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Food Safety on Domestic Markets of Developing Countries: How to Improve the Contribution of Export and Domestic Supply Chains?

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Abstract

The objective of this paper is to study the interactions between export and domestic supply chains in developing countries, particularly in terms of food safety in domestic markets and the availability of supply. An Industrial Economics approach is developed to analyze the interdependent relationship that may exist between the export and domestic sectors of developing countries. We demonstrate that the export sectors are not always rivals of the domestic sectors and some public interventions that may tend to increase the knock-on effects associated with advanced export sectors can simultaneously satisfy food security and safety objectives. In particular, we show how a public intervention that imposes a minimum production quota on exporters for allocation to local markets can create positive externalities on the levels of domestic supply and food safety.

Keywords: developing countries, food security, regulation, safety, standard

1. Introduction (Note 1)

The issue of the extent to which agricultural development schemes based on providing support for food crops should be promoted relative to those supporting export crops has been the focus of recurrent debates within development circles. According to a number of experts and development organizations (OXFAM, 2010; International Assessment of Agricultural knowledge, Science and Technology for Development [IAASTD], 2009), the massive supports granted to export crops harm food crop production and generate negative externalities that affect the local agricultural development capacity and, ultimately, food safety of these countries. As it is relatively more profitable for producers, export crop production would be likely to supplant food crops, which are a means of sustenance for a very broad mass of the population, particularly in rural areas (Note 2).

This thesis that a rivalry exists between the two types of crops is based on a series of arguments. One such argument refers to the competition that prevails between the two sectors for the use of local resources and services (land, infrastructure, transport, logistics, etc.). In countries with limited resources, this competition is more severe (Fadani & Temple, 1997; Madeley, 2002; Chaléard, 2003). Moreover, due to their greater financing capacity, export activities might absorb most of these resources and thus prevent the development of food crops, resulting in yield stagnation in domestic food production (Basler, 1986). Furthermore, there might be competition for the set of available labor resources, inputs and marketing networks (Fontan, 2006).

One of the significant competitive factors between the two forms of production is the competition over ownership for available land, with the overexploitation of land as a general outcome due to the expansion of export crops (Note 3). Access to the land remains a fundamental issue in developing countries (DCs). This issue is often a source of substantial tension between the parties involved because of the limited potential land resources available for agricultural activity (Note 4). Numerous examples in the literature suggest that the underproduction of food crops can often be attributed to the uncontrolled development of the export sector at the expense of food crops (Madeley, 2002; Teddy & Botafogo, 2003; OXFAM, 2011) (Note 5).

If food security is a constant priority for developing countries, in developed countries, concerns are gradually shifting towards more qualitative considerations. At present, the objective in the North is to control agricultural systems to ensure greater respect for the environment and consumer health. The spread of food safety crises (mad cow disease, dioxin in chickens, E.coli bacteria, etc.) has led to the erosion of consumers' trust in the food system. These crises led to the proliferation of public and private initiatives to secure agri-food markets (Hammoudi, Hoffmann, & Surry, 2009). We then witnessed the emergence of a considerable number of standards imposed on all links of the supply and marketing chains (Henson & Caswell, 1999; Henson & Jaffee, 2006). These standards are binding for any suppliers from the third countries' seeking to export to developed countries.

Unlike in developed countries, combating malnutrition remains a major challenge for DCs. It is even more challenging in countries that are highly dependent on imports and where domestic production cannot meet growing local demand. Food safety in DCs has never been given the priority it enjoys in developed countries (Hanak, Boutrif, Fabre, & Pineiro, 2002; Henson & Jaffee, 2006; Henson & Blandon, 2007). As a consequence, food production in many DCs often has little standardization with minimal imposition of sanitary requirements (Note 6), as opposed to their export sectors, which are carefully controlled by customers from developed countries (Jaffee, Henson, & Rios, 2011; Hanak et al., 2002).

To ensure their access to international markets, exporters from Southern countries are compelled to respect the food safety requirements established by Northern countries or their customers (Giraud-Héraud, Hammoudi, Hoffmann, & Soler, 2012). The export sectors of DCs, through the specific characteristics of the actors involved and the support they receive from financial backers and the public authorities, have acquired relevant technical and managerial knowledge and often seem to be more advanced than producers specializing in domestic markets. While export-related activities in some DCs are made by large operators (large agri-food companies, multinationals…), small producers play an important role in some countries and for certain specific sectors. For example, Côte d'Ivoire's exports of pineapples and banana and Ghana's vegetables exports are largely produced by small farmers (Minot & Ngigi, 2004; Maertens & Swinnen, 2009; Minten, Randrianarison, & Swinnen, 2009).

The positive development of certain export sectors in terms of good agricultural practice could, through its spillover effects on domestic sectors, represent a hope for positive developments in domestic markets (the availability and quality of supply). Such a hope might be reinforced by the fact that certain export crops are also consumed locally, and their improvement could benefit local consumers (Basler, 1986; PIP Magazine, 2011). Chaléard (2003) cites several examples of positive relationships between food and export crops (for example, in the south of Togo and the Ivory Coast), whereby an increase in export production generated an increase in food production.

The economics literature and development experts suggest policy instruments to accommodate both types of crops and avoid the negative spillover effect of the development of exports on domestic sectors. To encourage exporters to become involved in efforts to improve food safety in DCs, De Schutter (2009), the United Nations Special Rapporteur on the Right to Food, proposes that the State should mandate that each investment contract require that a minimum share of production be sold in local markets. He further suggests that this share should increase if the price of the product on international markets increases (Note 7). For instance, the Aga Khan Foundation's economic development experiment in Kenya constitutes a concrete example of the implementation of such a policy. In the experiment, a company, managing green bean production in Kenya and their export to Europe signed contracts with smallholder farmers guaranteeing a fair market price, provided that 75% of the land be reserved for food crops (La Creuse agricole, 2010; Clavé et al., 2010) (Note 8).

This article contributes to this debate. For this purpose, we propose an industrial economy model to study the interactions between the export and domestic sectors and the impact of these interactions on the output available to consumers. This model focuses, within an interdependent relationship, on producers specializing in local markets and others specializing in export markets. Under these conditions and in consideration of their strategic advantage, exporters can rationally decide to also service domestic markets. Analyzing the interactions between the two sectors and the endogenization of the correspondent stakeholders' strategic decisions enable us to evaluate the effects on local markets. We are specifically interested in the role that the export sector could eventually play in the positive or negative evolution of the micro-economic indicators associated with local supply (the availability of domestic supply, producer entry or exit in the domestic sector) and the sanitary quality of the local food supply.

The model simultaneously includes: (i) the quality dimension, through the existence of different sanitary regulations in the national and international markets, (ii) a dimension related to the relative scarcity of land or the competitive pressure for land acquisition, by explicitly accounting for the cost of land, and (iii) a dimension related to the low productivity of the domestic sector.

First, we show how the characteristics of the economic environment (differences in food safety regulations at the national and international levels, the size of the export market, availability of agricultural lands in a given country), affect the strategic behavior of the relevant actors, notably (i) whether exporters share their production between domestic and foreign markets and (ii) the entry decisions of producers specializing in the domestic market.

We demonstrate that the coexistence of two crops in the context of substantial heterogeneity in international and national regulations or in the presence of a relatively weak land constraint would reduce domestic supply relative to what would have prevailed had there only been one, exclusively domestic sector in the country (an absence of export activity).

We show that exporters' optimal share of cropland reserved for the domestic market (when following their individual interests, i.e., profit maximization) can be in opposition to the level that is socially and collectively suitable for the country. Taking this result into account, we evaluate the relevance of a regulation that would limit, without eliminating, the strategic freedom of exporters to select the proportion of their holdings they reserve for the food crop. The concept is to benefit domestic markets by imposing a quota on exporters' holdings that requires a certain amount of their production to be sold on domestic markets. We determine the conditions under which this measure may be desirable while simultaneously considering effectiveness criteria (price and quantity on the domestic market) and sanitary criteria (improvements to the safety and quality of the food on the domestic market). We demonstrate how, under certain conditions, such a public intervention serves to improve both the availability and average safety of the domestic food supply. However, we also show that food security (availability of supply) might be not compatible with another significant factor in the development of local sectors: the participation of a larger number of possible producers specializing in domestic markets.

The remainder of the article is organized as follows. We present the model in section 2. In section 3, we determine the optimal decisions of stakeholders (exporters and producers) and their effects on the price, quantity and quality of supply available in the domestic market and on the market access of producers specializing in food crops. Section 4 is devoted to the analysis of the public intervention established to encourage exporters to supply output to the domestic market. We explore the main findings of the article in the conclusion.

2. Model

We consider a developing country economy characterized by a mixed sector with two types of crops. The first "*domestic crop*" is intended for the local market and the second "*export crop*" is intended for the international market.

These two types of crops are grown by N producers, each with identical holdings of size q, and of which only N_e export (Note 9). The remaining N_L producers target their production to the domestic crop (Note 10). The parameter N thus represents the total number of active producers in the country considered and is given by:

$$N = N_L + N_e \tag{1}$$

Each producer i is assumed to have holdings of size q (Note 11). We further assume that the use of modern production techniques and higher-quality inputs provides improved yields (Note 12) and results in holdings of size q having a given production level $(1 + m_i)q$.

Furthermore, $m_i \geq 0$ is an index of operating productivity.

2.1 Sanitary Regulation

To protect consumer health, the public authorities establish a minimum good production practice requirement K, intended to ensure that consumers receive foodstuffs that satisfy a minimum level of product safety. An increase in the level of the standard (increase in K) indicates more stringent food safety regulations in the country in question (Note 13).

Each exporter/producer must invest in improving the quality of production practices to comply with domestic market regulation.

