 \prod_I}{\partial x_I^{\,2}} = -b < 0$$

Since the intermediate firms are assumed to be identical, we get their total offer from:

$$X_I = n_I x_I = \frac{n_I}{b}\left(P_w - w\right) \tag{13b}$$

Thus, the total quantity of green coffee offered by all the intermediaries on the domestic market, for a given *w*, is:

$$X_I(w) = \frac{\frac{n_I}{b} G}{\frac{n_I}{b} + G} \left[\left(a - \frac{(1-\gamma) n_C}{\alpha + (1-\gamma)^2 (1+ n_C)} \right. \right. \\ \left. \left. ((1-\gamma)\ a + \gamma (P_S - \mu) - t_C) \right) - w \right] \quad (13c)$$

Thus, P_w is obtained by equating X_I and X_E. Thus, for a given w we get:

$$P_w(w) = \frac{1}{\frac{n_I}{b} + G} \left[\frac{n_I}{b}\ w + G \left(a - (1-\gamma)\ a - \frac{(1-\gamma) n_C}{\alpha + (1-\gamma)^2 (1+ n_C)} \right. \right. \\ \left. \left. ((1-\gamma)\ a + \gamma P_S - t_C\ - \gamma\mu) \right) \right] \quad (14)$$

where

$$G = \frac{1+n_E}{2+n_E} \left(1 - \frac{1+n_E}{2+n_E} \times \frac{(1-\gamma)^2 n_C}{\alpha + (1-\gamma)^2 (1+ n_C)} \right) \quad (15)$$

We can demonstrate without any difficulty that

$$1 - \frac{1+n_E}{2+n_E} \times \frac{(1-\gamma)^2 n_C}{\alpha + (1-\gamma)^2 (1+ n_C)} \in]0, 1[\ . \text{ Thus, } G > 0.$$

Stage 2

The semi-processed division of the multinational is considered to be a dominant firm. As for the intermediaries, they are small local firms which constitute a competitive fringe in the purchase of green coffee at the farm gate.

Therefore at this stage one has to determine the semi-processed division's optimal demand for green coffee. Resolving this problem requires determining first the offer of green coffee made by farmers who are not members of the exporter cooperative.

Total offer by non-members of Coopex and equilibrium farm gate price

The cost function of a representative farmer is $f(x) = \frac{1}{2} \alpha x^2$, where x is his or her green coffee production. From this function, one can deduce the supply made by the farmer delivering his or her production to private firms in the following way:

$$w = \alpha x_{-C} \tag{16a}$$

or in the following way:

$$x_{-C} = \frac{1}{\alpha} w \tag{16b}$$

Thus, the total offer by all the farmers supplying their production to private firms is:

$$X_{-C} = \frac{n_{-C}}{\alpha} w \tag{16c}$$

As a result, the residual offer that is made to the semi-processed coffee division is:

$$X_S = X_{-C} - X_I \tag{17a}$$

or the following:

$$X_S = \left(\frac{n_{-C}}{\alpha} + \frac{\frac{n_I}{b} G}{\frac{n_I}{b} + G} \right) w - \frac{\frac{n_I}{b} G}{\frac{n_I}{b} + G} \left(a - \frac{(1-\gamma) n_C}{\alpha + (1-\gamma)^2 (1+ n_C)} \left((1-\gamma) a + \gamma (P_S - \mu) - t_C \right) \right) \tag{17b}$$

The manner in which this division sets its farm gate price is obtained by expressing w based on X_S from this equation. Thus, we get:

$$w X_S = \left(\frac{n_{-C}}{\alpha} + \frac{\frac{n_I}{b} G}{\frac{n_I}{b} + G} \right) \times \left[X_S + \frac{\frac{n_I}{b} G}{\frac{n_I}{b} + G} \left(a - \frac{(1-\gamma) n_C}{\alpha + (1-\gamma)^2 (1+ n_C)} \left((1-\gamma) a + \gamma (P_S - \mu) - t_C \right) \right) \right] \tag{18}$$

Assuming that the semi-processed coffee division is a price taker on the world market for semi-processed coffee, the optimal quantity of green coffee that it buys at the farm gate is obtained through the resolution of the following problem:

$$\max_{X_S} \prod_S = (P_S - t_S - c) \; X_S - w(X_S) X_S \tag{19}$$

The necessary maximization condition is:

$$\frac{\partial \prod_S}{\partial X_S} = P_S - t_S - c - \left[w'(X_S) X_S + w(X_S) \right] = 0$$

