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Does input trade liberalization boost downstream firms' exports?

Theory and firm-level evidence*

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Abstract: We analyze the impact of input tariffs on the export status and export performance of processing firms. From a theoretical model with heterogeneous downstream firms, we show that lower input tariffs may increase the export sales of the high productivity firms at the expense of low productivity firms and may decrease the probability of firms entering foreign markets. We compare the predictions of the theoretical model with firm-level data from the French agrifood sector by developing a two-stage estimation procedure that uses an equation for selection into export markets in the first stage and an exports equation in the second stage. Liberalization of agricultural trade appears to favor the reallocation of market share from low to high productive firms. In addition, our result suggests that, whether lower input tariffs increase total exports sales and jobs, a large fraction of least productive exporting firms may lose from an additional decrease in agricultural product tariffs.

La réduction des tarifs à l'importation de biens intermédiaires peut-elle accroître les performances à l'exportation des entreprises de transformation ?
Le cas des firmes agro-alimentaires

Résumé : Nous analysons l'impact des barrières tarifaires sur les importations de biens intermédiaires sur la performance des exportations des entreprises de transformation. A partir d'un modèle théorique, nous montrons que la diminution de ces barrières augmente non seulement les exportations des entreprises les plus productives au détriment des entreprises à faible productivité mais aussi peut réduire la part des firmes accédant aux marchés étrangers. Nous comparons les prédictions du modèle théorique avec des données d'entreprises du secteur agro-alimentaire français en mobilisant une méthode d'estimation en deux étapes qui utilise une équation de sélection des firmes pour les marchés d'exportation dans la première étape et une équation d'exportations dans la deuxième étape. La libéralisation du commerce agricole semble favoriser la redistribution des parts de marché à l'étranger des entreprises à faible productivité vers les firmes les plus productives. En outre, nos résultats suggèrent que, si une diminution des tarifs sur les importations de biens intermédiaires accroit les exportations totales, une fraction importante des firmes exportatrices peut subir une diminution de leurs exportations.

Keywords: Input tariffs; heterogeneous donwstream firms; exports
Mots-clés: tariffs sur les intrants, firmes de transformation hétérogènes, exportations
JEL classification: F12, L11, L66

1 Introduction

Much attention has been paid to the impact of input trade liberalization on the domestic input sector, but relatively little to the impact on the final good sector (Amiti, 2000, Goldberg et al., 2009). Although standard and new trade theories do not agree on the impact of liberalization on the domestic upstream sector, they do predict that downstream industries would expand with lower tariffs in the intermediate inputs market. In this paper, we argue that tariff cuts on intermediate products may be detrimental to some downstream firms, depending on their labor productivity level.

Initially, it may seem reasonable to expect that a fall in input tariffs would reduce the production costs of downstream firms allowing them to increase their exports or their probability of serving foreign markets. This simple mechanism is captured in all models of trade with perfect or imperfect competition with an intermediate sector. Yet the real story is much more complex. The standard trade literature considers all downstream firms to be equally productive, whereas in practice, they differ considerably in productivity, and a more detailed analysis is required. Indeed, depending on its labor productivity, each downstream firm adjusts its output price differently in response to a change in input prices (under imperfect competition), leading to reallocation of market shares among downstream firms. In other words, *a priori* we do not know whether input tariff cuts favor the entry or the exit of exporters or boost or reduce firms' exports.[1] Hence, the effects of cuts in input tariffs on downstream firms deserve particular attention.

The effects of the reform of markets trade on productivity and export have been thoroughly analyzed, in both theoretical and empirical studies (Pavcnik, 2002; Fernandes, 2007). Since the seminal paper of Melitz (2003), many theoretical models with heterogeneous firms analyzed the effects of reducing output tariffs on final goods, showing that it leads to reallocation of resources and market shares from less productive to more productive firms, and subsequently to a rise in the average productivity of firms. But fewer theoretical models studied the effects of the liberalization of *input* trade on downstream firms. Some studies tested whether cuts in input tariffs would improve productivity of downstream firms by increasing imports of intermediate inputs (Amiti and Konings, 2007; Kasahara and Rodrigue, 2008; Luong, 2009; Halpern et al., 2011). The idea is that domestic firms can import higher quality inputs, leading to higher productivity. Hence, cuts in input tariffs can give a technological advantage to importing firms leading to a rise in

[1] For example, Greenaway, Kneller and Zhang (2010) show empirically that the impact of the exchange rate of an imported intermediate input on export sales differs depending on the size of firms.

their productivity levels. More recently, Goldberg et al. (2010) studied the impact of input tariffs on the range of products produced by domestic firms. They showed that lower input tariffs led to the production of new goods by domestic importing firms because they access to not only cheaper inputs, but more importantly, through importing of new input goods. Our objective is different. While the existing literature focuses on the effects input trade liberalization on the productivity or the domestic market, our attention is devoted to the impact of lower *input* tariffs on *export* performance of the *downstream* firms.

In this paper, we theoretically and empirically analyze the effects of lower input tariffs on the export selection process and on the export performance of downstream firms with different levels of labor productivity. To reach our goal, we first develop a model of trade with heterogeneous firms producing a differentiated good and using not only labor, as in Melitz (2003) or in Chaney (2008), but also an intermediate good. Contrary to recent trade literature with an intermediate sector (for instance, Luong, 2009 and Goldberg et al., 2010), we do not consider the extreme case where labor and intermediate products are combined with a Cobb-Douglas technology. In addition, unlike Goldberg et al. (2010), we consider that downstream firms differ in labor productivity. By allowing labor and intermediate products are not perfectly substituable and firms are heterogeneous, we show that the output price elasticity to a change in input tariffs increases with labor productivity of firms. These different responses lead to reallocation of export market shares from low productivity producers to high productivity firms with input tariff cuts. As a consequence, the impact of input tariffs on the probability of exporting depends on the level of fixed export costs. When fixed export costs are high enough, a fall in input tariffs increases the probability of exporting. Under this configuration, the exports of all processing firms increase but the most productive firms gain more than the less productive firms. In contrast, when fixed export costs are low enough, a fall in input tariffs decreases the probability of entering foreign markets. In other words, input trade liberalization forces the least productive firms to exit the foreign markets. Under these circumstances, export sales of high productivity firms increase at the expense of low productivity firms.

We test the main predictions of our model from firm-level data on French agri-food sector. We motive the choice of this sector for two reasons. First, in European and North American countries, the agri-food sector is still highly concerned by trade reforms contrary to the manufacturing sectors. Indeed, in the last two decades, tariff barriers at European borders for agricultural products which are mainly processed by the agri-food firms decreased considerably. For example, between 1995 and 2002, tariff barriers for agricultural products at European borders decreased by 30% and French imports of agricultural commodities increased by 25% (Bagoulla et al., 2010). Second, we can identify the main agricultural products purchased by the agri-food firms at a very disaggregated level and, in turn, calculate tariffs applied to the inputs they process.

The econometrical analysis is based on a two-stage estimation procedure that uses an equation for selection into export markets in the first stage and an exports equation in the second. Note that our empirical analysis concerns not only the importing firms but also the other firms. Indeed the non-importing firms enjoy indirectly lower input tariffs because domestic and imported input prices are positively correlated (Amiti and Konings, 2007; Kugler and Verhoogen, 2009; Auer and Fischer, 2010; Auer et al., 2010). Our results reveal that a decrease in tariffs on intermediate products favors the exit of agri-food French firms from foreign markets. In addition, the results suggest that more productive exporting firms gain from a fall in input tariffs at the expense of less productive firms. More precisely, our analysis reveals that, all other things being equal, around 45% of exporting firms can potentially gain from agricultural trade liberalization. In other words, a large proportion of French agrifood exporting firms may loose from liberalization of agricultural goods trade, confirming our predictions. However, the negative effects of input trade liberalization in terms of jobs or export sales are lower than the positive effects enjoyed by the more productive firms. Indeed, it appears a fall by ten per cent in input tariffs induces a rise in *total* export sales by 1,5% and in *total* employment by 0,1% if no firms exit from the export markets. Such a result emerges because the firms gaining from input trade liberalization hire the majority of employees and their export sales represent a very large fraction of aggregate export value in the agri-food sector.

In the following section, we develop the framework we use to identify some testable predictions. In section 3, we describe the empirical model and in section 4, we present the data. In section 5, we present our results and their analysis. In the last section, we conclude.