Satisfying the regulatory requirement K necessitates investing in the quality of agricultural practices, which induces, for each producer of size q, a total production cost given by:

$$CT(q, K) = cq + (F + cq)K \tag{2}$$

In addition to the production cost cq, compliance with the regulation K thus induces a fixed compliance cost of FK and a variable compliance cost of cqK.

In the absence of a requirement ($K = 0$), the total production cost for each producer is simply equal to cq (Note 14).

2.2 Land Access

We also include a "land cost" that represents a cost of obtaining the parcel of land to be allocated to agricultural activity. This cost is more or less easy depending on the size of a producer's holdings and the number of producers already operating in the market. The land price increases if the producers are more numerous or the area under cultivation q is larger. Given the total number of active producers N and individual holding size q, we assume that the total cost related to the price of land is:

$$G(\alpha, q, N) = \alpha q N \tag{3}$$

Each producer/exporter is thus required to cover the cost of entering the agricultural sector given by (3). The form of this land cost function may be explained as follows: the initial cost of accessing land depends on the initial availability of cultivable land (cultivation potential) in the country (Note 15). The more important the cultivation potential, the lower the pressure on the land and the lower the land price. This initial cost that thus reflects the initial availability of cultivable land is denoted α (Note 16). As plots of land are marketed and become less available following an increase in cultivated area, we observe an increase in the cost of accessing land. Finally, for a given initial cost α, the cost of accessing land G increases in q and N. When a producer increases its area under cultivation (q increases) or the number of producers increases (N increases), this leads to an increase in area under cultivation, inducing an increase in the cost of land $G(\alpha, q, N)$.

2.3 Domestic Supply Chain and Export Supply Chain

In the local market, we assume that the producers' limited financial means and the need to avoid excessively burdensome regulations and the resulting decline in supply; the Government establishes a relatively low level of the safety standard $K \equiv K_n$.

The implementation of the national standard K_n requires relatively little investment in good production practices or high-quality inputs. We assume that the production practices of the exclusively local producers lead to a low yield $m_i = m_n = 0$ (Note 17). In other words, a holding size of q is assumed to simply yield output equal to q. The production cost faced by a producer specializing in the domestic market is thus given by:

$$cq + (F + cq)K_n \tag{4}$$

However, exporters must conform to a higher export standard K_e, where $K_e > K_n$. The parameter N_e thus indicates the number of producers that are financially able to conform to the international standard, which is more costly than the national standard.

We assume that this type of producer is characterized by productivity m_e, which is better than that of exclusively local producers, $m_e > m_n$ (Note 18).

Using (1), for a given level of the standardK_e, the production cost incurred by each exporter is given by:

$$cq + (F + cq)K_e \tag{5}$$

The exporter is assumed to be a price-taker in the export market. The unit price of each exported quantity is given by p (Note 19).

As in the local market, we assume that the market price w is determined by local supply and demand (Note 20). The local demand function is given by:

$$D = a - w \tag{6}$$

2.4 Strategic Behavior of Exporters

We assume that the N_e exporters can select between simultaneously serving the domestic market and the export market (dual strategy) or exclusively specializing in exporting (specialization strategy). In other words, exporters can decide whether to allocate part of their holdings to the domestic market. Thus δ represents the proportion of the land each exporter reserves for domestic food production ($\delta \geq 0$) (Note 21). We assume that the share assigned to the domestic market is strategic, in the sense that an exporter rationally selects it based on his anticipated profits in the two markets.

We assume that all exporters employ identical production technologies and methods, for both export crops and those intended for the local market, and hence quality and productivity are identical for the two crop types (Note 22).

The production system described previously is summarized in Fig. 1.

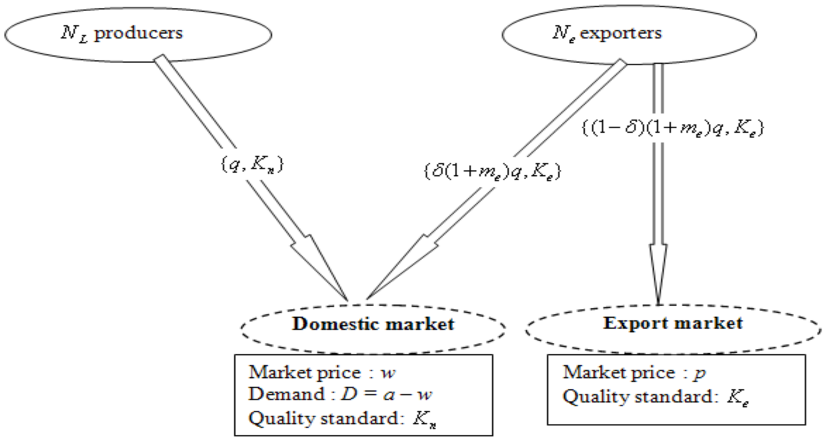

Figure 1. National production marketing system

For a given N_e, we consider the following game:

Stage 1: Each exclusively local producer decides whether to enter the domestic market. Simultaneously, each exporter selects the share of land he will dedicate to local crop production and that allocated to the export market.

Stage 2: In the local market, the exclusively local producers sell the entirety of their production capacities q and the exporters sell the share of their production dedicated to the local market. The market price w is determined by equilibrium supply and demand.

Thus given the share of individual holdings dedicated to export crop production $(1-\delta)q$ and the number of exporters N_e, the total quantity produced and intended for the export market is given by:

$$Q_X = N_e(1+m_e)(1-\delta)q \quad (7)$$

Moreover, given the share of individual holdings devoted to crop production for the local market δq, the total quantity produced by the N_e exporters and destined for the local market is given by:

$$Q_{XL} = N_e(1+m_e)\delta q \text{ (Note 23)} \quad (8)$$

Thus, the quantity offered by the exclusively local producers is given by:

$$Q_L = N_L q \quad (9)$$

Further, using (8) and (9), the total quantity offered on the local market is thus:

$$QT_L = N_L q + N_e(1+m_e)\delta q \quad (10)$$

Given the total supply given by (10), the equilibrium price on the local market w is determined by the equilibrium conditions for supply and demand given by (6).

Using (3) and (4), the total cost paid by each exclusively local producer is given by:

$$cq + (F+cq)K_n + \alpha qN \quad (11)$$

Ultimately, the profit obtained by each exclusively local producer is thus written as follows:

$$\pi_L = wq - cq - (F+cq)K_n - \alpha qN \quad (12)$$

We assume that there is free entry to the local market. Thus, by observing the entry condition in the local market, the number of exclusively local producers N_L is fixed at the level at which the profit of each producer, given by (12), is zero.

Using (3) and (5), the total operating cost for each exporter is given by:

$$cq + (F+cq)K_e + \alpha qN \quad (13)$$

Using (7), (8) and (13), the profit of an exporter is given by:

$$\pi_X = w\delta(1+m_e)q + p(1-\delta)(1+m_e)q - cq - (F+cq)K_e - \alpha qN \quad (14)$$

By observing the access conditions for both the domestic and export markets, the exporter's optimal behavior consists in determining the share of holdings δ that maximizes his profits.

2.5 Reference (Benchmark) Scenario

We consider a reference scenario in which the agricultural sector in the country in question is exclusively domestic. This situation is characterized by the absence of export crop production, i.e., the number of exporters is equal to zero ($N_e = 0$).

The total number of the active producers in the country considered is given by:

$$N = N_L \tag{15}$$

Using (3) and (15), each producer must thus pay a land cost given by:

$$G = \alpha q N_L \tag{16}$$

The total quantity offered on the local market is given by:

$$QT_L = Q_L = N_L q \tag{17}$$

Finally, the producer's profit is given by:

$$\pi_L = wq - cq - (F + cq)K_n - \alpha q N_L \tag{18}$$

Provided free entry to the local market, N_L thus denotes the number of producers at which each producer's profit given by (18) is zero.

3. Interactions between the Domestic and Export Supply Chains

In this first stage of the game, each exporter observes the characteristics of both markets and determines the optimal share of his holdings allocated to each crop. The optimal behavior of each exporter then consists in determining the share of holdings δ reserved for domestic food production that maximizes his profits.

In this context, we will study the exporters' strategic behavior and determine the impact of shifting from an economy that only has a domestic sector to one with both domestic and export sectors on food security, in a quantitative sense, and food safety.

Proposition 1. *Each exporter's optimal share of holdings reserved for domestic food production is given by:*

$$\delta^*(N_e, \alpha, q, K_n, m_e) = Max\left\{0, \frac{\alpha(\alpha + qN_e) - p(\alpha + q) + (FK_n + c(1 + K_n)q)}{qN_e(1 + m_e)(2\alpha + q)}\right\}$$

For the proof, see the Appendix.

The restriction $\delta^*(N_e, \alpha, q, K_n, m_e) > 0$ indicates the threshold conditions for pursuing the dual strategy, i.e., when the exporter opts to serve both the domestic and export markets by allocating a share of his holdings to domestic food production. We can verify that this strategy is valid in the presence of an appropriate (not overly strict) export standard ($K_e < \overline{K}_e(q, K_n, m_e)$) and a relatively high pressure on land resources ($\alpha > \bar{\alpha}(q, K_n)$ or $N_e > \overline{N}_e(\alpha, q, K_n)$) (Note 24).

The specialization strategy ($\delta^*(N_e, \alpha, q, K_n, m_e) = 0$) implies the absence of interactions between food and export crops: this is a *passive* strategy in the sense that the introduction of modernized elements in the export sector does not benefit food crop production (Note 25). We can verify that such a strategy is available if the export standard is relatively strict ($K_e > \overline{K}_e(q, K_n, m_e)$) or the pressure on land resources is relatively moderate ($\alpha \leq \bar{\alpha}(q, K_n)$ and $N_e \leq \overline{N}_e(\alpha, q, K_n)$).