And thus we get:

$$X_S^* = \frac{1}{2} \left(\frac{n_{-C}}{\alpha} + \frac{\frac{n_I}{b} G}{\frac{n_I}{b} + G} \right) (P_S - t_S - c) - \frac{1}{2} \frac{\frac{n_I}{b} G}{\frac{n_I}{b} + G} \left(a - \frac{(1-\gamma) n_C}{\alpha + (1-\gamma)^2 (1+ n_C)} \left((1-\gamma) a + \gamma (P_S - \mu) - t_C \right) \right) \tag{20}$$

This is the real maximum quantity of green coffee bought by the semi-processed coffee division, since we have:

$$\frac{\partial^2 \prod_S}{\partial X_S^{\,2}} = -2\left(\frac{n_{-C}}{\alpha} + \frac{\frac{n_I}{b}G}{\frac{n_I}{b}+G}\right) < 0$$

Given that this equation is based on the assumption of the buyer's illusion, X_S^* is valid only under certain conditions that will be specified further below.

The equilibrium farm gate price is obtained by replacing X_S^* by its value in Equation 18. Thus, we get:

$$w^* = w\left(X_S^*\right)$$

which gives the following:

$$w_1{}^* = \frac{1}{2}\left(P_S - t_S - c\right) + \frac{1}{2}\frac{\frac{n_I}{b}G}{\frac{n_I}{b}+G}\left(\frac{n_{-C}}{\alpha} + \frac{\frac{n_I}{b}G}{\frac{n_I}{b}+G}\right)^{-1} \times \left(a - \frac{(1-\gamma)n_C}{\alpha + (1-\gamma)^2(1+n_C)}\left((1-\gamma)a + \gamma(P_S - \mu) - t_C\right)\right) \quad (21)$$

The domain of the validity of X_S^*

As emphasized previously, from the buyer's illusion hypothesis it is possible for the dominant firm to make a demand for green coffee that is greater than the total offer made by non-members of the exporter cooperative, which would not be realistic. However, this problem can be resolved by imposing constraints on the model's parameters, which makes it possible to define a domain in which the problem does not arise. So, we need to find a minimizer $\underline{X}_{-C}$ of X_{-C} and we need to show that there exist parameters of the model for which the semi-processed coffee division's optimal demand is lower than $\underline{X}_{-C}$.

A computer simulation using the current characteristics of the coffee market in Côte d'Ivoire can show that the raw coffee farm gate price w is an increasing function of the number n_C of members of *Coopex* and a decreasing function of the number n_{-C} of farmers supplying their production to private firms. (The particular case where $\gamma = 1$ is verified by the expression in Equation 24a). Under such conditions, we get the following:

$$\lim_{n_{-C} \to \infty} w_1^* = \frac{1}{2} \left(P_S - t_S - c\right) X_S - \underline{w}_1$$

By assuming,

$$\underline{X}_{-C} = \frac{n_{-C}}{\alpha} \quad \underline{w}_1 = \frac{n_{-C}}{2\alpha} \left(P_S - t_S - c\right) \tag{22a}$$

we get:

$$\underline{X}_{-C} \geq \underline{X}_{-C} \text{ for every } n_{-C} > 0 \tag{22b}$$

Thus,

$$X_S^* \leq \underline{X}_{-C}$$

implies that:

$$P_S < \overline{P_S} \tag{22c}$$

with $\overline{P_S} = t_S + c + a - \dfrac{\left(1 - \gamma\right)^2 n_C}{\alpha + \left(1 - \gamma\right)^2 \left(1 + n_C\right)} \left((1 - \gamma)\, a + \gamma \left(P_S - \mu\right) - t_C\right)$

The expression in Equation 22c thus places a condition on the international price for semi-finished coffee which makes it possible to determine the validity of the optimal demand (X_S^*) from the semi-processed division of the multinational. This condition means that, using the buyer's illusion hypothesis, the dominant firm will not make a demand for green coffee that is higher than the total supply from non-Coopex farmers as long as the price does not exceed $\overline{P_S}$. So, for $P_S < \overline{P_S}$, part of the supply from these farmers will be bought by the intermediary firms at the farm gate.

The optimal profit for the farmer supplying coffee to private firms

This profit is expressed as follows:

$$\pi^*_{-C} = w_1^* \,.\, x_{-C} - \frac{1}{2}\,\alpha \,.\, x^2_{-C} \qquad (23a)$$

Yet, following the expression in (16c), we get:

$$x_{-C} = \frac{X_{-C}}{n_{-C}} = \frac{w}{\alpha}$$

which gives:

$$\pi^*_{-C} = \frac{1}{2\alpha}\left(w_1^*\right)^2 \qquad (23b)$$

Proposition 1

If $\gamma = 1$, *then the relative efficiency of the exporter cooperative (that is, its capacity to attract additional members) is an incentive for private firms to do better and, hence, to offer a high farm gate price*.