2 Theory

The objective of this section is to develop a simple model of trade with heterogeneous firms, which captures the main effects of input tariffs on exports. We consider a domestic country trading with n countries where each country hosts a representative consumer and a continuum of downstream heterogeneous firms. The mass of firms in the economy is exogenously assumed to be given while the mass of exporting firms is endogenous. Firms process an intermediate product in order to produce a differentiated product under monopolistic competition. Firms have to pay a fixed cost f_x to serve foreign markets, which represents the adaptation costs to foreign markets (distribution and servicing network, learning bureaucratic procedures, adapting the products for foreign markets, ...). In addition, shipping the final product between any pair of countries results in an iceberg transport cost $\tau > 1$. The domestic economy puts a tariff T on the import of the intermediate product. The n foreign countries are identical in size and apply the same tariff on imported intermediate inputs.

2.1 Technology

The production of any variety requires two inputs, labor and intermediate inputs. We assume for sake of simplicity that intermediate inputs and labor are used *by each firm* in a fixed proportion. We show in the end of this section that our results hold for different technologies as long as we exclude the Cobb-Douglas production function.[2] Formally, we assume to produce one unit of the final good, each firm i uses α units of the intermediate good and, following Melitz (2003), draws a random unit labor productivity φ_i from a common distribution $g(\varphi)$. Two comments are in order concerning the intermediate input. First, we consider that downstream firms differ only in labor productivity but not in the use of intermediate inputs. Our assumption captures the idea that to produce the same good, downstream firms have similar input requirements. Second, the intermediate good is assumed to be homogeneous. These different assumptions are discussed at the end of this section.

Hence, each downstream firm i is characterized by its own variety and by its labor productivity φ_i. As a result, the marginal cost of production is given by $z\alpha + w/\varphi_i$ where w and z are, respectively, the labor price and the prevailing domestic price of the intermediate product with

$$z = (1 + T)\bar{z},$$

$\bar{z}$ being the world price of the intermediate product and T the input tariff applied at entry to the home country

[2] Note our approach differs from that of Bernard et al. (2007) and Bas (2009) who condiser that the firms use two inputs. Bernard et al. (2007) consider skilled and unskilled labor in their trade model with heterogeneous firms. However, both factors are combined with a Cobb-Douglas technology. Bas (2009) also develops a trade model with heterogeneous downstream firms using two inputs: a local intermediate good and a foreign intermediate good, combined in a CES technology. However, the final good production does not require labor and the marginal requirement in each input does not vary across firms.

2.2 Preferences, demand and prices

Because we study exports, our framework focuses on foreign demand. The preferences of a representative consumer located in a foreign country are given by a C.E.S. utility function over a continuum of varieties indexed by ω:

$$U_x = \left[\int_{\omega \in \Omega_x} y_x(\omega)^{\rho} \mathrm{d}\omega\right]^{1/\rho} \tag{1}$$

where Ω_x represents the set of varieties available in a foreign country. Varieties are substitutes, which implies that $0 < \rho < 1$, and the elasticity of substitution between any two varieties is given by $\sigma = 1/(1-\rho) > 1$. Considering the budget constraint in each foreign country $R_x = \int_{\omega \in \Omega} p_x(\omega) y_x(\omega) \mathrm{d}\omega$ where p_x is the price of a domestic variety prevailing in a foreign country, the demand of a foreign consumer for a variety produced by a firm with a labor productivity φ_i located in the home country is given by:

$$y_x(\varphi_i) = R_x P_x^{\sigma-1} [p_x(\varphi_i)]^{-\sigma}. \tag{2}$$

where P_x is the price index in a foreign country (defined in Appendix A). Note that, because foreign countries are symmetrical in size and input prices, the price index does not differ across foreign countries.

Under monopolistic competition with a CES utility, each firm i in the domestic country faces a residual demand curve with constant elasticity σ which leads to the pricing rule:

$$p(\varphi_i) = \frac{(1+T)\bar{z}\alpha + w/\varphi_i}{\rho} \tag{3}$$

where $1/\rho$ is the markup. As a result, the price prevailing in a given foreign country is expressed as follows $p_x(\varphi_i) = \tau p(\varphi_i)$. The main difference between Melitz (2003) and our approach lies in the fact we consider that the production cost function of a firm can be divided into two: the wage rate divided by its labor productivity and the unit cost of the intermediate good, where only labor productivity varies across firms. The elasticity of the output price to a change in input tariffs is then given by:

$$\varepsilon_{p(\varphi_i),T} \equiv \frac{\partial p(\varphi_i)}{\partial T} \frac{T}{p(\varphi_i)} = \frac{\bar{z}\alpha T}{(1+T)\bar{z}\alpha + w/\varphi_i} \tag{4}$$

where $\varepsilon_{p(\varphi_i),T}$ increases with φ_i. In other words:

Lemma 1. *The elasticity of the output price to a change in input tariffs increases with labor productivity.*

Because our setup involves an increasing *share* of intermediate good costs in the total production cost with labor productivity (our dataset confirms this result, see Table 3 in

Section 4). Hence, the most productive firms are more impacted by input price variations because they use relatively less labor and more intermediate commodities to produce final goods.

2.3 Export revenues and intermediate product prices: some properties

Let r_i be the export sales on any foreign market of a domestic firm i where $r_i = \tau p(\varphi_i) y_x(\varphi_i)$. Knowing (2) and (3), r_i can be rewritten as follows:

$$r_i = \tau^{1-\sigma} R_x \left[\frac{\rho P_x}{(1+T)\bar{z}\alpha + w/\varphi_i} \right]^{\sigma-1} \tag{5}$$

The impact of T on r_i at a given labor productivity (or for a firm) is not obvious. Indeed, input tariffs affect not only the variety price but also the foreign price index. Some standard calculations reveal that

$$\frac{\partial r_i}{\partial T} = (\sigma - 1)\frac{r_i}{T} \left(\frac{\partial P_x}{\partial T}\frac{T}{P_x} - \frac{\partial p\left(\varphi_i\right)}{\partial T}\frac{T}{p\left(\varphi_i\right)} \right) \tag{6}$$

or, equivalently, $\varepsilon_{r_i,T} = (\sigma - 1)\left(\varepsilon_{P_x,T} - \varepsilon_{p(\varphi_i),T}\right)$ where $\varepsilon_{r_i,T}$ and $\varepsilon_{P_x,T}$ are the elasticities of the revenue and foreign price index to input tariffs, respectively. Note that $\varepsilon_{P_x,T}$ can be viewed as the average elasticity of prices to input tariffs in the foreign market. In other words, the sign of the effect of input tariffs on export sales of a firm depends on the gap between the elasticity of the foreign price index and that of its variety price. In Appendix A, we show that the sign of the impact if input tariff on export sales of firm i (characterized by labor productivyty φ_i) is given by

$$\text{sign}\left\{\frac{\partial r_i}{\partial T}\right\} = \text{sign}\left\{ \begin{array}{c} \tau^{1-\sigma} \int_{\varphi_x}^{\infty} \frac{p(\varphi)^{1-\sigma}}{p(\varphi)} g(\varphi)\mathrm{d}\varphi \\ - \int_0^{\infty} \frac{p(\varphi)^{1-\sigma}}{p(\varphi_i)} g(\varphi)\mathrm{d}\varphi - n\tau^{1-\sigma} \int_{\varphi_x}^{\infty} \frac{p(\varphi)^{1-\sigma}}{p(\varphi_i)} g(\varphi)\mathrm{d}\varphi \end{array} \right. \tag{7}$$

where φ_x is the threshold value of labor productivity above which it is profitable for a domestic firm to serve a foreign country. Hence, the sign of $\partial r_i/\partial T$ depends on $p(\varphi_i)$ and, in turn, on labor productivity of the firm. It is easy to check that $\partial r_i/\partial T < 0$ when $p(\varphi_i)$ is relatively low or, equivalently, when φ_i is relatively high. In contrast, we have $\partial r_i/\partial T > 0$ when $p(\varphi_i)$ is relatively high or, equivalently, when φ_i is low. Hence, the price set by a firm with a high labor productivity decreases more than the price index when input tariffs decline inducing a rise in its export sales. In contrast, for a firm with a low labor productivity, the fall in its price is lower than the decline in the price index so that its export sales decrease with lower input tariffs. Because the expression of $\partial r_i/\partial T$ is continuous and monotone, there exists a unique value of labor productivity $\widehat{\varphi}$ such as $\partial r(\widehat{\varphi})/\partial T = 0$. In other words, the export revenues of a firm with labor productivity equal to $\widehat{\varphi}$ do not vary when input tariffs vary.