Case 1: $K_e \geq \overline{K}_e(q, K_n, m_e)$ **Case 2:** $K_e < \overline{K}_e(q, K_n, m_e)$

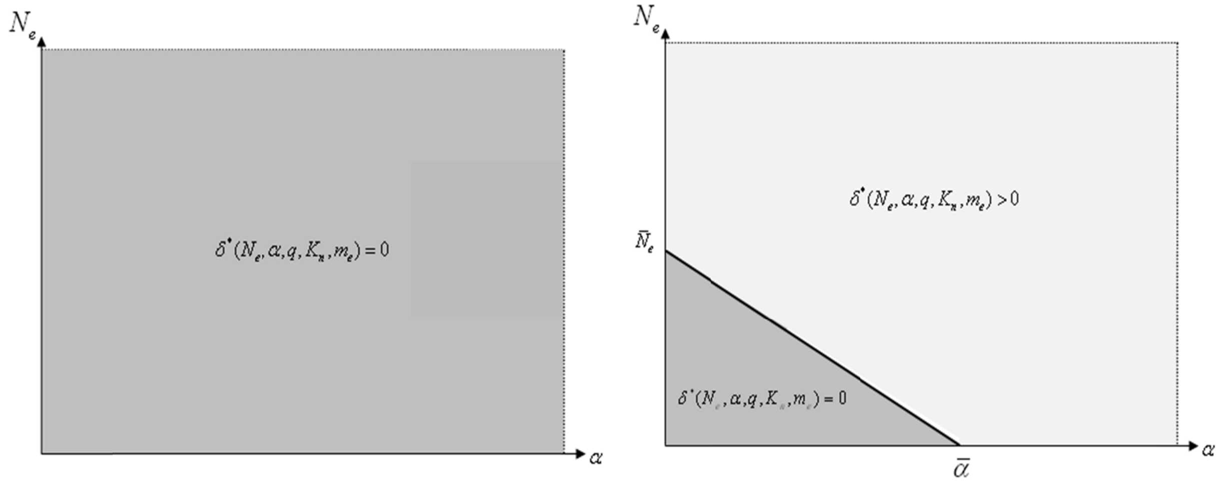

Figure 2. Conditions for the emergence of a dual/mixed supply chain

This result makes it possible to understand how the exporter chooses between the two strategies, which depend on the cultivation potential of the domestic country, the number of exporters in the country and the level of food safety regulation applicable to exports.

In the presence of a relatively strict export standard ($K_e > \overline{K}_e(q, K_n, m_e)$), the production cost faced by exporters is too high to encourage them to adopt a dual strategy and leads them to exclusively produce for the export market to compensate for their costs and ensure sufficient revenues. It is not in the exporters' interest to produce for the local market at a high cost and face competition from exclusively local producers who produce according to a low standard. As a result, the two sectors are independent in the presence of a relatively strict export standard.

Conversely, when the export standard is not overly strict ($K_e < \overline{K}_e(q, K_n, m_e)$), the exporter's strategic decision depends on both the (aggregate) size of the export sector, determined by the number of exporters N_e and agricultural land potential, represented by the parameter α .

When cultivation potential is low ($\alpha > \overline{\alpha}(q, K_n)$) or in the presence of a relatively large number of exporters ($N_e > \overline{N}_e(\alpha, q, K_n)$), there is relatively higher pressure on land resources. Consequently, accessing the market is costly for exclusively local producers who, unlike exporters, have no resources other than those they can obtain from the local market. This means that the number of exclusively local producers is relatively low. Under these conditions, it is attractive for exporters to also produce for the local market.

Conversely, in the presence of significant cultivation potential ($\alpha \leq \overline{\alpha}(q, K_n)$) and when the number of exporters is not too high ($N_e \leq \overline{N}_e(\alpha, q, K_n)$), it remains easy for exclusively local producers, who will influence the market price, to access the market. The level of supply in the domestic market is thus high, and exporters are not attracted by the local market and will specialize in the export sector.

In summary, when the export standard is not overly strict, exporters will only have an incentive to produce for the local market when agricultural potential is low ($\alpha > \overline{\alpha}(q, K_n)$) or in the presence of a relatively high number of exporters in the country considered ($N_e > \overline{N}_e(\alpha, q, K_n)$). Thus, the exporters' contribution to domestic supply will be low, if not zero, in countries with significant agricultural potential.

Proposition *1* demonstrates that there is a negative correlation between the exporter participation in the domestic market and the scarcity of agricultural land ($\delta^*(N_e, \alpha, q, K_n, m_e)$ increases in α). The share of holdings each exporter dedicates to the domestic market $\delta^*(N_e, \alpha, q, K_n, m_e)$ increases as cultivation potential decreases (i.e., α increases). Indeed, a limited availability of cultivable land implies a relatively high cost of engaging in agricultural activity, thus limiting the number of exclusively local producers and implying a fairly low supply from these producers. In view of this low level of supply from the exclusively local producers, the exporters tend to increase their individual shares of holdings dedicated to domestic food production ($\frac{\partial \delta^*}{\partial \alpha} > 0$).

Moreover, we can deduce from proposition *1* that there is a positive correlation between exporter involvement in the domestic market and the number of exporters ($\delta^*(N_e, \alpha, q, K_n, m_e)$ increases in N_e) if and only if agricultural potential is relatively high ($\alpha < \bar{\alpha}(q, K_n)$). Growth in the number of exporters thus only encourages them to increase their individual shares of holdings reserved for food crops when the agricultural potential is high ($\alpha < \bar{\alpha}(q, K_n)$).

When agricultural land is scarce ($\alpha > \bar{\alpha}(q, K_n)$), the share each exporter allocates to the food crop tends to be relatively high because of the limited entry of exclusively local producers due to the high cost of entry. Moreover, any increase in the number of exporters decreases the level of individual supply they devote to the local market ($\frac{\partial \delta^*}{\partial N_e} < 0$).

Conversely, when the cultivation potential is relatively large ($\alpha < \bar{\alpha}(q, K_n)$), the share each exporter allocates to the food crop tends to be relatively low because of the large number of exclusively local producers entering the local market. However, any increase in the number of exporters will result in increased land costs, impeding the entry of exclusively local producers. As a consequence, the exporters will increase their share of holdings allocated to local crop production ($\frac{\partial \delta^*}{\partial N_e} > 0$).

Proposition 2. *The export supply chain improves food safety and food security relative to the benchmark scenario if and only if* $K_e < \bar{K}_e(q, K_n, m_e)$, $\alpha > \bar{\alpha}(q, K_n)$ *and* $N_e < \bar{\bar{N}}_e(\alpha, q, K_n)$.

Proposition *2* demonstrates shifting the structure of agricultural production from an exclusively domestic sector to one with both export and domestic sectors only ensures an improvement in local consumers' health and an increase in the total quantity offered on the local market when three elements coexist: an export standard that is not overly strict ($K_e < \bar{K}_e(q, K_n, m_e)$),low agricultural potential ($\alpha > \bar{\alpha}(q, K_n)$) and a sufficiently limited number of exporters ($N_e < \bar{\bar{N}}_e(\alpha, q, K_n)$).

Moreover, the way in which each exporter divides his holdings between food and export crops has implications for the exclusion of exclusively local producers and the supply and quality of products available in the domestic market. The strategic choice of each exporter determines the type of relationship (rivalry or complementarity) that will exist between export crop production and food crop production.

Case: $K_e < \overline{K}_e(q, K_n, m_e)$

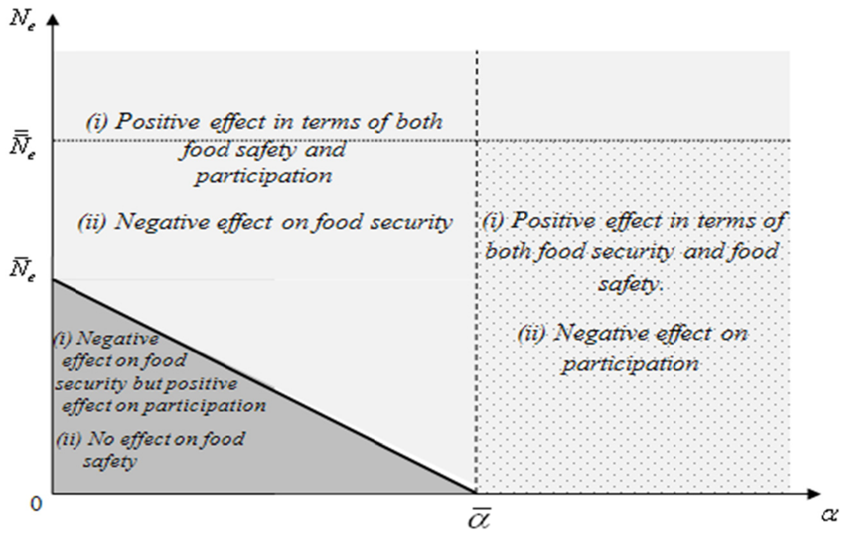

Figure 3. Domestic food production and export crop production: Competition or complementarity?

First, when the exporters adopt a specialized strategy, the shift from an exclusively domestic sector to a mixed sector always induces a reduction in local supply without having an effect on the health criteria. This result is intuitive. In such a case, the exporters exclusively produce for the export market. The shift from an exclusively domestic sector to a mixed sector implies a shortage of agricultural land and thus an increase in the associated cost. This increase in the cost of land limits access to the local market and thus induces a reduction in total local supply. This reduction in supply becomes more important as the number of exporters is increases and potential agricultural land decreases (an increasing level of α). In that case, the two sectors are rivals (Note 26).