Proof

When the exporter cooperative (Coopex) processes all its members' produce locally, that is, when $\gamma = 1$, then we get:

$$w_1\left(\gamma = 1\right) = \frac{1}{2}\left(P_S - t_S - c\right) + \frac{1}{2}\,\frac{\dfrac{n_I}{b}\,\dfrac{1+n_E}{2+n_E}}{\dfrac{n_I}{b}+\dfrac{1+n_E}{2+n_E}}\left(\frac{n-n_{-C}}{\alpha}+\frac{\dfrac{n_I}{b}\,\dfrac{1+n_E}{2+n_E}}{\dfrac{n_I}{b}+\dfrac{1+n_E}{2+n_E}}\right)^{-1} a \qquad 24a)$$

So, we derive the following:

$$\frac{dw_1(\gamma=1)}{dn_C} = \frac{a}{2\alpha}\frac{\frac{n_I}{b}\frac{1+n_E}{2+n_E}}{\frac{n_I}{b}+\frac{1+n_E}{2+n_E}}\left(\frac{n-n_{-C}}{\alpha}+\frac{\frac{n_I}{b}\frac{1+n_E}{2+n_E}}{\frac{n_I}{b}+\frac{1+n_E}{2+n_E}}\right)^{-2} > 0 \quad (24b)$$

This means that the farm gate price that farmers who supply their produce to private firms (when $\gamma = 1$) get is an increasing function of the number of members of Coopex. The corresponding profit is:

$$\pi_{-C}(\gamma=1) = \frac{1}{2\alpha}\left[w_1(\gamma=1)\right]^2 \quad (25)$$

Similarly, the delivery price which a member of *Coopex* gets when this cooperative processes all of its members' production is given by the following equation:

$$w_M(\gamma=1) = P_S - t_C - \mu \quad (26)$$

while the corresponding profit is given by:

$$\pi_{-C}(\gamma=1) = \frac{1}{2\alpha}(P_S - t_C - \mu)^2 \quad (27)$$

Stage 1

The resolution of this stage will help determine the equilibrium distribution of farmers, that is, the optimum number of farmers who will join the exporting cooperative. This distribution will be determined by comparing the optimal profit of each member of *Coopex* to the optimal profit of a farmer who is not a member of the cooperative. This renders the farmer independent from the buyer (namely *Coopex* or private firms) to whom he or she has to supply his or her production.

An overall analytical resolution of this problem is not easy to achieve. That is why our analysis will be limited to the case where *Coopex* processes all of its members' produce (that is, when $\gamma = 1$). If, in addition, we consider that *Coopex* is as efficient as the private processing firm (that is, if $t_C = t_S$ and $\mu = c$), and that we compare the two profits, then optimal membership of *Coopex* will be such that:

$$n^*_{-C}(\gamma = 1) = \alpha \frac{\frac{n_I}{b} \frac{1 + n_E}{2 + n_E}}{\frac{n_I}{b} + \frac{1 + n_E}{2 + n_E}} \left(\frac{a}{P_S - t_C - c} - 1 \right) \text{ for every } P_S < \overline{P_S}(\gamma = 1),$$

where $\overline{P_S}(\gamma = 1) = t_S + c + a$

And,

$$n^*_C(\gamma = 1) = n - n^*_{-C}(\gamma = 1)$$

Proposition 2

If the international market is advantageous, then the farmers will choose not to incur an additional processing cost by becoming members of the exporting cooperative. In this case, they will be encouraged to supply their produce to private firms. However, if the price on the international market for semi-processed coffee is high, then the profit of a member of Coopex will be high. This will attract more farmers to the cooperative.

Proof

From the equilibrium equations above, we can derive the following:

$$\frac{dn^*_{-C}}{da} = \alpha \frac{\frac{n_I}{b} \frac{1 + n_E}{2 + n_E}}{\frac{n_I}{b} + \frac{1 + n_E}{2 + n_E}} (P_S - t_S - c)^{-1} \geq 0$$

and

$$\frac{dn^*_{-C}}{dP_S} = -\alpha \frac{\frac{n_I}{b} \frac{1 + n_E}{2 + n_E}}{\frac{n_I}{b} + \frac{1 + n_E}{2 + n_E}} (P_S - t_S - c)^{-2} a \geq 0$$