Figure 1 about here: Impact of T on r_i

Figure 1 illustrates the effect of a change in input tariffs on export sales which differs according to labor productivity of firms. Two export revenue curves are plotted against labor productivity for two different levels of input tariffs (a high input tariff, T^+ and a low input tariff, T^-). The export revenue curve rotates around point $A(\widehat{\varphi}, r(\widehat{\varphi}))$ when input tariffs change. Export revenues increase when input tariffs shift from T^+ to T^- for firms with a labor productivity superior to $\widehat{\varphi}$ ($r_i(T^-, \varphi) > r_i(T^+, \varphi)$). Conversely, export revenues decrease with a fall in input tariffs for firms with a labor productivity inferior to $\widehat{\varphi}$. Consequently, decreasing input tariffs do not relocate the export revenue curve upwards but rotates it anticlockwise. This reveals that there is a reallocation of export revenues from low productive firms to high productive firms. This mechanism arises from the different responses of variety prices to changes in input tariffs with respect to labor productivity (see (4)). The price of a downstream firm decreases more in response to a drop in input tariffs than the price of a firm with lower productivity, leading to the reallocation of shares in the export market.

Note that in the Melitz model (2003), trade liberalization benefits to more productive firms while less productive exporting firms reduce their total revenues. However, the Melitz model focuses on the effects of output trade liberalization while our study is on the impact of lower input tariffs. In addition, in the Melitz model, the openness to output trade in the home country induces a decline in export sales for all firms. In our model, the liberalization of inputs in the home country leads to a decline in export sales only for less productive exporting firms.

2.4 Impact of input tariffs on export decisions

Our next task is to determine the impact of a variation in T on φ_x^* (or, equivalently, on the probability of exporting $1 - G(\varphi_x^*)$ where $G(\varphi)$ is the cumulative distribution function of $g(\varphi)$) and on the equilibrium export revenues. The export profit of firm i serving a foreign country is given by

$$\pi_i = r_i/\sigma - f_x. \tag{8}$$

A firm enters the foreign market as long as $\pi_i \geq 0$. We consider the export threshold φ_x, which is the labor productivity level such as $\pi(\varphi_x) = 0$ or, equivalently, $r(\varphi_x)/\sigma = f_x$. Because $\partial r(\varphi)/\partial\varphi > 0$ (see (5)), $\pi_i > 0$ if and only if $\varphi_i > \varphi_x$. Because we have $r(\varphi_x) = \sigma f_x$ at equilibrium, by using the envelope theorem, it appears that

$$\frac{\mathrm{d}\varphi_x}{\mathrm{d}T} = -\frac{\partial r(\varphi)}{\partial T} \Big/ \frac{\partial r(\varphi)}{\partial \varphi}. \tag{9}$$

We know that $\partial r(\varphi)/\partial\varphi > 0$ regardless of φ whereas $\partial r(\varphi)/\partial T < 0$ iff $\varphi > \widehat{\varphi}$ and $\partial r(\varphi)/\partial T > 0$ iff $\varphi < \widehat{\varphi}$. Thus, if $\varphi_x > \widehat{\varphi}$, then $\mathrm{d}\varphi_x/\mathrm{d}T > 0$. Stated differently, if all exporting firms exhibit a labor productivity higher than $\widehat{\varphi}$ (because fixed export costs are high), then the productivity cutoff for exporting decreases with falling input tariffs. In contrast, if $\varphi_x < \widehat{\varphi}$, then $\mathrm{d}\varphi_x/\mathrm{d}T < 0$. In other words, if the firms with a low productivity can export, then lower input tariffs reduce the probability of exporting. Hence, the occurrence of $\mathrm{d}\varphi_x/\mathrm{d}T > 0$ or $\mathrm{d}\varphi_x/\mathrm{d}T < 0$ depends on fixed costs, f_x (see Figures 2a and 2b). Indeed, φ_x is equal to 0 when $f_x = 0$ and rises when f_x increases while the rotation point $\widehat{\varphi}$ is not affected by changes in f_x. Thus, there is a fixed level of export costs $\widehat{f_x}$ which is defined as $\widehat{f_x} \equiv r(\widehat{\varphi})/\sigma$ so that if $f_x = \widehat{f_x}$, then $\varphi_x^* = \widehat{\varphi}$.

Figures 2a & 2b about here: Impact of T on φ_x with respect to fixed export costs.

When fixed export costs are higher than the critical level $\widehat{f_x}$ (see Figure 2a), we have $\varphi_x > \widehat{\varphi}$ so that φ_x decreases with a decrease in T. In other words, a reduction in input tariffs allows some non-exporting firms to enter foreign markets. In addition, when $f_x > \widehat{f_x}$, export sales increase with lower input tariffs, regardless of labor productivity of exporting firms (see Figure 2b). However, the value of export sales increases in a higher proportion for more productive firms. In other words, the level of export sales and the market share of more productive increases with input trade liberalization.

In contrast, when fixed export costs are low enough, $f_x < \widehat{f_x}$ (see Figure 2b), we have $\varphi_x < \widehat{\varphi}$ so that φ_x increases with a decrease in T. In other words, a reduction in input tariffs forces some low productivity firms to exit foreign markets. Further, when $f_x < \widehat{f_x}$, a decrease in T increases the value of exports for firms with high productivity (such that $\varphi_i > \widehat{\varphi}$) and decreases the value of exports for firms with a low labor productivity (such that $\widehat{\varphi} > \varphi_i > \varphi_x$), as illustrated in Figure 2a. Hence, when fixed export costs are low enough ($f_x < \widehat{f_x}$), more productive firms increase their exports at the expense of less productive exporting firms when input tariffs decrease.

To sum up, our framework show that lower input tariffs lead to reallocation of export sales from low productivity firms to high productivity firms. In addition, it appears that a fall in input tariffs increases the probability of exporting and export sales, provided that fixed export costs are high. However, if fixed export costs are relatively low, a fall in input tariffs decreases the probability of exporting and increases export sales of more productive producers at the expense of less productive firms (their export sales decline).

2.5 Discussion

Our main results hold as long as the price set by high productivity firms react more to a change in input tariffs than the price set by low productivity firms (lemma 1). This result holds as long as labor and intermediate products are not combined in a Cobb-Douglas technology.[3] For example, if we consider they are combined according to the CES aggregator, we obtain the same result. In this case, the marginal cost is given by $\{(w/\varphi)^{\zeta-1} + [\alpha(1+T)\overline{z}]^{\zeta-1}\}^{1/(\zeta-1)}$ where ζ is the elasticity substitution between labor and the intermediate product. Then, it is easy to check that, in this case,

$$\varepsilon_{p(\varphi),T} = \frac{[\alpha(1+T)\overline{z}]^{\zeta-1}}{(w/\varphi)^{\zeta-1} + [\alpha(1+T)\overline{z}]^{\zeta-1}} \frac{T}{1+T}$$

increases with labor productivity as long as $\zeta > 1$.

In addition, we could consider that the intermediate products differ in quality and are not homogeneous. Under this configuration, the marginal cost could be given by $w/\varphi + \{\int_\Lambda [a_i(1+T)z_i^w]^{\xi-1} \mathrm{d}i\}^{1/(\xi-1)}$ where ξ is the elasticity substitution between intermediate inputs, Λ is the set of inputs used by the firm, a_i is the quality parameter for a differentiated intermediate good i and z_i^w is the world price of the intermediate good with a quality i. Again, under this configuration, the price set by high productivity firms reacts more to a change in input tariffs than the price set by low productivity firms.

Further, we can consider that firms are heterogeneous in the use of the intermediate product. In other words, we can also assume that each firm draws α randomly from a common distribution. In this case, the price elasticity to a change in input tariffs increases with labor productivity, that is $\varepsilon_{p(\varphi_1,\alpha_1),T} > \varepsilon_{p(\varphi_2,\alpha_2),T}$ with $\varphi_1 > \varphi_2$, provided that:

$$\frac{\alpha_1}{(1+T)\bar{z}\alpha_1 + w/\varphi_1} > \frac{\alpha_2}{(1+T)\bar{z}\alpha_2 + w/\varphi_2} \tag{10}$$

or, equivalently, $\varphi_1/\varphi_2 > \alpha_2/\alpha_1$. If the ranking of firms with respect to labor productivity corresponds to the ranking of firms according to the intermediate input productivity

[3]With a Cobb-Douglas technology, the output price elasticity to a change in intermediate product price does not differ among firms.

$(1/\alpha)$, a sufficient condition is that heterogeneity in labor productivity be higher than heterogeneity in intermediate input productivity. More generally, inequality (10) means that the share of expenditure for the intermediate good in the total production cost must increase with labor productivity to obtain a positive relationship between $\varepsilon_{p(\varphi),T}$ and T.