Conversely, in the presence of an export standard that it is not overly strict ($K_e < \overline{K}_e(q, K_n, m_e)$) and relatively greater pressure on land resources ($\alpha > \bar{\alpha}(q, K_n)$ or $N_e > \overline{N}_e(\alpha, q, K_n)$), the exporters divide their holdings between food and export crops (Proposition *1*) by providing local consumers with products that conform to the export standard K_e. The shift from an exclusively domestic sector to a mixed sector implies an improvement in the health criteria.

From a quantitative perspective, the effect of a transition from an exclusively domestic sector to a mixed sector on the local supply level necessarily depends on the trade-off between the negative effect of the declining supply of exclusively local producers and a positive effect due to the involvement of exporters in domestic food production.

On the one hand, in the presence of a mixed sector, the total local supply declines in the number of exporters ($\frac{\partial QT_L^*}{\partial N_e} < 0$). Thus, given a mixed sector, the local supply is greater in the presence of a low number of exporters (N_e is low).

On the other hand, the supply provided by exporters in the domestic market decreases when agricultural land is less scarce (α decreases) ($\frac{\partial Q_{XL}^*}{\partial \alpha} > 0$).

Finally, given low agricultural potential ($\alpha > \bar{\alpha}(q, K_n)$) and a sufficiently limited number of exporters ($N_e < \overline{\overline{N}}_e(\alpha, q, K_n)$), a mixed sector generates more supply than in the benchmark scenario.

Indeed, under these conditions, the supply provided by exporters is proportionally higher than the decrease in the supply provided by exclusively local producers. The shift from an exclusively domestic structure (the benchmark scenario) to a mixed structure has a positive effect on the local market both in terms of the level of supply and improving local consumers' health.

4. Public Intervention

In the previous section, we demonstrated that exporters do not always have an incentive to invest in food crop production and adopt a dual strategy.

Moreover, adopting a dual strategy improves the extent of health protection enjoyed by local consumers, but under certain conditions it can also have negative effects on the domestic sector: a reduction in the land dedicated to food crop production and thus a decrease in supply and an increase in the price on the local market (proposition *2*).

Faced with this negative impact on food security, a public regulation could be designed that permits exports while fostering the development of local supply. Therefore, the aim of this section is to evaluate a type of public intervention that imposes a minimum production quota that must be allocated to food crop cultivation on each exporter. We analyze the conditions under which this measure may be desirable both in terms of effectiveness criteria (the price and quantity on the domestic market) and sanitary criteria.

In this version of the model, the State thus seeks to maximize the collective surplus W by requiring exporters to allocate a minimum share of their holdings to domestic food production. This social welfare is given by:

$$W(\delta) = SC(\delta) + N_L^*(\delta)\pi_L + N_e\pi_X(\delta) \qquad (19)$$

with: $SC(\delta) = \frac{(QT_L^*(\delta))^2}{2}$ being the local consumer surplus.

Proposition 3. *When the potential of a country's agricultural land is not too high ($\alpha > \hat{\alpha}(q, K_n)$) or the number of exporter is relatively large ($N_e > \hat{N}_e(\alpha, q\,K_n)$), the public authorities should intervene by imposing a minimum production quota on exporters for allocation to the local market, which is given by:*

$$\bar{\delta}(N_e, \alpha, q, K_n, m_e) = \frac{\alpha(\alpha + 2q)(a + qN_e) - p(\alpha + q)^2 + q(cq + (F + cq)K_n)}{\alpha(1 + m_e)N_e q(\alpha + 2q)}$$

For the proof, see the Appendix.

Proposition *3* expresses the socially desirable level of exporter production allocated to the local market.

We can verify that given sufficient agricultural potential and a fairly small number of exporters ($\alpha \le \hat{\alpha}(q, K_n)$ and $N_e \le \hat{N}_e(\alpha, q\,K_n)$), the legislator adopts a laissez-faire approach and decides not to intervene (Note 27). In this case, the legislator's optimal decision is compatible with that of the exporter. Under these conditions, the exporter's optimal strategy is to produce exclusively for the export market ($\bar{\delta}(N_e, \alpha, q, K_n, m_e) = \delta^*(N_e, \alpha, q, K_n, m_e) = 0$).

Indeed, when the agricultural potential is high and the number of exporters is relatively small, the cost of local market access is low because of the low cost of land. The domestic market is therefore supplied by a sufficient number of exclusively local producers, and the market price is relatively low. It is more beneficial for the collective interest to have the small number of exporters (we have $N_e < \hat{N}_e(\alpha, q\,K_n)$) specializing in export crop production to obtain higher profits on the export market (Note 28).

Conversely, given relatively low agricultural potential (case *1*: $\alpha > \hat{\alpha}(q, K_n)$) or a relatively higher number of exporters (case *2*: $N_e > \hat{N}_e(\alpha, q\,K_n)$), the legislator's optimal strategy is to require that a minimum share of exporter holdings be dedicated to domestic food production, whatever the level of export regulation K_e (Note 29). The threshold imposed by the public authorities is always higher than that selected by the exporter ($\bar{\delta}(N_e, \alpha, q, K_n, m_e) > \delta^*(N_e, \alpha, q, K_n, m_e)\ \forall N_e$ *and* $\forall\alpha$). Indeed, in both cases, the export sector is likely to increase the cost of entry faced by exclusively local producers because of an increase in the cost of land, resulting in the exclusion of certain producers. Two cases can explain this mechanism:

When agricultural potential is relatively low ($\alpha > \hat{\alpha}(q, K_n)$), the number of producers entering the local market is relatively small, which results in a relatively low level of supply. The presence of exporters further increases land costs and leads to the exclusion of exclusively local producers.

When agricultural potential is relatively high ($\alpha \leq \hat{\alpha}(q, K_n)$), the cost of accessing the local market is low. In this case, there are a sufficient number of producers supplying the local market. By authorizing exports, there should be a significantly large number of exporters ($N_e > \widehat{N}_e(\alpha, q\ K_n)$) to increase the cost of land to the extent necessary to induce a sufficiently substantial decrease in local supply.

In these two cases, a rational legislator must ensure that the domestic market obtains a sufficient quantity from the exporters to correct for the lack of local supply and/or to halt its decline.

Case 1: $K_e \geq \bar{K}_e(q, K_n, m_e)$ **Case 2:** $K_e < \bar{K}_e(q, K_n, m_e)$

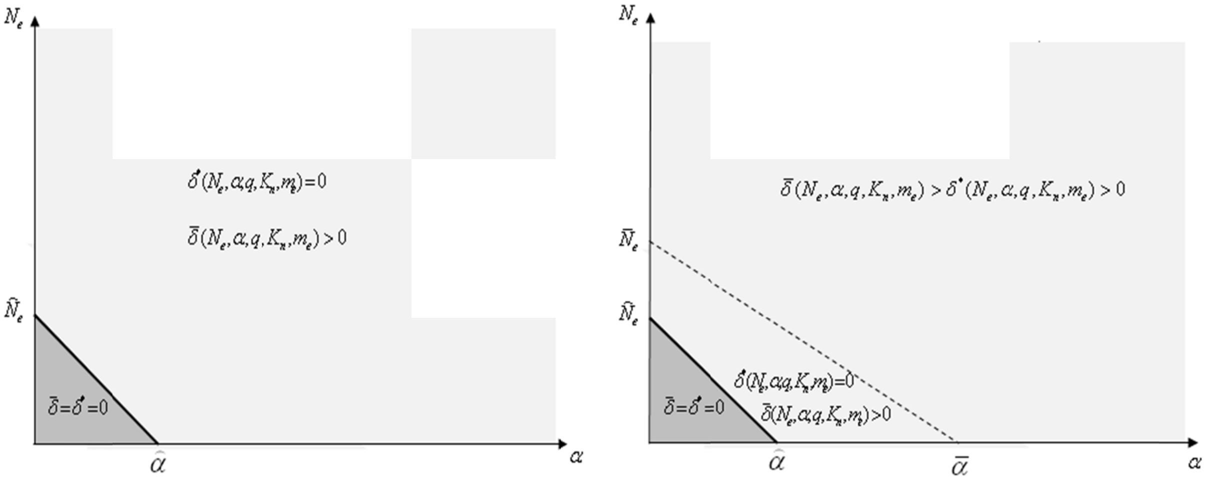

Figure 4. Public intervention: Which strategic choice is optimal for social welfare?

Proposition 4. *We verify that State intervention always induces an improvement in terms of both food security and food safety relative to the situation in which the exporter independently selects the share of his production he allocates to the domestic market. However, the effect on participation is always negative.*

Compared to laissez-faire approach, in which the exporter independently selects the share of his production he allocates to the local market, public intervention increases an exporter's domestic production by imposing a minimal production quota above the level otherwise selected by the exporter ($\bar{\delta}(N_e, \alpha, q, K_n, m_e) > \delta^*(N_e, \alpha, q, K_n, m_e)$). This public intervention increases the level of public health protection in the domestic market by increasing the level of production supplied by exporters in the domestic market.

However, this increase is accompanied by a negative effect on market entry for the exclusively local producers. An increase in supply by exporters induces the exclusion of certain producers because of the increase in the total supply and the decrease in the market price.

The exclusion of producers also implies a reduction in the total cost of land. Such a reduction in the cost of land, to a certain extent, limits exclusion due to the increase in the local supply provided by the exporters. In this case, exclusion occurs at a slower rate than the increase in the exporters' domestic food supply.

Finally, State intervention thus ensures a higher local supply and improved food safety in the domestic market compared to the situation without public intervention. However, this positive effect both in terms of quality and quantity comes at the expense of participation.

Proposition 5. *Public intervention induces an improvement in terms of both food security and food safety* *relative to an exclusively domestic market if and only if agricultural potential is relatively low* $(\alpha > \hat{\alpha}(q, K_n))$.

Relative to the scenario in which the export sector is absent, we verify that when agricultural potential is relatively low $(\alpha > \hat{\alpha}(q, K_n))$, Public intervention not only makes it possible to ensure higher quality products but also to increase local supply (Fig. 5).