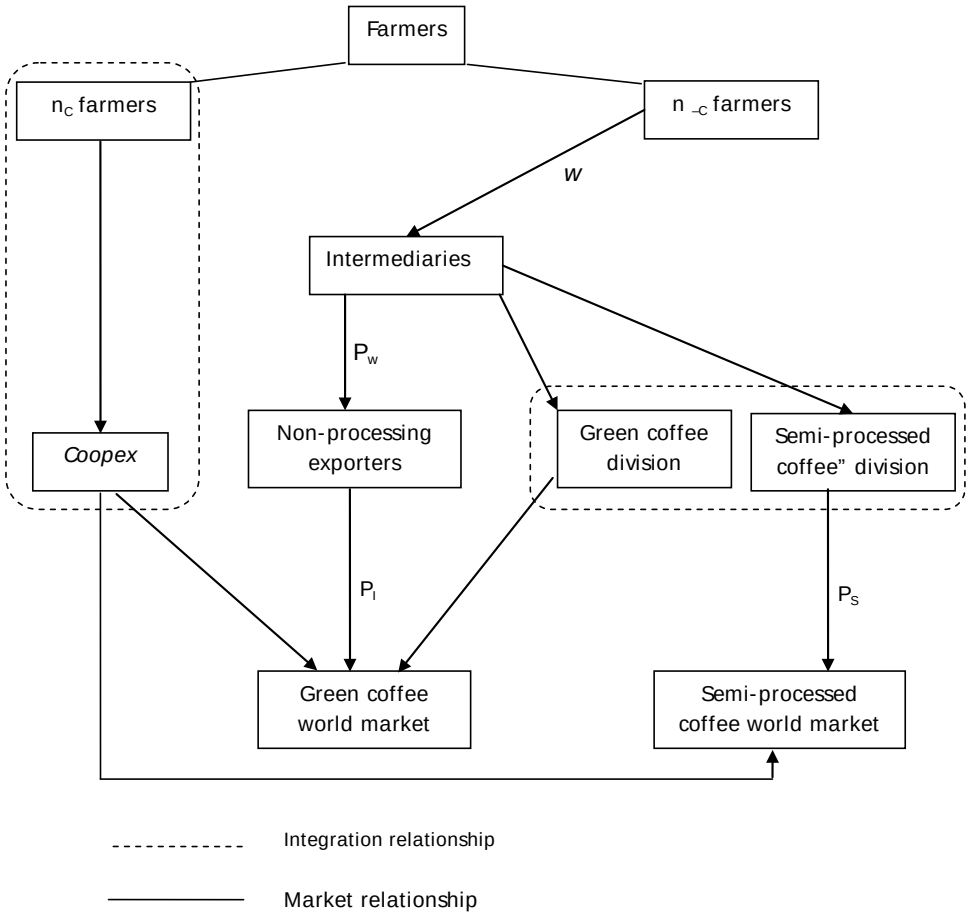
Model 2: The non-integration of the processing firm

This model represents an alternative organization of the domestic coffee market where the regulations in force require all the exporters (except the exporter cooperative) to get green coffee from local intermediaries. In this way, the semi-processed division of the multinational no longer has access to the farm gate to buy coffee. However, we consider that this division still remains a dominant firm and that all the exporters of green coffee constitute a competitive fringe. Figure 2 presents this alternative marketing chain.

In this alternative organization, the game is still played in four stages and it unfolds in a similar way to the game in Model 1.

As we see in Figure 2, stage 1 of the game remains that of the membership of farmers. At stage 2, the members of *Coopex* deliver all their coffee produce to the cooperative and non-members deliver theirs exclusively to intermediary firms. At stage 3, the intermediaries resell the coffee they bought at the farm gate to the private exporters of green coffee and to the semi-processed coffee division of the multinational.

Figure 2: Alternative (Model 2) marketing chain



At the last stage, the green coffee exporters in turn resell the quantities of coffee bought from the intermediaries on the green coffee world market. For their part, *Coopex* (for a γ portion of the quantity bought at the farm gate) and the semi-processed coffee division of the multinational partially process the coffee locally and then sell the by-product on the world market for semi-processed coffee.

To simplify the argument and to better compare the two models, we will also assume here that the two divisions of the multinational act independently of each other.

The semi-processed coffee division will be considered as a dominant firm. So, assume that it will set its intermediate price P_{w2} which will maximize its profit. The green coffee exporters constitute a competitive fringe. They will observe the price fixed and determine what their demand for green coffee on the local green coffee market will be. The resolution is done by backward induction. The results are summarized below.