Finally, we could also extend our framework by introducing import fixed costs. In this case, the more productive firms can import cheaper inputs while the less productive firms purchase more expensive inputs produced domestically. As a result, the exporting firms importing inputs gain much more from lower input tariffs when a fraction of exporters does not import.

3 Empirical model and estimation strategy

In this section, we precise how we test the main predictions of our model concerning the impact of input tariffs on the export sales at the firm level. More precisely, we test whether lower input tariffs induce a reallocation of export sales across firms and its consequences in terms of probability of exporting. In section 2, we have shown the effect of input trade liberalization depends on labor productivity and fixed export costs. Although data on fixed export costs are not available, we can check the validity of the main predictions by estimating an export sale equation taking into account the selection of firms into export markets. We proceed in two stages.

We first estimate the following system of equations:

$$\begin{cases} \Pr(r_{ist} > 0) = \Phi(\gamma_0 + \gamma_1 \ln T_{st} + \gamma_2 \ln \varphi_{it} + \gamma_3 \ln T_{st} \ln \varphi_{it} + \gamma_4 C + \gamma_5 \ln H_{st} + \varepsilon_{it}) \\ \ln r_{ist} = \beta_0 + \beta_1 \ln T_{st} + \beta_2 \ln \varphi_{it} + \beta_3 \ln T_{st} \ln \varphi_{it} + \beta_4 C + \nu_{it} \end{cases} \tag{11}$$

where subscripts i and s refer to firm i belonging to sector s, and t is the year. The variable r_{ist} is the value of total exports and T_{st} is the tariff on inputs processed by firms belonging to sector s, and φ_{it} is the labor productivity of firm i at time t where C represents control variables (time dummies, sector dummies, output tariff, number of exporters located in the same area...) and H_{st} is a selection variable (discussed below). Parameters γ_0, γ_1, γ_2, γ_3, γ_4 and γ_5 as well as β_0, β_1, β_2, β_3, and β_4 are the coefficients to be estimated. From our framework, we expect firms with high labor productivity to gain (resp., lose) more when tariffs on inputs decrease (resp., increase), regardless of fixed costs, i.e. we expect $\beta_3 < 0$. It should be also noted that we expect that γ_2 and β_2 are positive in accordance with the standard literature on the relationship between productivity and exports. More productive firms are more likely to export and do tend to export more.

Second, we check that the sign of the total effect of input tariff on exports, given by

$$\Gamma(\varphi_{it}) \equiv \frac{\mathrm{d}\ln r_{ist}}{\mathrm{d}\ln T_{st}} = \beta_1 + \beta_3 \ln \varphi_{it}, \tag{12}$$

is consistent with γ_1, the sign of the coefficient associated with T_{st} in the probability of exporting $P(r_{ist} > 0)$. Indeed, we have shown that, when fixed export costs are relatively *high*, the probability of serving foreign markets decreases with T_{st} ($\gamma_1 < 0$) and all firms gain from a fall in tariffs on inputs ($\Gamma(\varphi_{it}) < 0$). In other words, we must have $\Gamma(\varphi_{it}) < 0$ regardless of firms' labor productivity if $\gamma_1 < 0$.

However, when fixed export costs are relatively *low*, the probability of serving foreign markets increases with T_{st} ($\gamma_1 > 0$) and the total effect of input tariff on firms' exports is negative only for more productive firms. Hence, if $\gamma_1 > 0$, we must have $\Gamma(\varphi_{it} > \widehat{\varphi}) < 0$ and $\Gamma(\varphi_{it} < \widehat{\varphi}) > 0$ where the critical productivity level $\widehat{\varphi}$ is given by

$$\widehat{\varphi} = \exp(-\beta_3/\beta_1)$$

with $\max \varphi_{it} > \widehat{\varphi} > \min \varphi_{it}$.

Thus, the model is rejected if $\Gamma(\varphi_{it}) > 0$ for some observations and $\gamma_1 < 0$ or if $\Gamma(\varphi_{it}) < 0$ regardless of φ_{it} and $\gamma_1 > 0$. Table 1 summarizes the checks made in the second stage.

Table 1 about here

4 Data and variables

We use data on Food processing firms located in France. In 2009, France is the first agricultural producer in Europe (with a total of €61 billion) and is the second European producer of agrifood goods, with a total of €125 bn. France is also the fourth exporter in the world of agrifood and agricultural products with a total of €47.2 bn, which represents more than 6% of the world export market share.[4] In the last two decades, tariff barriers at European borders for agricultural products which are mainly processed by the agrifood firms decreased considerably. EU agriculture policies changed fundamentally due to international pressure and internal policy. Product price gaps between EU and world

[4]The food and agriculture industry generates around 13% of the value added of French industry as a whole and accounts for 1.7% of the French gross domestic product and 7.1% of French exports.

market levels have declined substantially. For example, between 1995 and 2002, tariff barriers for agricultural products at European borders decreased by 30% and French imports of agricultural commodities increased by 25% (Bagoulla et al., 2010). Note also agricultural tariffs vary greatly with respect to agricultural commodities.

4.1 Firm data

Our main data source is the annual survey of firms (EAE) provided by the French National Institute of Statistics. This is a compulsory survey of all firms located in France with more than 20 employees or with total sales of over 5 million €. The EAE database captures a wide range of variables including total sales, total export sales, value added, the number of employees, capital, investment, expenditures for intermediates and some accounting data as well as the main activity of the firm at the 4-digit industry level (NACE code). Hence, the dependent variable is total export sales at the firm level.

From this database, we evaluate the firm's labor productivity. Labor productivity is measured by computing the ratio of value added to the number of employees at the firm level. However, we need to check whether our results are robust to a change in the measure of productivity. In order to check the robustness of our results, we also calculate the TFP for each firm using Olley and Pakes' methodology (1996) as well as the ratio of total sales to the number of employees.

4.2 Tariffs

Tariffs come from the DbTAR database which includes ad-valorem equivalent of MFN tariffs as tariffs of preferential agreements at the European border for agrifood and agricultural products (nc8) over the period 2001-2004[5]. The major issue is to calculate the input tariff associated with each agrifood firm. Ideally, we would use information on the structure of intermediate consumption for each firm. Unfortunately, such data are not available. Nevertheless, it is possible to identify the different inputs used and their proportion for each 4-digit industry (the EAE survey gives the main activity of the firm at the 4-digit level). As a result, we can compute the tariff applied at entry to the European market associated with each bundle of intermediate products processed by the 4-digit industry. The agrifood sector is divided into 41 4-digit industries. The variation in input tariffs is mainly due to the variation in protection across 4-digit industries.

[5] See Gallezot, 2005.

4.2.1 Input identification.

Because there is no input/output table at a disagregated level in France, we have to build our own input-output table. To determine the set of products k processed by a 4-digit industry s, denoted by Ω_s^k, we use the French Customs Register which gives imports of all French firms, by product (at the 8-digit level of the combined nomenclature) in value and quantity. We have selected all the agri-food firms included in the EAE survey. We identify all products imported by a given 4-digit industry using imports and main activity of firms included in the EAE survey. Knowing the main activity of the firm (NACE 4-digit) from the EAE survey, we identify all products imported by a given 4-digit industry. Note that a product is considered as a potential input of the industry if at least one firm of this industry imports this product over the period. Among those imported goods, we drop some of goods which are identified as output of the 4-digit industry.[6] Hence, we obtain a bundle (Ω_s^k) of intermediate products associated to each agri-food industry.[7]

4.2.2 Input tariff at the European border.

Further, we must calculate tariffs applied to each product k at the European border at time t, denoted by T_t^k. Such a calculation is computed in two steps. First, we use the TARIC database (European Commission, DG Taxation and Customs Union) where all tariff measures potentially applied to each country by the European Union are reported.[8] From this database, we compute an ad-valorem equivalent tariff at the 8-digit level per country of origin j (T_{jt}^k) and for the year t. By this way, our measure takes into account not only MFN tariff but also preferential trade agreements between EU and foreign countries.[9]. Second, we must compute an average tariff at the 8-digit level at the European border

[6] For that, we use a correspondence table from Ramon metadata (Eurostat)

[7] Note that we do not consider the inputs which are not imported and are locally sourced exclusively. In this case, the firms can be weakly sensitive to a change in input tariffs if the share of inputs which are exclusively sourced in France is elatively high. However, as we will see in Section 5, our results show that our proxy for input tariffs plays a significant role, even if our regressions concern only the non-importing firms.