Indeed, in the absence of an export sector, given relatively high agricultural potential $(\alpha < \hat{\alpha}(q, K_n))$, there are sufficient producers in the local market. In this case, the local supply level is relatively important. An export-orientation increases the cost of land and induces a decline in the output supplied by the exclusively local producers because some of them are excluded. Nevertheless, the share $\bar{\delta}(N_e, \alpha, q, K_n, m_e)$ selected by the State decreases in the availability of cultivable land ($\bar{\delta}(N_e, \alpha, q, K_n, m_e)$ increases in α, see proposition *3*). Then, even with significant agricultural potential $(\alpha < \hat{\alpha}(q, K_n))$, the each exporter's level of participation in domestic food production remains low. An export-orientation creates pressure on land resources without sufficiently exporter participation in domestic crop production. The local supply level in the presence of export activity remains lower, despite State intervention, than would be obtained in the absence of an export sector (Note 30). However, public intervention allows for higher local supply and higher quality than would be obtained in the absence of intervention (as we demonstrated in proposition *4*).

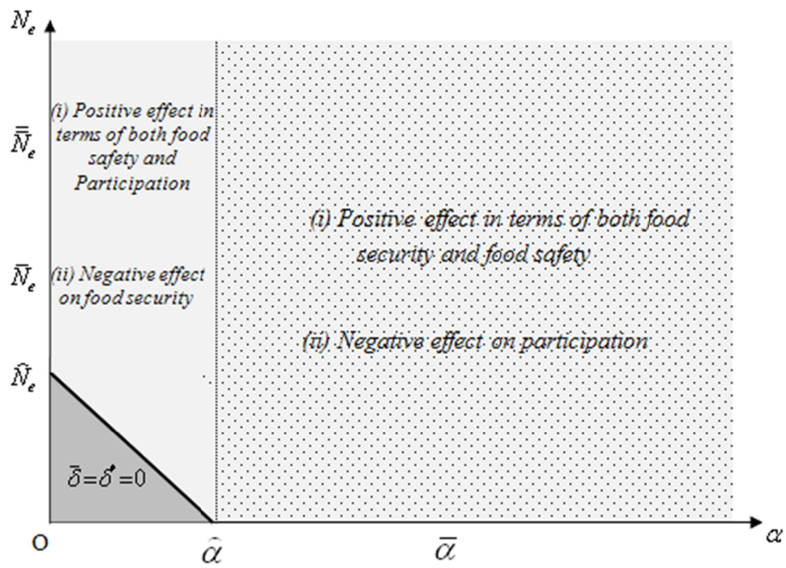

Figure 5. Transition from an exclusively domestic sector to a mixed sector with public intervention

Given relatively low agricultural potential $(\alpha > \hat{\alpha}(q, K_n))$, the cost of entering the local market is relatively high. The number of producers and total supply are then relatively low in the absence of an export sector. In the presence of export activity, the share of each exporter's holdings allocated to domestic crop production selected by the State is high. The entry of exporters into the market induces the exclusion of certain producers from the market. Given the large share of production that public authorities require exporters to supply to the domestic market, the local supply is higher in the presence of export activity than would be obtained in the absence of an export sector.

5. Conclusion

Food crops are a primary means of subsistence for the populations of many developing countries. However, food crop production in these countries faces strong constraints that impede their development in both qualitative and quantitative terms: low-productivity technologies, poor infrastructure, insufficient adoption of good agricultural practices among small producers, limited access to land, and low-quality or inadequate agricultural inputs (Calkins, Martin, & Larivière, 1996; Jaffee et al., 2011). All of these constraints negatively affect the level of supply available in domestic markets and the quality of products offered to consumers.

A thesis that is broadly shared in development circles states that the intensive development of export crops to the detriment of food crops tends to further aggravate the problem of food security in these countries (Madeley, 2002). The competition between food and export crops for access to land can reduce the land available for food crops because of land grabs by the export sector. This situation can lead to under-production in domestic markets (Madeley, 2002; Kisare, 2011). Conversely, according to another strand of the literature, the development of export chains is an unavoidable consequence of any development policy for these countries. At the macroeconomic level, export crops are an essential instrument for certain DCs to maintain a trade balance and could even strengthen the domestic sector (Fadani & Temple, 1997). By promoting export crops, a country could generate substantial revenues that make it possible to finance institutions, research or extension services. Thanks to the foreign currency accumulated through such activity, a country can import food products and intermediate goods that ultimately improve food crop productivity (Note 31).

This debate, in which strong opinions are often expressed, appears in the media during every crisis affecting international markets, as for example was the case in recent years in response to the rise in the world food prices observed since the 2008 financial crisis (OXFAM, 2011; GRAIN, 2008). During such crises, the legitimacy of policies designed to encourage exports are called into question, as they are considered an impediment to achieving the objective of food sovereignty, which is presented as the only means of ensuring food security (in the sense of supply availability). We contributed to this debate by considering criteria associated with the safety of the food offered to local consumers in addition to food security criteria. Consumers in DCs should be secured not only in terms of the availability of supply but also in terms of the quality of the food supply.

The theoretical approach proposed in this paper is designed to evaluate the effectiveness of imposing a production quota on the export sector regarding the quantity of food production that must be allocated to the domestic market. The original Industrial Economics model that we proposed allows us to explain the development of prices in the domestic market by assessing the strategic behaviors of locally oriented and export-oriented actors in an interactive context. We determined the conditions under which, despite export crops dominating a portion of available agricultural land, export crops can contribute to the development of domestic supply, both quantitatively and qualitatively.

We have shown that depending on the different characteristics of the economic environment faced by actors involved (the country's agricultural potential, land use and domestic and international health standards), the two types of crops can coexist and satisfy the two types of criteria, provided that public authorities intervene by regulating export activity. Indeed, our results suggest that requiring exporters to dedicate a minimum share of their holdings to food crop production can effectively satisfy both types of criteria. Without the imposition of such a quota, i.e., the exporters independently allocate their holdings between food and export crops, the competition between the two types crops would be less beneficial to social welfare in both quantitative and qualitative terms.

The model focuses on the potential incompatibility between the two types of criteria that authorities in DCs must pursue and the simultaneous satisfaction of which is highly socially desirable. These two types of criteria are food security (in quantitative sense), on the one hand, and the participation (or entry) of producers specializing in food crop production, on the other hand. Our results suggest that by requiring improvements in food safety in the domestic market to reconcile the effects of the two sectors (in the sense previously defined), DC authorities must either address greater exclusion of exclusively local producers or lower available supply. This partially negative result also suggests that to simultaneously satisfy all of these criteria, DC authorities should seek instruments that would complement the quota imposed on exporters. Providing support for producers specializing in food crops may be a possible solution and a subject for future investigation in this area.

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Notes

Note 1.This paper is funded by the European research project SAFEMED (ARIMNET program, http://www.arimnet.net/index.php?p=fp_safemed). We thanks all the partners of that project for their suggestions.

Note 2. The distinction between food and export crops is not always very clear. Depending of the country, some crops can be both food and cash crops (for example, peanut and oil palm crops). The two types of crops are rarely separate in existing production systems, and the coexistence of these two crop typologies is very often the rule rather than the exception.

Note 3. From a strictly agronomic perspective, there is always competition over the time allocations for both export crops and those intended for the local market (bottlenecks in the agricultural calendar).

Note 4. Madeley (2002) mentions the Kenyan case, where the growth in agricultural exports causes conflicts over access to land and water: "*In Kenya, for example, floriculture has expanded considerably around Lake Naivasha, where the land was previously dedicated to livestock and smallholding farmers. However, Kenya already faces a shortage of land to feed its people, and conflicts have arisen between the flower farmers and the Maasai cattle producers, who claim ownership of the lands around Lake Naivasha*" (Madeley, 2002, p. 87).

Note 5. Madeley (2002) cites the example of Chile, where from 1989 to 1993, the land under food crop cultivation declined by nearly 30% and the crops destined for export (such as fruits and flowers) replaced staple foods (such as beans and wheat). The small farmers have gradually been driven to less fertile land, while the large firms capture the best land for their export crops**.**

Note 6. This failure to focus on the question of safety in certain countries is likely accentuated by consumers' laxity concerning product quality and their lack of information regarding food-borne risks. (Hanaket al., 2002; Kopper, 2002)

Note 7. This measure is intended to regulate large-scale investments in land, where production is often destined for export. This measure is realistic because, in many developing countries and particularly in Sub-Saharan Africa, much of the land is formally owned by the government (De Schutter, 2009).

Note 8. This company is a leader in the vegetable industry in West Africa and manages substantial holdings of "extra-fine" green bean fields in Kenya. Each year, 15 000 tons of processed beans are exported to Europe. This process is based on contractual partnerships with nearly 60 000 small-scale farmers. (La Creuse Agricole, 2010; Clavé et al., 2010).

Note 9. The number of exporters N_e is exogenous. Their participating in export activities can be explained by a number of factors, such as their large initial allocations, international market knowledge and networks, agricultural knowledge (yield), etc. The option of introducing an additional game sequence in the model, in order to endogenize the number of exporters, is particularly technically complicated. Furthermore, this extension is not necessary in our context. We are interested by identify the incentives of export sector to participate to domestic markets through the quality of the products and level of supply.

Note 10. In what follows, we term this type of producers N_L, which specialize in the domestic market, "exclusively local producers". However, we simply call the producers that export N_e "exporters".

Note 11. Contrary to a widely acknowledged, export activities are not systematically dominated by the large producers of DCs. Studies conducted in Senegal and Madagascar show that small-holders participate in export markets (Maertens & Swinnen, 2009; Minten et al., 2009). Similarly, Kenyan horticultural export is a "success story" for family farming. The majority of exports is carried out by small holders (Minot & Ngigi, 2004).