So, for a given w, the price of green coffee on the local green coffee market is given by the following expression:

$$P_{w2} = \frac{1}{2}\left(P_S - c\right) + \frac{1}{2}\left(\frac{n_I}{b} + G\right)^{-1} \tag{28}$$

$$\times \left[G\left(a - \frac{\left(1-\gamma\right) n_C}{\alpha + \left(1-\gamma\right)^2 \left(1+ n_C\right)} \left(\left(1-\gamma\right) a + \gamma \left(P_S - \mu\right) - t_C \right) \right) \frac{n_I}{b} w \right]$$

At this price, the raw product is sold by the intermediary firms to private exporters (both the non-processing exporters and the semi-processed coffee division of the multinational).

For a given farm gate price w, the quantity of green coffee which the intermediary firms would want to supply to the local green coffee market is given by the following expression:

$$X_{I2} = \frac{n_I}{2b}\left(P_S - c\right) + \frac{\frac{n_I}{2b}}{\frac{n_I}{b} + G} \tag{29}$$

$$\times \left(a - \frac{\left(1-\gamma\right) n_C}{\alpha + \left(1-\gamma\right)^2 \left(1+ n_C\right)} \left(\left(1-\gamma\right) a + \gamma \left(P_S - \mu\right) - t_C \right) \right)$$

$$+ \frac{n_I}{b}\left(\frac{\frac{n_I}{2b}}{\frac{n_I}{b}+G} - 1\right) w$$

By comparing the farm gate demand from the intermediaries (which is their supply on the local green coffee market)with the farmers' supply (that is, comparing it with $X_{-C} = \frac{n_{-C}}{\alpha} w$), we get the equilibrium farm gate price which derives from this alternative organization as follows:

$$w^*_2 = \frac{1}{2}\left(\frac{n_{-C}}{\alpha} - \frac{n_I}{b}\left(\frac{\frac{n_I}{2b}}{\frac{n_I}{b}+G} - 1\right)\right)^{-1} \left(\times \frac{n_I}{b}\left(P_S - c\right)\frac{\frac{n_I}{2b}G}{\frac{n_I}{b}+G}\left(a - \frac{(1-\gamma)n_C}{\alpha + (1-\gamma)^2(1+n_C)}\right.\right. \left.\left.\left((1-\gamma)a + \gamma(P_S - \mu) - t_C\right)\right)\right) \quad (30)$$

Thus, the corresponding profit for a farmer supplying its coffee to the intermediary firms is given by:

$$\pi_{-C2} = \frac{1}{8\alpha}\left(\frac{n_{-C}}{\alpha} - \frac{n_I}{b}\left(\frac{\frac{n_I}{2b}}{\frac{n_I}{b}+G} - 1\right)\right)^{-2} \quad (31)$$

$$\times \left(\frac{n_I}{b}\left(P_S - \mathrm{c}\right) + \frac{\frac{n_I}{b}G}{\frac{n_I}{b}+G}\left(a - \frac{\left(1-\gamma\right)n_C}{\alpha + \left(1-\gamma\right)^2\left(1+n_C\right)} \right.\right.$$

$$\left.\left. \left((1-\gamma)\,a + \gamma\,(P_S - \mu) - t_C\right) \right) \right)^2$$

When the exporting cooperative processes the totality of its members' coffee produce into semi-processed coffee, then the farm-gate equilibrium price is:

$$w^*_2\left((\gamma = 1) = \frac{1}{2}\left(\frac{n - n_C}{\alpha} - \frac{n_I}{b}\left(\frac{\frac{n_I}{2b}}{\frac{n_I}{b} + \frac{1+n_E}{2+n_E}} - 1 \right) \right)^{-1} \right.$$

$$\left. \left(\frac{n_I}{b}\left(P_S - \mathrm{c}\right) + \frac{\frac{n_I}{b}\,\frac{1+n_E}{2+n_E}}{\frac{n_I}{b} + \frac{1+n_E}{2+n_E}}\, a \right) \right. \tag{32}$$

and,

$$\frac{dw_2\left(\gamma = 1\right)}{dn_C} = \frac{1}{2\alpha}\left(\frac{n_I}{b}\left(P_S - \mathrm{c}\right) + \frac{\frac{n_I}{b}\,\frac{1+n_E}{1+n_E}}{\frac{n_I}{b} + \frac{1+n_E}{1+n_E}}\, a \right)$$

$$\left(\frac{n - n_C}{\alpha} + \frac{n_I}{b}\left(\frac{\frac{n_I}{2b}}{\frac{n_I}{b} + \frac{1+n_E}{2+n_E}} - 1 \right) \right)^{-2} > 0$$