[8] Note that for each country, we take the lowest tariff applied at entry to the EU, considering that exporters choose systematically the most favorable agreement. Indeed, exporting countries to the European Market may benefit from different tariffs depending on their trade agreements with EU.

[9] A simplest method could be to assess the protection level on the basis of the Most Favored Nation (MFN) tariff only. All countries belonging to the WTO are submitted to this tariff which is the highest tariff countries face. With this MFN tariff, we miss all trade agreements between European countries and their partners. However, over the considered period, trade liberalization came more from bilateral or regional trade agreements than from multilateral negotiations.

T_t^k. In the literature, most papers use an average of tariffs weighted by the share of the country in European imports. This measure is biased since it excludes from the measure all the countries which cannot export due to prohibitive tariffs (Bouet et al., 2008). Our strategy is to introduce the potential effect of a decrease of tariffs, even for countries which are not able to export to the European Market due to high tariffs. Thus, our measure T_{jt}^k is weighted by the potential supply of country j relative to the world potential supply for product k. The potential supply of country j is measured as the exports of country j (X_j^k) divided by the distance between this country and France ($Dist_j$).[10] We compute T_t^k as follows:

$$T_t^k = \frac{\sum_j \left(\frac{X_j^k}{Dist_j} T_{jt}^k \right)}{\sum_j \frac{X_j^k}{Dist_j}}.$$

Last, knowing the protection at the 8-digit level at the European border (T_t^k) and the different 8-digit inputs of the bundle (Ω_s^k) processed by 4-digit industries, we compute the tariff for each bundle of inputs (T_{st}). However, we must take into account that the weight of each input within a bundle is not equal. As a result, we consider that the share of inputs in the industry imports reflects the relative importance of inputs in the production process. Consequently, we propose to weight the tariffs calculated at the product level by the share of imports of inputs (M_s^k) at the 4-digit industry level. In order to avoid variations over the period concerned, the weight used in the average is calculated from the total imports over the period 2001-2004.[11] Hence, we have

$$T_{st} = \sum_{k \in \Omega_s^k} \left(\frac{T_t^k M_s^k}{\sum_{k \in \Omega_s^k} M_s^k} \right)$$

where T_{st} is the applied tariff associated with the input bundle of a 4-digit industry s at time t and M_s^k is the imports of product k by industry s.

4.2.3 Alternative measures of input tariffs.

To check the robustness of our results, we consider other measures of input tariffs. The first alternative measure is based on the Most Favoured Nation (MFN) tariff. This tariff is

[10] Data on exports come from BACI database which is United Nations Commodity Trade Statistics Database (Comtrade) harmonized by the Centre for Prospective Studies and International Information (CEPII), which gives the bilateral trade at world level for each product (HS 4-digit level) in value and quantity.

[11] Note that some of inputs are not imported each year. Hence, ur tariff computation allows us to take into account all inputs imported over the period. In addition, weights are computed according to the mean value of imports so that the structure of the bundle is given over the period.

the same for all countries. By using the strategy mentioned above, we obtain the following index

$$T_{st}^{MFN} = \sum_{k \in \Omega_s^k} \left(\frac{T_t^{k^{MFN}} M_s^k}{\sum_{k \in \Omega_s^k} M_s^k} \right)$$

The second alternative measure is commonly used in the trade literature: tariffs are weighted by the share of the trading partner in the total imports of the EU. Thus, only tariffs applied to countries that export to the EU are taken into account. Using the same methodology, the tariff of the input bundle is given by:

$$T'_{st} = \sum_{k \in \Omega_s^k} \left(\frac{T_t^{k\prime} M_s^k}{\sum_{k \in \Omega_s^k} M_s^k} \right)$$

where T_{jt}^k is the tariff at the 8-digit level applied to country j at the European border given by:

$$T_t^{k\prime} = \sum_j \left(\frac{M_j^k}{\sum_j M_j^k} T_{jt}^k \right)$$

with M_j^k the EU imports of product k from country j.

4.3 Selection variable

We have to account for the selection of firms into export markets. To do so, we need a selection variable. A firm exports if and only if $r_i/\sigma > f_x$ (see section 2). Ideally, we would use the fixed export cost as the selection variable because it influences the decision to export but does not affect the level of exports. Unfortunately, data on factors that directly influence fixed export costs are not available. However, we know empirically that fixed export costs are incurred by the firm before it benefits from export sales. This means that a firm is more likely to export when its profit on the domestic market is high enough. Indeed, when a firm decides to enter the foreign market, it has to paid fixed export costs. Thus, the higher its profit on domestic market, the higher its ability to pay these fixed export costs. Because domestic profits decrease with the degree of competition on the domestic market, the lower the competition on the domestic market, the higher the level of profits and the higher the ability of firms to pay fixed export costs. In other words, because we do not have proxy for fixed export costs, we use a variable measuring on the ability of firms to pay these fixed costs. To capture this effect, we use the following Herfindhal index

$$H_{st} = \sum_i \left(\frac{y_d(\varphi_{ist})}{\sum_i y_d(\varphi_{ist})} \right)^2$$

where $y_d(\varphi_{ist})$ represents the domestic sales of firm i of industry s at time t which represent the ability of firms to pay these fixed export costs.

4.4 Descriptive statistics

The final dataset is an unbalanced panel of 3,716 exporting and non-exporting firms over the period 2001-2004 with a total of 12,531 observations. Table 2a lists some descriptive statistics concerning our main variables. The three first variables are computed at the 4-digit industry level. Input tariffs vary greatly across industries with an average of 24.5% for the whole agrifood sector. Agri-food industries also differ with respect to their labor productivity. Further, for a considerable proportion of firms, the share of intermediate consumption in their total costs is relatively high. On average, intermediate consumption accounts for nearly 85% of the total costs of a firm (intermediate consumption plus wages and salaries).

We compute quartile at the 3-digit industry level in order to understand the relationship between export performance and labor productivity (table 2b). Thus, Q1 represents all firms belonging to the first quarter of their 3-digit industry according to their labor productivity level. Table 2b shows that the average export rate and the share of exporting firms increase with average labor productivity. In other words, more productive firms export more and are more likely to export, as expected.

Table 2a & 2b about here

Our dataset supports one of our main hypotheses. Remember that in our theoretical model, because labor and intermediate good are not combined with a Cobb-Douglas technology, the more productive firms are more impacted by changes in input tariffs. This is due to the fact that the share of intermediate goods in the total cost increases with an increase in labor productivity. From our sample, we find that firms with higher productivity have higher ratio of intermediate consumption to production costs. Table 3 contains two regressions showing the correlation between ratio of intermediate consumption to production costs and labor productivity for French agrifood firms. Each regressions control for year fixed effects and 3-digit industry fixed effects. Whatever the measure of labor productivity, *the* ratio of expenditure for intermediate products to total cost *increases with an increase in labor productivity.* Our data supports the idea that the more productive firms should be more sensitive to a change in input prices.

Table 3 about here

Our data also reveal that the ratio of exports by the top 20% of firms with the highest labor productivity to total export within 4-digit industries decreases with a decrease in input tariffs. In other words, without controlling for the impact of the other factors, a fall in input tariffs appears to lead to reallocation of exports from low productivity firms to high productivity firms, as suggested above.

Figure 3 about here:

Export market share of the top 20 percent most productive exporters against input tariffs.

5 Results

Here we estimate the system of equations (11). Because we have a selection problem, we use a Heckman procedure where the model (11) is estimated by maximum likelihood. Tables 3 and 4 show the results of these estimations. From an econometric point of view, the two steps in modelling (selection procedure through probit and regression on exports) are interdependent (the inverse Mills ratio is statistically significant), regardless of estimations, which justifies the use of the Heckman procedure. Moreover, the coefficients associated with the Herfindhal index are all significant only for the export decision and have the expected sign, which highlights different processes involved in the selection and in the level of exports. It should also be noted that all estimations control for year fixed effects and 3-digit industry fixed effects and robust standard errors are corrected for clustering at the industry-year level.

We begin by commenting the effects of the control variables. The results are in accordance with the current literature. The sign of the coefficients associated with labor productivity (whatever its proxy) are in line with expectations from the literature on the impact of productivity on exports, regardless of estimations. The higher the productivity of a firm, the higher its probability of exporting ($\gamma_2 > 0$), and the higher its export value ($\beta_2 > 0$). Like in Amiti and Konings (2007), we also control for the effect of output tariffs on export decisions and export revenues. Indeed, a decrease in output tariffs at the EU border may force less productive firms to exit the domestic market and thus mechanically increase the probability of exporting.[12] As expected, higher output tariffs at the EU border raise export sales and the probability of exporting. Further, as in Mayneris et al. (2010), we have included the number of firms located in the same area (the Département) and exporting the same type of product (i.e. belonging to the same 4-digit industry) in our regressions[13]. This variable captures the presence of local export spillovers. It appears that the number of exporters (Local Spillover) affects the probability of exporting as well as the export sales.