Note 12. The quality of seeds and fertilizers used by the producers and training and knowledge concerning good agronomic practices, for example, affect productivity.

Note 13. We assume here that the level of the standard *K* don't constitute an element of product differentiation. We are here in the case where the regulations deal with production practices, for example, the application of good hygiene practice, implementing the HACCP system.

The attribute of safety in a product place this one in the category of "credence" goods (Gozlan & Marette, 2000; OCDE, 1999). Thus, with a credence good, consumers never discover the quality of good before consumption. Because of this informational asymmetry about sanitary quality between producers and consumers, the government guarantees a minimum level of safety quality by imposing a standard. Consequently, the demand is not affected by the level of the standard *K*.

Note 14. Without loss of generality, in the absence of a food safety regulation (i.e. in absence of investment *K*), we consider that production cost is restricted to the variable costs. Thus, we assume that the fixed costs associated to the production of the "generic goods" are zero or have already been amortized. The objective of the model is the issues related to the food safety constraints involving both fixed and variable compliance costs (e.g. infrastructure and equipments installation, implementation of training, certification costs, etc., see for example Shafaeddin, 2009; The Technical Centre for Agricultural and Rural Cooperation [CTA], 2003).

Note 15. Land availability thus varies from one country to another and from one region to another. For example, availability is low in areas with high population densities and relatively low in deserts and arid regions.

Note 16. This parameter is exogenous and depends on a certain considerations such as climatic and social factors which vary from country to country. α is lowest when a substantial amount of available agricultural land in a county is under cultivation.

Note 17. There are a number of different examples demonstrating how the development of food crops in developing countries faces a number of obstacles. In the example of the sorghum sector in Uganda, the use of the Epuripur variety provides a yield of between 2500 and 3000 kg/ha. However, due to the use of low-quality production technologies, at the farmer level, the yield ranges from 500 to 800 kg per acre (Jaffee et al., 2011). The example of national dairy value chains in three countries in sub-Saharan Africa (Kenya, Uganda and Zambia) also highlights the problem of low productivity in developing countries. Jaffee et al. (2011) thus demonstrate how investments in infrastructure, equipment, technology (including cooling systems) and practices supported by donors were necessary to increase milk production. The dairy value chains in these countries are primarily constrained by issues related to animal husbandry, farm productivity, and realizing economies of scale, etc. The poor productivity of domestic farmers can also be explained by the low level of efficiency resulting from the standard K_n.

Note 18. The literature highlights several factors to explain exporters' higher productivity relative to domestic producers. Modernizing certain procedures, the use of high-quality fertilizers and phytosanitary products, and the implementation of good production practices can, inter alia, affect productivity.

Note 19. We consider that international price is exogenous because its fluctuations not only depend on supply exporters represented in the model but also on a various of international producers that it is difficult to take into account here.

Note 20. It is possible to endogenize the local market price because we have represented in the model all producers who contribute to this market.

Note 21. The proportion $(1-\delta)$ is thus destined for the export market.

Note 22. For example, according to Suwanrangsi (2002), improvements in the safety and quality of fish and fishery products in Thailand, from primary production through processing, will directly affect the welfare of domestic consumers, as most exporting firms also produce products for local market. Moreover, in the Summary

Report of the Food and Agriculture Organization [FAO] (2009) concerning project GCP/RAF/404/GER, the majority of producers reported broadly applying the production practices resulting from the project to other crops.

Note 23. Provided that an exporter's optimal choice is such that $\delta = 0$, the quantity Q_{XL} is zero. In such a case, the exporters exclusively produce for the export market.

Note 24. We easily verify that there exist $\bar{\alpha}(q, K_n)$, $\overline{N}_e(\alpha, q, K_n)$ and $\overline{K}_e(q, K_n, m_e$ whereby: $\delta^*(N_e, \alpha, q, K_n, m_e) > 0$ if and only if $K_e < \overline{K}_e(q, K_n, m_e)$ and $\alpha > \bar{\alpha}(q, K_n)$ or $K_e < \overline{K}_e(q, K_n, m_e)$ and $N_e > \overline{N}_e(\alpha, q, K_n)$.

Note 25. In this context, Basler (1986) notes that in the case of holdings that are not mixed/dual, the effects of *transmission* might become *virtual*.

Note 26. This rivalry is particularly observed when the number of exporters is not too small or agricultural potential is not particularly high. In the presence of significant agricultural potential (α is low) and a small number of exporters, local supply declines, but this negative effect related to the presence of the export crop remains marginal and does not affect the country's food security. This is notably the case when $\alpha \leq \bar{\alpha}(q, K_n)$ and $N_e \leq \overline{N}_e(\alpha, q, K_n)$.

Note 27. We verify that $\bar{\delta}(N_e, \alpha, q, K_n, m_e) > 0$ if and only if $\alpha > \hat{\alpha}(q, K_n)$ or $N_e > \widehat{N}_e(\alpha, q\ K_n)$.

Note 28. Even if there is a very weak rivalry between the two sectors, any negative impact that the export crop can have on the local crop both in terms of a decrease in supply and the exclusion of local producers is, in this case, marginal compared to the increased income that could be generated by the export crops.

Note 29. For $K_e > \overline{K}_e(q, K_n, m_e)$, the two crops, food and export crops, are separated in the absence of intervention ($\delta^*(N_e, \alpha, q, K_n, m_e) = 0$). In this case, public intervention, by requiring exporters to divide their holdings between food and export crops, allows the negative effect that an export-orientation can have on food crop production to be corrected.

Note 30. Even if an export-orientation leads to a decrease in local supply relative to the benchmark scenario, supply remains high due to the presence of a high agricultural potential and exporter participation in domestic food production

Note 31. Some studies argue that export crops would permit the introduction of modernized elements through technology transfers to food crop production, and thus export crops could contribute, through this alternative channel, to improving productivity and *yield* per hectare (Basler, 1986 ; Raymond & Fok, 1995 ; PIP Magazine, 2011). The results of the Pesticides Initiative Programme (PIP) administered by COLEACP (African, Caribbean and Pacific Liaison Committee) demonstrate that the export horticulture sectors of the ACP countries contribute to the modernization and development of local horticulture in these countries. Compliance with good agricultural practices or the adoption of modern cultivation techniques benefits local production. Indeed, some export crops are also local subsistence crops, which consequently allow for improved yields and quality of food crops (PIP Magazine, 2011).

Appendix

1. Structure of exclusively domestic sector : the Benchmark

By using (6) and (17), the market price w is given by the equilibration of supply $QT_L = N_L q$ and demand $D = a - w$:

$$w = a - Q_L = a - N_L q \tag{A1}$$

By substituting (A1) in the profit function (18), we obtain :

$$\pi_L = (a - N_L q)q - cq - (F + cq)K_n - \alpha q N_L \tag{A2}$$

Given the free entry to the local market, the equilibrium number of producers is given by $\pi_L = 0$

The equilibrium number of producers N^B is given by :

$$N^B \equiv N_L^B = \frac{aq - (cq + (F + cq)K_n)}{(\alpha + q)q} \tag{A3}$$

By substituting (A3) in (A1), we determine the equilibrium price w^B :

$$w^B = a - N^B q = \frac{a\alpha + (cq + (F + cq)K_n)}{\alpha + q} \tag{A4}$$

By substituting (A3) in (17), we determine the total supply on the local market QT_L^B :

$$QT_L^B \equiv Q_L^B = \frac{aq - (cq + (F + cq)K_n)}{\alpha + q} \tag{A5}$$

2. Structure of mixed sector

Proof Proposition 1

By using (6) and (10), the market price w is given by the equilibration of supply $QT_L = N_L q + N_e \delta(1 + m_e)q$ and demand $D = a - w$:

$$w = a - QT_L = a - N_L q - N_e \delta(1 + m_e)q \tag{A6}$$

By substituting (A6) in (12), we determine the profit of each exclusively local producer π_L :

$$\pi_L = (a - N_L q - N_e \delta(1 + m_e)q)q - cq - (F + cq)K_n - \alpha q(N_L + N_e) \tag{A7}$$

By substituting (A6) in (14), we determine the exporter's profit π_X :

$$\pi_X = (a - N_L q - N_e \delta(1 + m_e)q)q_{XL} + pq_X - cq - (F + cq)K_e - \alpha q(N_L + N_e) \tag{A8}$$

$$\text{with : } \left| \begin{array}{l} q_{XL} = \delta\ 1 + m_e)q \ \ and \ \ q_X = (1 - \delta)(1 + m_e)q \\ \dfrac{\partial^2 \pi_X}{\partial \delta^2} = -2(1 + m_e)^2 N_e q^2 \end{array} \right.$$

By using :

(A8), the exporter's maximization program is given by $\underset{\delta}{Max}\, \pi_X$

(A7), the number of exclusively local producers is given by $\pi_L = 0$

We thus obtain the holding share reserved for domestic food production by each exporter δ^* and the number of exclusively local producers N_L^* respectively given by :

$$\delta^*(N_e, \alpha, q, K_n, m_e) = Max\left\{0 \ , \ \frac{\alpha(a + qN_e) - p(\alpha + q) + (FK_n + c(1 + K_n)q)}{qN_e(1 + m_e)(2\alpha + q)}\right\} \tag{A9}$$

$$N_L^*(N_e, \alpha, q, K_n, m_e) = \frac{q(a + p - 2\alpha N_e) - 2(FK_n + c(1 + K_n)q)}{q(2\alpha + q)} \tag{A10}$$

Given that the N_e producers are mainly exporters, the holding share reserved for domestic food production by each exporter never attains its maximal level ($\delta^* = 1$). Since we assume that $\frac{\alpha(a + qN_e) - p(\alpha + q) + (FK_n + c(1 + K_n)q)}{qN_e(1 + m_e)(2\alpha + q)} < 1$. Thus, we assume the following hypothesis:

$$\left| \begin{array}{l} p > \overline{p} \\ \overline{p} = \dfrac{\alpha(a + qN_e) - qN_e(1 + m_e)(2\alpha + q) + (FK_n + c(1 + K_n)q)}{(\alpha + q)} \end{array} \right.$$

We consider that the exporting country's price is relatively high.