This latter expression confirms the exporter cooperative's pro-competition effect highlighted in Model 1. The profit arising from such a situation is expressed as:

$$\pi_{-C2}\left(\gamma = 1\right) = \frac{1}{8\alpha}\left(\frac{n - n_C}{\alpha} - \frac{n_I}{b}\left(\frac{\frac{n_I}{2b}}{\frac{n_I}{b} + G} - 1\right)\right)^{-2} \left(\frac{n_I}{b}\left(P_S - \mathrm{c}\right) + \frac{\frac{n_I}{b} G}{\frac{n_I}{b} + G} a\right)^2 \tag{33}$$

5. Results analysis and economic policy implications

In the two models, the parameter (a) is the ordinate from which the curve for the residual demand for green coffee intended for green coffee exporters in Côte d'Ivoire ($P_I = a - X$) derives. For a fixed X, any variation of a strongly influences the international price P_I. Indeed the bigger a is, the higher the international price of green coffee, and the smaller a is, the lower this price. Thus, a reflects the "profitability" of the green coffee world market.

Proposition 3

The farm gate price is an increasing function of the international green coffee price and the world-wide fluctuations affect this farm gate price.

Proof

From equations 21 and 30, we get the following:

$$\frac{dw^*_1}{da} = \frac{1}{2} \frac{\frac{n_I}{b} G}{\frac{n_I}{b} + G} \left(\frac{n_{-C}}{\alpha} + \frac{\frac{n_I}{b} G}{\frac{n_I}{b} + G} \right)^{-1} \left(1 - \frac{(1-\gamma)^2 n_C}{\alpha + (1-\gamma)^2 (1+ n_C)} \right) > 0$$

and,

$$\frac{dw^*_2}{da} = \frac{1}{2} \frac{\frac{n_I}{b} G}{\frac{n_I}{b} + G} \left(\frac{n_{-C}}{\alpha} - \frac{n_I}{b} \left(\frac{\frac{n_I}{2b}}{\frac{n_I}{b} + G} + 1 \right) \right)^{-1}$$

$$\left(1 - \frac{(1-\gamma)^2 n_C}{\alpha + (1-\gamma)^2 (1+ n_C)} \right) > 0$$

These two expressions allow us to understand how the international price has repercussions on the farm gate one: when the international price rises, so does the farm gate price, a situation which benefits the farmers. But if the international price falls, so does the farm gate price, together with the farmers' income. This means that with two types of organization of the local market, the farmer is highly exposed to world market fluctuations. However, the models do not enable us to determine the extent of the repercussions of world market prices on the farm gate ones.

Proposition 4

Any strategic behaviour on the part of the actors involved (private exporters in particular) that is likely to bring down the price of green coffee on the local market will lead to a fall in the farm gate price as well.

Proof

From Equation 14, we derive the following:

$$\frac{dP_w}{dw} = \frac{n_I}{b}\left(\frac{n_I}{b} + \mathrm{G}\right)^{-1} > 0$$

Similarly, Equation 28 allows us to derive the following:

$$\frac{dP_{w2}}{dw} = \frac{1}{2}\,\frac{n_I}{b}\left(\frac{n_I}{b} + G\right)^{-1} > 0$$

As a result, the green coffee local market price (P_w) and the farm gate price vary in the same direction.

This proposition means that if, for example, there is collusion between private exporters when they are buying coffee from the local intermediaries, such behaviour is likely to lead to a fall in the price on the local green coffee market. This, in turn, will bring down the farm gate price.

Comparison of the farm gate prices in the two models, for γ = 1

It is assumed here that this comparison is done before the resolution of stage 1 in the two models.

Proposition 5

When the exporter cooperative processes the entire quantity of coffee it has bought (that is, when $\gamma = 1$), the vertical integration of the private processing firm on the local coffee market will increase the farm gate price if and only if the world price of the semi-processed coffee does not exceed the threshold value P'_S.

Proof

For a very large number of farmers in the coffee industry, that is for n = infinity, we get the following expressions:

$$\lim_{n_C \to n} w_1 (\gamma = 1) = \frac{1}{2}(P_S - t_S - c) + \frac{1}{2}\, a = \overline{w}_1$$

$$\lim_{n_C \to 0} w_1 (\gamma = 1) = \frac{1}{2}(P_S - t_S - c) = \overline{w}_1$$

$$\lim_{n_C \to n} w_1 (\gamma = 1) = \frac{1}{2}\, \frac{\frac{1 + n_E}{2 + n_E} + \frac{n_I}{b}}{\frac{1 + n_E}{2 + n_E} + \frac{n_I}{2b}} (P_S - c) + \frac{1}{2}\, a \frac{\frac{1 + n_E}{2 + n_E}}{\frac{1 + n_E}{2 + n_E} + \frac{n_I}{2b}} = w_2$$

$$\lim_{n_C \to 0} w_2 (\gamma = 1) = 0 = \underline{w}_2 < \underline{w}_1$$

We can equally show that:

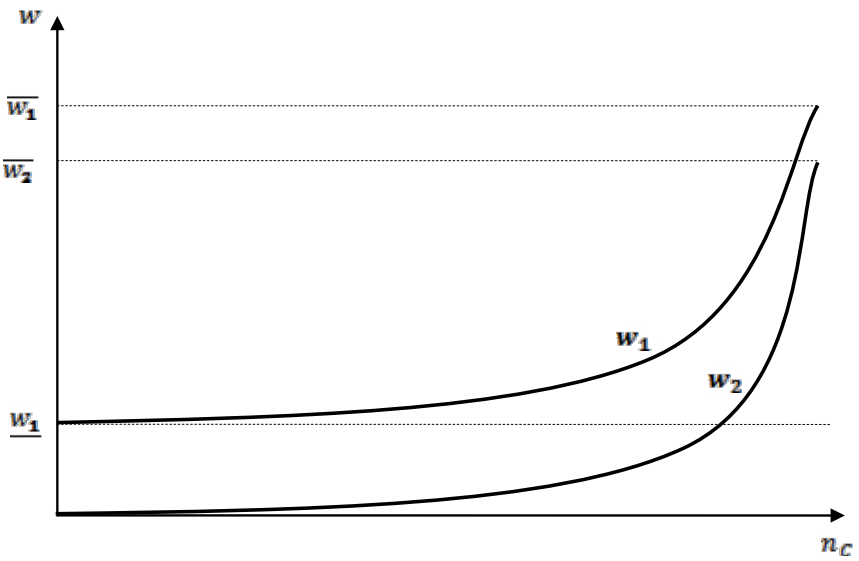
$w_2 - w_1 > 0$ if and only if $P_S < P'_S$

where

$$P'_S = \left(1 - \frac{\frac{1 + n_E}{2 + n_E}}{\frac{n_I}{2b}}\right) t_S + c + 2\left(1 - \frac{\frac{n_I}{2b}}{\frac{1 + n_E}{2 + n_E} + \frac{n_I}{b}}\right) a$$

Figure 3 presents the evolution of farm gate prices for the two types of organization as a function of the number of farmers who are members of the exporter cooperative.

Figure 3: Evolution of farm gate prices as a function of the number of members of *Coopex* for $\gamma = 1$ and $P_S < P'_S$



6. Conclusion and recommendations

The aim of this study was to analyse the extent to which the vertical integration of the processing firm would have an effect on the farm gate prices on the local coffee market in Côte d'Ivoire. To this end, we constructed two game-theory models. The first model described a very simplified organization of the local coffee market which allows the processing firm to buy green coffee at the farm gate. The second model presented an alternative organization of the same market which obliges every exporter to buy the green coffee from intermediary firms. The way the game would unfold in the two models, and a comparison of the results obtained from both, has shed light on several aspects of the behaviour of the actors in the coffee industry, on the interaction between them, and on the manner in which this behaviour and this interaction influence farm gate prices and farmers' income.

The study has contributed to the understanding of how price fluctuations on the international market have repercussions on the farm gate prices. Now we know that the farm gate price is an increasing function of the world green coffee price. We also know that the local green coffee price (P_w) and the farm gate price vary in the same direction. Therefore, any strategic behaviour on the part of the players involved (private exporters in particular) that is likely to bring down the price of green coffee on the local market will lead to a fall in the farm gate price as well.

The study has shown that the current organization of the coffee industry, the relative efficiency of the exporter cooperative, that is, its capacity to attract additional members, is an incentive for private firms to do better and, hence, to offer a high farm gate price.

The study findings show that the more profitable the world green coffee market is, the more likely it is that farmers will stop incurring an additional processing cost by becoming a member of the exporter cooperative. In this case, they will instead be encouraged to supply their produce to private firms. However, the higher the price of the semi-processed coffee, the higher the profit for the farmer who is a member of the exporter cooperative. This will cause more farmers to join the cooperative.

Finally, the findings of this study have demonstrated that when the exporter cooperative processes the entire quantity of coffee it has bought (that is, when $\gamma = 1$), the vertical integration of the private processing firm on the local coffee market will increase the farm gate price only if the world price of the semi-processed coffee does not exceed the threshold value P'_S.

We, therefore, recommend that:

- Exporter cooperatives be promoted through technical or financial assistance (or both) so as to maintain a high farm gate price and a high farmers' income.