Because we focus on the effect of input tariffs, we must also control for the fact that some firms in each sector do not import intermediate products. The gains from input trade liberalization could be different whether firms import or not. Indeed, whether the importing firms are directly impacted by changes in input tariffs, the non-importing firms enjoy indirectly lower input tariffs since domestic and imported input prices move together (Amiti and Konings, 2007; Kugler and Verhoogen, 2009; Auer and Fischer, 2010; Auer et al., 2010). In addition, imported and domestically sourced intermediate inputs could be different in quality. To this end, we introduce a dummy variable controlling for import status in each equation of the system (11). Firms are importers if they import any of their intermediate products. The results listed in Tables 3 and 4 show that importing firms are more likely to export and export more than non-importing firms (as highlighted in Bas, 2009, from data on Chile and Argentina's manufacturing sector).

5.1 Input tariffs, export status and exports

We now focus on the impact of input tariffs on export status and the level of export sales and discuss the results given in Table 4. According to the results in column I and II of Table 4, the coefficient associated with the interaction term (β_3) is negative and significant for the level of exports, regardless of the variable measuring labor productivity. As predicted by the theoretical model, the effect on exports of changes in input tariffs depends on the level of labor productivity of the firm concerned. In addition, the more productive firms are more impacted by a decrease in input tariffs. In other words, input trade liberalization appears to lead to reallocation of exports from less productive firms to more productive firms. This reveals that downstream firms react differently to lower input tariffs according to their labor productivity. In addition, this reallocation process revealed by our estimations and, as shown by our data, the fact that the more productive

[12]The measure of output tariffs at the European border is calculated by using the same methodology applied to the measure of input tariffs.

[13]The metropolitan France is divided into 96 Départements

firms use relatively more intermediate goods (see Table 3), confirm that the prices set by the more productive firms seem to decline in higher proportion than the prices determined by the low productivity firms when input tariffs decrease.

In addition, in column I and II of Table 4, the coefficient associated with input tariff (γ_1) is positive while the marginal crossed effect on the probability of exporting is not significant. Note that we cannot directly interpret the sign and the significance of the coefficient associated with the crossed variable (γ_3) because the probit model is not linear. Following the methodology of Ai and Norton (2003), we calculate the real marginal effect on the regression I and test the significance for each observation. The test concludes that the crossed effect is not significant for all observations (see Appendix B). Hence, a fall in input tariffs decreases the probability of exporting.

Table 4 about here

Let us now turn to the consistency of the signs of the coefficients associated with input tariffs in the selection equation and in the exports equation in the light of our theoretical model. According to our theoretical predictions, the positive sign of γ_1 (a fall in input tariffs decreases the probability of exporting) suggests that in the French agrifood sector, fixed export costs are relatively low. Thus, as illustrated by Figure 2b, we would expect the most productive firms to gain from lower input tariffs and the less productive firms to be negatively impacted. We determine the total effect of input tariffs on exports $\Gamma(\varphi_{it})$ from the results of the estimation in column I of Table 3 (labor productivity measured as the ratio of value added to employment). Hence, we have $\Gamma(\varphi_{it}) = 1.208 - 0,304 \ln \varphi_{it}$ which is illustrated from our data in Figure 4 for year 2004. It appears that the rotation point $\ln \widehat{\varphi} = 3.974$ (given by $\Gamma(\varphi_{it}) = 0$) with $\max \varphi_{it} > \widehat{\varphi}_t > \min \varphi_{it}$ (of exporting firms). Hence, Γ is positive for less productive firms with a labor productivity inferior to $\ln \widehat{\varphi} = 3.974$ and negative for more productive firms ($\ln \varphi_{it} > 3.974$). In other words, the coefficients associated with input tariffs in the export equation and in the selection equation are consistent ($\gamma_1 > 0$ and $\max \varphi_{it} > \widehat{\varphi}_t > \min \varphi_{it}$). In accordance with our theoretical model, all other things being equal, a fall in input tariffs would reduce the number of exporting firms and lead to reallocation of exports from low productivity firms to high productivity firms.

Figure 4 about here: Total effect of T on export level against labor-productivity.

5.2 Alternative measures

We now check if our results hold when we use other measures for input tariffs, productivity or exports. Results are listed in column III, IV, and V of Table 4 and in Table 5. In the estimation of systems III and IV, we use two alternative measures of input tariffs. In system III, only tariffs of the most favoured nation (MFN input tariff) are taken into account (preferential tariffs are excluded from our calculations). Results show that coefficients associated with input tariffs are no longer significant in the selection equation, but remain significant in the export equation. Such a result reveals that we need to account for all the preferential trade agreements in the calculation of input tariffs. In the estimation of system IV, we consider another strategy of aggregation of tariffs widely used in literature (only tariffs applied to EU partners are taken into account and are weighted by the share of the country in EU imports). Our main conclusions hold, but the overall impact of tariffs is reduced.

In addition to alternative measures of input tariffs, we need to check if our results are robust to a change in the measure of productivity. Instead of labor productivity, we use the total factor productivity (TFP) of firms, calculated according to the method of Olley and Pakes (1996). When TFP is considered instead of labor productivity (see system V in Table 4), our main results remain in accordance with our predictions. There is still a reallocation process of foreign market share due to input trade liberalization from less productive firms to more productive firms and the probability of exporting decreases with falling input tariffs.

Table 5 about here (3 x 2 estimations)

Finally, we implement the same regressions reported in Table 4 except that the dependent variable becomes the ratio of exports of firm i to total exports of 4-digit industry s. Here the aim is to account for the heterogeneity of the level of exports at the 4-digit industry level. Indeed, some 4-digit industries export much more than others, which can lead to misspecification. The results are given in Table 5. The selection equation is the same as the equation reported in Table 4. Concerning the export share equation, all coefficients are significant and have the expected sign. The reallocation process of the share of exports between firms at the expense of less productive firms is at work again.

All these results do not invalidate the predictions highlighted by our theoretical model. In the agrifood industry, input trade liberalization has a negative impact on the probability of exporting and leads to reallocation of export sales from less productive firms to more productive ones.

It is worth stressing that our results confirm also our choice to select a production function which is not a Cobb-Douglas technology. Remember that, with a Cobb Douglass function, there would not be no reallocation mechanism of export sales between firms in our theoretical framework (see subsection 2.5). Since our empirical analysis suggests that more productive firms gain from input trade liberalization at the expense of the less productive firms, this reveals indirectly that a Cobb-Douglas function does not fit the data well, as shown convincingly in Raval (2011). Within a 4 digit industry, the author shows that US manufacturing plants have large differences in their labor shares while Cobb-Douglas production function implies that firm productivity does not affect the relative proportions of factors that are used by the firm. In addition, his study reveals that firms with higher value added have lower labor shares. Our data share the same properties and our empirical results confirm this finding.

5.3 The magnitude of the input tariff effects on export sales and jobs

We now give the magnitude of the effects a lower input tariffs on export sales and employment. We do not use the coefficients associated with the estimation using the TFP measure. Indeed, TFP is calculated by using the Olley and Pakes methodology, i.e. by assuming a Cobb-Douglas function. However, our empirical results reject implicitly that the production functions in our data are characterized by Cobb-Douglas technologies. In addition, TFP measures based on Olley and Pakes methodology are also likely to be biased because non-neutral productivity is not taken into account (Raval, 2011). For example, Raval (2011) shows neutral productivity may be not correlated with plant size. To assess the magnitude of the input tariffs effects, we use the estimates obtained in system I because it can be considered as the preferred empirical method.

We simulate the impact of a fall by ten per cent in input tariffs applied to all sectors. The reference year is 2004 (the last year in our data). In our data, there are 1332 exporting agrifood firms with 234972 jobs and the total export sales reached around 20 billions euros (19 284 728 euros). Our result suggests that, all other things being equal, about 45% of more productive exporting firms can potentially gain from agricultural trade liberalization (i.e. the share of firms with $\Gamma(\varphi_{it}) < 0$). The firms gaining from input trade liberalization hired the majority of employees in the sector (53%) and their export sales represent more than 70% of aggregate export value in 2004. In other words, whether a large proportion

(55%) of French agrifood exporting firms may loose from liberalization of agricultural goods trade, this negative effect of lower input tariffs is lower in terms of jobs.