However, for $\delta^*(N_e, \alpha, q, K_n, m_e) = 0$, the number of exclusively local producers is given by $\pi_L = 0$. We thus obtain the number of exclusively local producers N_L^* when $\delta^*(N_e, \alpha, q, K_n, m_e) = 0$:

$$N_L^*(N_e,\alpha,q,K_n)=\frac{q(a-\alpha N_e)-(FK_n+c(1+K_n)q)}{q(\alpha+q)} \quad \text{(A11)}$$

By using (A10) and (A11), the number of exclusively local producers N_L^* can be written as follows:

$$N_L^*=\begin{cases}\dfrac{q(a-\alpha N_e)-(FK_n+c(1+K_n)q)}{q(\alpha+q)} & si\ \delta^*(N_e,\alpha,q,K_n,m_e)=0\\ \dfrac{q(a+p-2\alpha N_e)-2(FK_n+c(1+K_n)q)}{q(2\alpha+q)} & si\ \delta^*(N_e,\alpha,q,K_n,m_e)>0\end{cases} \quad \text{(A12)}$$

- *Conditions for* $\delta^*(N_e,\alpha,q,K_n,m_e)>0$

By using (A9), we verify that:

$\delta^*(N_e,\alpha,q,K_n,m_e)>0$ if and only if $\alpha(a+qN_e)-p(\alpha+q)+(FK_n+c(1+K_n)q)>0$

Let us denote $\bar{N}_e(\alpha,q,K_n)=\dfrac{-a\alpha+p(\alpha+q)-(FK_n+c(1+K_n)q)}{\alpha q}$

We verify that $\delta^*(N_e,\alpha,q,K_n,m_e)>0$ if and only if $N_e>\bar{N}_e(\alpha,q,K_n)$

By using (A8) we also verify that $\pi_X\geq 0$ if and only if $N_e\leq N_e'(\alpha,q,K_n,K_e,m_e)$

with $N_e'(\alpha,q,K_n,K_e,m_e)=\dfrac{A_0+\sqrt{B_0}}{2\alpha q^2(\alpha+q)}$

Given that:

$A_0=-a\alpha q^2+pq[m_e(2\alpha+q)^2+q(q+\alpha)]-q^2(cq+K_e(F+cq))-4\alpha(\alpha+q)(K_e-K_n)(F+cq)$

$B_0=A_0^2+4\alpha q^2(\alpha+q)[a\alpha-p(\alpha+q)+(cq+(F+cq)K_n)]^2$

We easily verify that $N_e'(\alpha,q,K_n,K_e,m_e)>\bar{N}_e(\alpha,q,K_n)$ if and only if $K_e<\bar{K}_e(q,K_n,m_e)$

with $\bar{K}_e(q,K_n,m_e)=K_n+\dfrac{m_e pq}{(F+cq)}$

We then verify that if $K_e\geq\bar{K}_e(q,K_n,m_e)$ we have $\delta^*(N_e,\alpha,q,K_n,m_e)\leq 0 \quad \forall\pi_X\geq 0$

If $K_e<\bar{K}_e(q,K_n,m_e)$ then $N_e'(\alpha,q,K_n,K_e,m_e)>\bar{N}_e(\alpha,q,K_n)$. With $\bar{N}_e(\alpha,q,K_n)\geq 0$ if and only if $\alpha\leq\bar{\alpha}(q,K_n)$

Let us denote $\bar{\alpha}(q,K_n)=\dfrac{pq-(FK_n+c(1+K_n)q)}{(a-p)}$

Hence, if $K_e<\bar{K}_e(q,K_n,m_e)$, we distinguish the following two cases:

if $\alpha>\bar{\alpha}(q,K_n)$ then $\delta^*(N_e,\alpha,q,K_n,m_e)>0$, $\forall N_e$

if $\alpha\leq\bar{\alpha}(q,K_n)$ then $\delta^*(N_e,\alpha,q,K_n,m_e)>0$ if and only if $N_e>\bar{N}_e(\alpha,q,K_n)$

On the understanding that $\delta^*(N_e,\alpha,q,K_n,m_e)$ cannot be negative, we thus obtain the following relation (A13) :

$$\delta^*=\begin{cases}0 & \text{if } K_e\geq\bar{K}_e(q,K_n,m_e) \text{ or } \alpha\leq\bar{\alpha}(q,K_n) \text{ and } N_e\leq\bar{N}_e(\alpha,q,K_n)\\ \dfrac{\alpha(a+qN_e)-p(\alpha+q)+(FK_n+c(1+K_n)q)}{qN_e(1+m_e)(2\alpha+q)} & \text{if } K_e<\bar{K}_e\ q,K_n,m_e) \text{ and } \alpha>\bar{\alpha}(q,K_n) \text{ or} K_e<\bar{K}_e(q,K_n,m_e) \text{ and } N_e>\bar{N}_e(\alpha,q,K_n)\end{cases}$$

- *The variation in* $\delta^*(N_e,\alpha,q,K_n,m_e)$ *in relation to* N_e *and* α *:*

By using (A9), we determine:

$$\frac{\partial\delta^*}{\partial\alpha}=\frac{q(a+p)+N_eq^2-2(FK_n+c(1+K_n)q)}{qN_e(1+m_e)(2\alpha+q)^2} \tag{A14}$$

By using (A14) we verify that $\frac{\partial\delta^*}{\partial\alpha}>0$ if and only if $q(a+p)+N_eq^2-2(FK_n+c(1+K_n)q)>0$.

We also verify that $N_L^*>0$ if and only if $q(a+p-2\alpha N_e)-2(FK_n+c(1+K_n)q)>0$. We then verify that $q(a+p)-2(FK_n+c(1+K_n)q)+N_eq^2>0$.

We thus verify that $\frac{\partial\delta^*}{\partial\alpha}>0\ \forall\alpha$.

By using (A9), we determine:

$$\frac{\partial\delta^*}{\partial N_e}=\frac{-a\alpha+p(\alpha+q)-(FK_n+c(1+K_n)q)}{qN_e^2(1+m_e)(2\alpha+q)} \tag{A15}$$

By using (A15), we easily verify that $\frac{\partial\delta^*}{\partial N_e}>0$ if and only if $[-a\alpha+p(\alpha+q)-(FK_n+c(1+K_n)q)]>0$.

We thus easily verify that $\frac{\partial\delta^*}{\partial N_e}>0$ if and only if $\alpha<\bar{\alpha}(q,K_n)$.

Proof of Proposition 2

By substituting (A13) and (A12) in (A6), we determine the price w^*:

$$w^*=\begin{cases}\dfrac{\alpha(a+qN_e)+(FK_n+c(1+K_n)q)}{(\alpha+q)} & \text{if } \delta^*(N_e,\alpha,q,K_n,m_e)=0\\ \dfrac{\alpha(a+p+qN_e)+(FK_n+c(1+K_n)q)}{2\alpha+q} & \text{if } \delta^*(N_e,\alpha,q,K_n,m_e)>0\end{cases} \tag{A16}$$

By substituting (A13) and (A12) in (10), we determine the total quantity offered on the local market QT_L^*:

$$QT_L^*=\begin{cases}\dfrac{q(a-\alpha N_e)-(FK_n+c(1+K_n)q)}{(\alpha+q)} & \text{if } \delta^*(N_e,\alpha,q,K_n,m_e)=0\\ \dfrac{a(\alpha+q)-\alpha(p+qN_e)-(FK_n+c(1+K_n)q)}{(2\alpha+q)} & \text{if } \delta^*(N_e,\alpha,q,K_n,m_e)>0\end{cases} \tag{A17}$$

By substituting (A12) in (9), we determine the quantity offered by the local producers Q_L^*:

$$Q_L^*=\begin{cases}\dfrac{q(a-\alpha N_e)-(FK_n+c(1+K_n)q)}{(\alpha+q)} & \text{if } \delta^*(N_e,\alpha,q,K_n,m_e)=0\\ \dfrac{q(a+p-2\alpha N_e)-2(FK_n+c(1+K_n)q)}{2\alpha+q} & \text{if } \delta^*(N_e,\alpha,q,K_n,m_e)>0\end{cases} \tag{A18}$$

With $QT_L^*=Q_L^*$ if $\delta^*(N_e,\alpha,q,K_n,m_e)=0$.