- The country joins other coffee producing countries in a concerted effort to raise the price of coffee on the world market.
- The government support the farmers when the world prices are low.
- The current organization, which enables the coffee-processing firm rather than the non-transforming firms, to buy green coffee at the farm gate be maintained.

Notes

1. See FAOSTAT, www.fao.org

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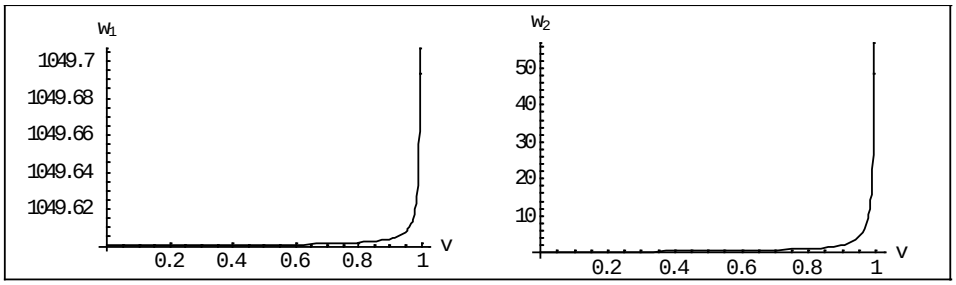
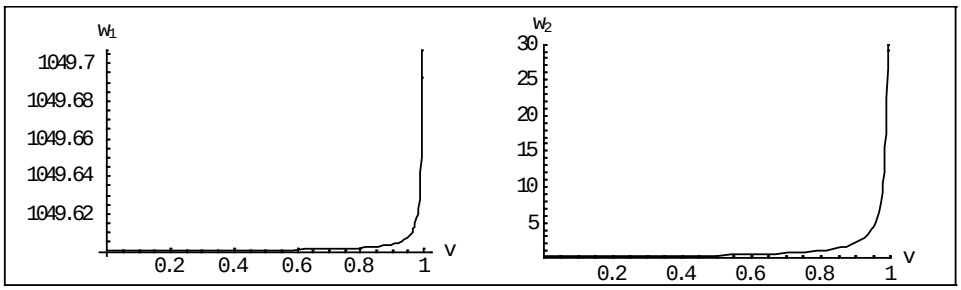
Appendix 1

$a = 1000$



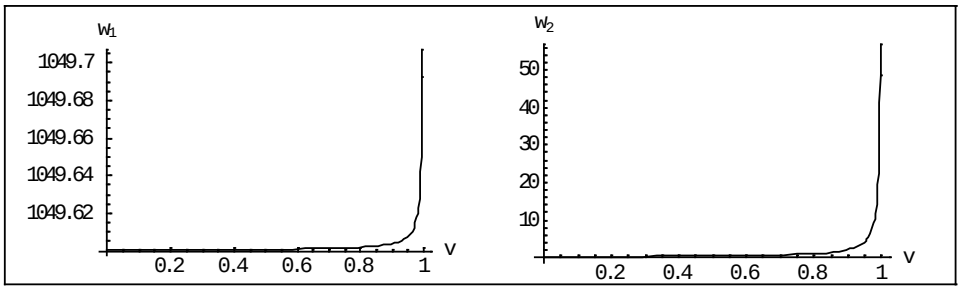
We show that $w_1(v=0) > w_2(v=0)$ and $w_1(v=1) > w_2(v=1)$. So $w_1 > w_2 \quad \forall v \in]0,1[$.

$a = 2500$



We show that $w_1(v=0) > w_2(v=0)$ and $w_1(v=1) > w_2(v=1)$. So $w_1 > w_2 \quad \forall v \in]0,1[$

$a = 10^6$



We show that $w_1(v=0) > w_2(v=0)$ and $w_1(v=1) > w_2(v=1)$. So $w_1 > w_2 \quad \forall v \in]0,1[$.

Note: $v = n_C / n$ is the proportion of the farmers who are members of the exporter cooperative (*Coopex*).

Conclusion: Profitability (a) has a very little impact on the rate of $w(v)$ in the two models.

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Abstract

The aim of this paper was to examine how coffee-processing firms influence the farm gate price on the domestic coffee market in Côte d'Ivoire. Two formalized models were constructed to study this domestic market. The models dealt with the interaction between its various players, the setting of the farm gate price and the performance of the current organizational structure of the industry (including the vertical integration of the coffee-processing firm), in comparison with an alternative organizational structure without vertical integration. The results of the study show that, under certain conditions, the vertical integration of the coffee-processing firms leads to an increase in the farm gate price on the world market for semi-processed coffee. The study also shows that the relative efficiency of the exporter cooperative (that is, its ability to attract new members) causes private firms to offer a high farm gate price.