Let r^e_{is} be the expected export sales of firm i due to a fall by 10% in input tariffs (ceteris paribus) with

$$r^e_{is} = e^{\Gamma(\varphi_{it}) \ln 0.9} r_{i0}$$

where r_{i0} is the level of export sales of firm i in Year 2004. To evaluate the impact on employment we apply a simple rule of three. Knowing the number of employees per firm in 2004 (denoted by l_{i0}) and the ratio of export sales to employment (r_{i0}/l_{i0}) at the firm level (this ratio is assumed to be constant), we can evaluate the expected level of jobs for each firm ($l^e_{is} = r^e_{is} l_{i0}/r_{i0}$). Our results are reported in Table 6. It appears a fall by ten per cent in input tariffs induces a rise in total export sales by 1,5% and in employment by 0,1% if no firms exit from the export markets.[14][15] For the winning firms, the export sales increase by 2,6% (358485/13610937) and employment by 0,5% (620/124058).

Table 6 about here

To sum up, even if lower input tariffs induce a rise in *total* export sales and in *total* employment, input trade liberalization may weaken a large fraction of firms. These exporting firms losing from lower input tariffs represent a low share in terms of export sales but hire a non negligible share of workers due to their low labor productivity.

5.4 Price effect *versus* variety effect

In this paper, we consider that falling input tariffs lower production costs through a decline in prices of existing imported inputs. However, as mentionned in Goldberg et al. (2010), more input varieties can be imported when input tariffs decline. Our theoretical approach focuses on the former effect (price effect) whereas Goldberg et al. (2010) highlights the role played by the latter effects (variety effect). Unfortunately, our data do not enable us to assess directly the two effects. However, our results suggest that the first is not negligible. Indeed, the price effect is profitable not only for importing firms but also for non-importing firms because domestic and imported input prices are positively correlated (Amiti and Konings, 2007; Kugler and Verhoogen, 2009; Auer and Fischer, 2010; Auer et al., 2010). In addition, only the importing firms benefit from the variety effect. Hence, whether

[14] Note that 1,5%=(358484-71276)/19284728 and 0,5%=(620-319)/234972.

[15] A fall of 10% in input tariff does not lead to negative export sales for any firm. However, some firms may exit if there exists a threshold level of exports to stay in the export market

the price effect is not at work, the reallocation from less productive to more productive non-importing firms would not be checked when input tariffs decline. However, when we perform our regressions by selecting exclusively the non-importing firms (see Table 7), it appears that the probability of exporting declines with falling input tariffs and the export sales of the more productive non-importing firms at the expense of the other firms (see Table 7). These results confirm that the first effect is at work. Regardless of subsample (importing firms or non importing firms), there is a reallocation of export sales from the less productive firms to the more productive firms and lower input tariffs do not increase the probability of exporting.

Table 7 about here

Note that the recent literature on the effect of input tariffs concerns developing countries while we study firms located in France. It is not surprising that the variety effect is strong in the developing countries because the growth of new imported variety (products that had not been imported prior to the trade reforms) is substantial (see for example Goldberg et al., 2010). In more developped countries, the price effect should be higher. The importance of the variety effect relative to the price effect of input trade liberalization merits more attention. Exploring the relationship between the number of new products and input tariffs is beyond the scope of our analysis. This is an area for future research. Our contribution to the literature is to show that only more productive firms gain from input trade liberalization.

6 Conclusion

We have studied the impact of input tariffs on export status and export performances. From a theoretical model with heterogeneous firms, we show that changes in input tariffs do not have a clear impact on the export level and export decision of food processing firms. The effect depends on fixed export costs. When fixed export costs are low enough, a fall in input tariffs decreases the probability of entering foreign markets and leads to reallocation of exports from low productivity firms to high productivity firms. Export sales of high productivity firms increase while export sales of low productivity firms decrease. When fixed export costs are high enough, lower input tariffs increase both the probability of exporting and the export sales of all firms. Nevertheless, the most productive firms gain more than the least productive firms. This model can be applied to all processing industries that use a fixed proportion of intermediate goods to produce a differentiated output. We then compared the predictions of the theoretical model to firm-level data on the food sector in France. Our empirical findings do not invalidate the conclusions of our theoretical model. It appears that whether liberalization of agricultural trade induced a rise in total export sales and in total employment, its effects vary according to firms. More precisely, lower tariffs in the agricultural sector favored the exit of French firms from foreign markets and increases export sales of more productive firms at the expense of less productive firms. These exporting firms losing from lower input tariffs represent a low share in terms of export sales but hire a non negligible share of workers due to their low labor productivity.

In our approach, we consider that the total mass of firms is given (only the share of exporting firms is endogenous). It would be interesting to explore the impact of input trade on domestic market structure. For example, our approach could be extended to theoretically and empirically analyze the impact of input trade liberalization on entry-exit decisions of domestic firms.

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A The impact of T on r_i

The price index in a foreign country is given by:

$$P_x = MG^{\frac{1}{1-\sigma}} \tag{13}$$

where M is the mass of firms in each country which is assumed to be identical in each country and

$$G \equiv \int_0^{\infty} p(\varphi)^{1-\sigma} g(\varphi) \mathrm{d}\varphi + n\tau^{1-\sigma} \int_{\varphi_x}^{\infty} p(\varphi)^{1-\sigma} g(\varphi) \mathrm{d}\varphi$$

where the first term corresponds to the price of varieties produced in the foreign country and the second term corresponds to the price of varieties imported from the other countries. Standard calculations reveal that:

$$\varepsilon_{P_x,T} = \frac{\alpha \bar{z} T}{\rho} \frac{\tau^{1-\sigma} \int_{\varphi_x}^{\infty} \frac{p(\varphi)^{1-\sigma}}{p(\varphi)} g(\varphi) \mathrm{d}\varphi}{G}$$

Knowing that

$$\varepsilon_{p(\varphi_i),T} = \frac{\alpha \bar{z} T}{\rho} \frac{1}{p(\varphi_i)},$$

we have:

$$\varepsilon_{P_x,T} - \varepsilon_{p(\varphi_i),T} = \frac{\alpha \bar{z} T}{G\rho} \left[\tau^{1-\sigma} \int_{\varphi_x}^{\infty} \frac{p(\varphi)^{1-\sigma}}{p(\varphi)} g(\varphi) \mathrm{d}\varphi - \int_0^{\infty} \frac{p(\varphi)^{1-\sigma}}{p(\varphi_i)} g(\varphi) \mathrm{d}\varphi - n\tau^{1-\sigma} \int_{\varphi_x}^{\infty} \frac{p(\varphi)^{1-\sigma}}{p(\varphi_i)} g(\varphi) \mathrm{d}\varphi \right]$$

B The crossed effect in the probit model

Ai and Norton (2003) show that interaction terms in probit models are frequently subject to misinterpretation in the literature due to the difficulty of computing and interpreting their coefficient and their significativity. Their demonstration is given below:

Let the dummy dependent variable y depend on two independent variables x_1 and x_2, their interaction. γs are unknown parameters.

The conditional mean of the dependent variable is:

$$E\left[y|x_1, x_2\right] = \Phi\left(\gamma_1 x_1 + \gamma_2 x_2 + \gamma_{12} x_1 x_2\right) = \Phi\left(\cdot\right)$$

where Φ is the standard normal cumulative distribution. Assume that x_1 and x_2 are continuous. The interaction effect is the cross derivative of the expected value of y:

$$\frac{\partial^2 \Phi\left(\cdot\right)}{\partial x_1 \partial x_2} = \gamma_{12} \Phi'\left(\cdot\right) + \left(\gamma_1 + \gamma_{12} x_2\right)\left(\gamma_2 + \gamma_{12} x_1\right) \Phi''\left(\cdot\right) \neq \gamma_{12} \tag{14}$$

There are four important implications of Eq.14 for nonlinear models.

1. The interaction effect could be non-zero, even if $\gamma_{12} = 0$. For the probit model with $\gamma_{12} = 0$, the interaction effect is:

$$\left.\frac{\partial^2 \Phi(\cdot)}{\partial x_1 \partial x_2}\right|_{\gamma_{12}=0} = \gamma_1 \gamma_2 \Phi''(\cdot)$$

2. The statistical significance of the interaction effect cannot be tested with a simple t-test on the coefficient of the interaction term γ_{12}.

3. The interaction effect depends on the independent variables, unlike the interaction effect in linear models.

4. The interaction effect may have different signs for different values of covariates. Consequently the sign of γ_{12} does not necessarily indicate the sign of the interaction effect.