By substituting (A13) in (8), we determine the quantity offered by the exporters on the local market Q_{XL}^*:

$$Q^*_{XL} = \begin{cases} 0 & if\ \ \delta^*(N_e,\alpha,q,K_n,m_e)=0 \\ \dfrac{\alpha(a+qN_e)-p(\alpha+q)+(FK_n+c(1+K_n)q)}{(2\alpha+q)} & if\ \ \delta^*(N_e,\alpha,q,K_n,m_e)>0 \end{cases} \quad \text{(A19)}$$

By substituting (A13) in (7) we determine the total quantity exported Q^*_X :

$$Q^*_X = \begin{cases} (1+m_e)qN_e & if\ \ \delta^*(N_e,\alpha,q,K_n,m_e)=0 \\ \dfrac{(\alpha+q)(p+qN_e(1+m_e))+\alpha(m_eN_eq-a)-(FK_n+c(1+K_n)q)}{(2\alpha+q)} & if\ \ \delta^*(N_e,\alpha,q,K_n,m_e)>0 \end{cases} \quad \text{(A20)}$$

By using (A5), (A12) and (A17), we distinguish the following cases:

If $K_e \geq \bar{K}_e(q,K_n,m_e)$ or $\alpha \leq \bar{\alpha}(q,K_n)$ and $N_e \leq \bar{N}_e(\alpha,q,K_n)$, then $QT^*_L - Q^B_L = -\dfrac{\alpha N_e q}{\alpha+q} < 0$ and

$$N^* - N^B = \frac{N_e q}{\alpha+q} > 0$$

If $K_e < \bar{K}_e(q,K_n,m_e)$ and $\alpha > \bar{\alpha}(q,K_n)$ or $K_e < \bar{K}_e(q,K_n,m_e)$ and $N_e > \bar{N}_e(\alpha,q,K_n)$, then $QT^*_L > Q^B_L$

and $N^* < N^B$ if and only if $\alpha(a-p)-pq-(\alpha+q)qN_e+(FK_n+c(1+K_n)q>0$

Let us denote $\bar{\bar{N}}_e(\alpha,q,K_n) = \dfrac{a\alpha-p(\alpha+q)+(FK_n+c(1+K_n)q)}{q(\alpha+q)}$

If $\alpha > \bar{\alpha}(q,K_n)$, we distinguish the following two cases:

if $N_e \geq \bar{\bar{N}}_e(\alpha,q,K_n)$ then $QT^*_L \leq Q^*_B$ and $N^* \geq N^*_B$

if $N < \bar{\bar{N}}_e(\alpha,q,K_n)$ then $QT^*_L > Q^*_B$ and $N^* < N^*_B$

If $\alpha \leq \bar{\alpha}(q,K_n)$ then $QT^*_L \leq Q^B_L$ and $N^* \geq N^*_B$ $\forall N_e$

We easily verify that $\bar{\bar{N}}_e(\alpha,q,K_n) > \bar{N}_e(\alpha,q,K_n)$

We thus distinguish the following three cases:

If $K_e \geq \bar{K}_e(q,K_n,m_e)$ or $\alpha \leq \bar{\alpha}(q,K_n)$ and $N_e \leq \bar{N}_e(\alpha,q,K_n)$ then $QT^*_L < Q^B_L$, $N^* > N^B$ and we have $Q^*_{XL} = 0$.

If $K_e < \bar{K}_e(q,K_n,m_e)$, $\alpha > \bar{\alpha}(q,K_n)$ and $N_e < \bar{\bar{N}}_e(\alpha,q,K_n)$ then $QT^*_L > Q^B_L$, $N^* < N^B$ and we have $Q^*_{XL} > 0$.

Si $K_e < \bar{K}_e(q,K_n,m_e)$ and $N_e > \bar{\bar{N}}_e(\alpha,q,K_n)$ or $K_e < \bar{K}_e(q,K_n,m_e)$ $\alpha < \bar{\alpha}(q,K_n)$ and

$N_e > \bar{N}_e(\alpha, q, K_n)$ then $QT_L^* < Q_L^B$, $N^* > N^B$ and we have $Q_{XL}^* > 0$.

Proof of Proposition 3

The number of exclusively local producers $\bar{N}_L$ is given by $\pi_L = 0$.

By using (19), the social welfare maximization program is given by $\underset{\delta}{Max} W(\delta)$

We thus obtain the holding share $\bar{\delta}(N_e, \alpha, q, K_n, m_e)$ that maximize the collective surplus :

$$\bar{\delta}(N_e, \alpha, q, K_n, m_e) = \frac{\alpha(\alpha+2q)(a+qN_e) - p(\alpha+q)^2 + q(cq+(F+cq)K_n)}{\alpha(1+m_e)N_e q(\alpha+2q)} \tag{A21}$$

By using (A9), we verify that:

$$\bar{\delta}(N_e,\alpha,q,K_n,m_e) > \delta^*(N_e,\alpha,q,K_n,m_e) \Leftrightarrow N_e > \frac{-a\alpha(\alpha+2q)+p(\alpha^2+\alpha q+q^2)+(\alpha-q)(cq+(F+cq)K_n)}{\alpha q(\alpha+2q)}$$

By using (A9) et (A21), we easily verify that :

If $N_e < \dfrac{-a\alpha(\alpha+2q)+p(\alpha^2+\alpha q+q^2)+(\alpha-q)(cq+(F+cq)K_n)}{\alpha q(\alpha+2q)}$ then $\bar{\delta}(N_e,\alpha,q,K_n,m_e) < 0$ and

$\delta^*(N_e,\alpha,q,K_n,m_e) < 0$

We thus obtain $\bar{\delta}(N_e,\alpha,q,K_n,m_e) > \delta^*(N_e,\alpha,q,K_n,m_e)$ $\forall\alpha$ and $\forall N_e$

- *Conditions for* $\bar{\delta}(N_e,\alpha,q,K_n,m_e) > 0$

By using (A21), we verify that :

$\bar{\delta}(N_e,\alpha,q,K_n,m_e) > 0$ if and only if:

$$\alpha(\alpha+2q)(a+qN_e) - p(\alpha+q)^2 + q(cq+(F+cq)K_n) > 0$$

Let us denote :

$\hat{N}_e(\alpha,q,K_n) = \dfrac{-a\alpha(\alpha+2q)+p(\alpha+q)^2 - q(FK_n + c(1+K_n)q)}{\alpha q(\alpha+2q)}$ and

$$\hat{\alpha}(q,K_n) = -q + \sqrt{\frac{q[aq-(FK_n+c(1+K_n)q)}{(a-p)}}$$

With We thus obtain:

If $\alpha > \hat{\alpha}(q,K_n)$ then $\bar{\delta}(N_e,\alpha,q,K_n,m_e) > 0$, $\forall N_e$

If $\alpha \le \hat{\alpha}(q,K_n)$ then $\bar{\delta}(N_e,\alpha,q,K_n,m_e) > 0$ if and only if $N_e > \hat{N}_e(\alpha,q,K_n)$

Proof of Proposition 4

By substituting (A21) in (10), we determine the total quantity offered on the local market $\overline{QT}_L$:

$$\overline{QT}_L = \frac{a(\alpha+2q) - p(q+\alpha) - (FK_n + c(1+K_n)q)}{\alpha+2q} \tag{A22}$$

The number of exclusively local producers is given by $\pi_L = 0$. By using (A21) and (A7), we thus obtain the number of exclusively local producers $\overline{N}_L$:

$$\overline{N}_L = \frac{q(\alpha+q)p - \alpha q(\alpha+2q)N_e - (\alpha+q)(FK_n + c(1+K_n)q)}{\alpha q(\alpha+2q)} \tag{A23}$$

By substituting (A23) in (1), the total number of the active producers in the country:

$$\overline{N} = \frac{(\alpha+q)[pq - (FK_n + c(1+K_n)q)]}{\alpha q(\alpha+2q)} \tag{A24}$$

By substituting (A21) in (8), we determine the quantity offered by the exporters on the local market:

$$\overline{Q}_{XL} = \frac{-(\alpha+q)^2 p + \alpha(\alpha+2q)(N_e q + a) + q(FK_n + c(1+K_n)q)}{\alpha(\alpha+2q)} \tag{A25}$$

By using (A12), (A17), (A22) and (A24), we verify that :

If $K_e \geq \overline{K}_e(q,K_n,m_e)$ or $\alpha \leq \overline{\alpha}(q,K_n)$ and $N_e \leq \overline{N}_e(\alpha,q,K_n)$ *then* $\overline{QT}_L > QT_L^*$ and $\overline{N} < N^*$ if and only if $[\alpha a(\alpha+2q) - p(\alpha+q)^2 + \alpha(\alpha+2q)qN_e + q(FK_n + c(1+K_n)q)] > 0$

If $K_e < \overline{K}_e(q,K_n,m_e)$ and $\alpha > \overline{\alpha}(q,K_n)$ or $K_e < \overline{K}_e(q,K_n,m_e)$ and $N_e > \overline{N}_e(\alpha,q,K_n)$ *then* $\overline{QT}_L > QT_L^*$ and $\overline{N} < N^*$ if and only if $[a\alpha(\alpha+2q) - p(\alpha^2+\alpha q+q^2) + \alpha q(\alpha+2q)N_e - (\alpha-q)(cq+(F+cq)K_n)] > 0$

By using (A9) and (A21), we easily verify that :

If $[\alpha a(\alpha+2q) - p(\alpha+q)^2 + \alpha(\alpha+2q)qN_e + q(FK_n + c(1+K_n)q)] < 0$ or $[a\alpha(\alpha+2q) - p(\alpha^2+\alpha q+q^2) + \alpha q(\alpha+2q)N_e - (\alpha-q)(cq+(F+cq)K_n)] < 0$ then

$\overline{\delta}(N_e,\alpha,q,K_n,m_e) < 0$ and $\delta^*(N_e,\alpha,q,K_n,m_e) < 0$

We thus obtain $\overline{QT}_L > QT_L^*$ and $\overline{N} < N^*$ $\forall\alpha$ and $\forall N_e$

Proof of Proposition 5

By using (A3), (A5), (A22) and (A24), we easily verify that :

$\overline{QT}_L > QT_L^B$ and $\overline{N} < N^B$ if and only if $[a\alpha(\alpha+2q) - p(\alpha+q)^2 + q(cq+(F+cq)K_n)] > 0$

We have $[a\alpha(\alpha+2q) - p(\alpha+q)^2 + q(cq+(F+cq)K_n)] > 0 \Leftrightarrow \alpha > \hat{\alpha}(q,K_n)$

We thus obtain $\overline{QT}_L > QT_L^B$ and $\bar{N} < N^B$ if and only if $\alpha > \hat{\alpha}(q, K_n)$