In order to test the significativity and the sign of our interaction term in the selection equation, we use the methodology developed by Norton, Wang and Ai (2004) for Stata.

The table below give indicators for the interaction coefficients computed using the Ai and Norton procedure.

Table B.1 about here

The following figure gives the value of the interaction effect depending on the predicted probability. For most firms, the interaction effect is negative, which is consistent with our model. Indeed, as the interaction effect is negative for the export level of firms, we expect that the probability to export depends positively on the latent export level, and thus negatively on the interaction term. However, the second figure shows that the interaction term is not significant for a large proportion of our sample. It appears that the interaction effect is relevant only for firms with a higher probability of exporting.

Figures B.1 about here: Ai and Norton effects of interaction term

Figures B.2 about here: Ai and Norton significativity of interaction term

Table 1. Consistency of the model.

	$\alpha_1 < 0$ (High fixed costs)	$\alpha_1 > 0$ (Low fixed Costs)
$\varphi_x^* > \widehat{\varphi}$	consistent	*unconsistent*
$\max \varphi_{it} > \widehat{\varphi} > \varphi_x^*$	*unconsistent*	consistent

Table 2a. Summary statistics.

variables	mean	standard deviation	Q1	Median	Q3
Input tariff*	24.50%	13.06	12.69%	27.79%	32.03%
Export rate*	14.95%	12.03	8.36%	10.10%	19.08%
Share of exporting firms*	44.10%	18.60	26.22%	42%	61.25%
Labor Productivity	54.41	163.37	31.48	42.18	60
Intermediate consumption share in total cost	84.49%	12.94	81.06%	87.94%	92.91%

* at the 4-digit industry level.

Table 2b. Descriptive statistics with respect to labor productivity distribution.

3-digit sectoral quartile on labor-productivity	Average labor productivity	Average export rate	Exporting firms
$< Q1$	17.98	8.99%	38.25%
$[Q1; Q2]$	39.57	7.80%	39.68%
$[Q2; Q3]$	51.94	9.10%	45.73%
$> Q3$	108.56	14.16%	52.52%

Table 3. The share of intermediate consumption against productivity

ln (intermediate consumption/total costs)		
	(1)	(2)
ln (value added/employment)	0.07***	
ln (total sales/employment)		0.18***

Controls include 4-digit industry fixed effects and year fixed effect

Table 4. Econometric results.

	I		II		III		IV		V	
VARIABLES	Select.	Reg.	Select.	Reg.	Select.	Reg.	Select.	Reg.	Select.	Reg.
Input Tariff	0.271	1.208	0.544	1.265					0.302	0.569
	(0.134)**	(0.215)***	(0.213)**	(0.315)***					(0.106)***	(0.185)***
MFN Input Tariff					0.0414	1.100				
					(0.140)	(0.255)***				
UE weighted Input Tariff							0.229	1.099		
							(0.128)*	(0.179)***		
Labor Productivity (value added)	0.290	1.504			0.217	1.554	0.219	1.309		
	(0.0787)***	(0.149)***			(0.0935)**	(0.185)***	(0.0754)***	(0.130)***		
Labor Productivity (total sales)			0.473	1.439						
			(0.0962)***	(0.147)***						
TFP									1.255	7.063
									(0.288)***	(0.672)***
Input Tariff x Labor Producivity (value added)	-0.0523	-0.304								
	(0.0275)*	(0.0483)***								
Input Tariff x Labor Productivity (total sales)			-0.0823	-0.234						
			(0.0374)**	(0.0554)***						
MFN Input Tariff x Labor Productivity (va)					-0.0271	-0.292				
					(0.0289)	(0.0561)***				
UE Input Tariff x Labor Productivity (va)							-0.0295	-0.255		
							(0.0282)	(0.0439)***		
Input Tariff x TFP									-0.399	-0.869
									(0.0937)***	(0.291)***
Output Tariff	0.226	0.295	0.149	0.0836	0.252	0.294	0.226	0.301	0.249	0.106
	(0.0833)***	(0.0803)***	(0.0792)*	(0.0725)	(0.0808)***	(0.0835)***	(0.0719)***	(0.0720)***	(0.0846)***	(0.0761)
Local Spillover	0.263	0.165	0.254	0.109	0.262	0.170	0.257	0.145	0.270	0.113
	(0.0249)***	(0.0445)***	(0.0257)***	(0.0431)**	(0.0254)***	(0.0435)***	(0.0240)***	(0.0440)***	(0.0258)***	(0.0414)***
Import Dummy	0.450	0.601	0.413	0.498	0.435	0.619	0.469	0.610	0.493	0.451
	(0.0419)***	(0.0921)***	(0.0378)***	(0.0805)***	(0.0439)***	(0.0939)***	(0.0394)***	(0.0857)***	(0.0463)***	(0.0863)***
Herfindhal	0.244		0.289		0.183		0.264		0.242	
	(0.0675)***		(0.0617)***		(0.0597)***		(0.0557)***		(0.0681)***	
Constant	-2.170	1.331	-3.269	0.254	-1.749	1.271	-1.882	1.999	-1.904	3.655
	(0.511)***	(0.790)*	(0.664)***	(0.969)	(0.595)***	(0.981)	(0.460)***	(0.612)***	(0.451)***	(0.669)***
Observations		12,115		12,337		12,115		12,115		11,869‡
lambda		-0.703		-0.870		-0.632		-0.770		-0.780
rho		-0.428		-0.534		-0.389		-0.464		-0.497
sigma		1.642		1.628		1.626		1.661		1.569

‡ A lack of data needed to compute Olley and Pakes TFP reduces the number of observations.

Significance levels: * : 10% ** : 5% *** : 1% All regressions include industry fixed effects (3-digit) and year fixed effects.

Robust standard errors corrected for clustering at industry-year level in parentheses.

Table 5. Alternative econometric results.

VARIABLES	VI Select	VI Reg	VII Select	VII Reg	VIII Select	VIII Reg
Input Tariff	0.291	0.0889	0.574	0.0770	0.319	0.0372
	(0.135)**	(0.0205)***	(0.210)***	(0.0274)***	(0.102)***	(0.0150)**
Labor Productivity (value added)	0.293	0.116				
	(0.0829)***	(0.0147)***				
Labor productivity (total sales)			0.481	0.103		
			(0.0966)***	(0.0130)***		
TFP					1.253	0.538
					(0.292)***	(0.0547)***
Input Tariff x Labor Productivity (va)	-0.0534	-0.0253				
	(0.0288)*	(0.00468)***				
Input tariff x Labor Productivity (total sales)			-0.0840	-0.0163		
			(0.0372)**	(0.00479)***		
Input Tariff x TFP					-0.396	-0.0741
					(0.0942)***	(0.0227)***
Output tariff	0.211	0.00541	0.130	-0.00913	0.232	-0.00784
	(0.0800)***	(0.00665)	(0.0750)*	(0.00659)	(0.0800)***	(0.00703)
Local Spillover	0.263	0.00329	0.255	-0.00117	0.270	-0.000966
	(0.0247)***	(0.00327)	(0.0256)***	(0.00324)	(0.0256)***	(0.00314)
Herfindhal	0.260		0.306		0.258	
	(0.0605)***		(0.0532)***		(0.0602)***	
Import Dummy	0.449	0.0522	0.412	0.0451	0.491	0.0415
	(0.0417)***	(0.00627)***	(0.0376)***	(0.00529)***	(0.0458)***	(0.00566)***
Constant	-2.131	0.191	-3.260	0.143	-1.851	0.370
	(0.505)***	(0.0685)***	(0.651)***	(0.0808)*	(0.430)***	(0.0495)***
Observations		12,115		12,337		11,869‡
lambda		-0.0663		-0.0778		-0.0740
rho		-0.518		-0.611		-0.594
sigma		0.128		0.127		0.125

‡ A lack of data needed to compute Olley and Pakes TFP reduces the number of observations.

Significance levels: $*$: 10% $**$: 5% $***$: 1% All regressions include industry fixed effects (3-digit) and year fixed effects. Robust standard errors corrected for clustering at industry-year level in parentheses.

Table 6. The expect levels of export sales and jobs due to a fall by 10% in input tariffs

	Nb of firms	$\Sigma_i r_{i0}$	$\Sigma_i(r^e_{is} - r_{i0})$	$\Sigma_i l_{i0}$	$\Sigma_i(l^e_{is} - r_{i0})$
Winning firms	607	13 610 937	358 485	124 058	620
Losing firms	725	5 673 790	- 71276	110 914	- 319
Total	1 332	19 284 728	287 209	234 972	301

Table 7. Importing and non importing firms.

	IX		X	
	Importing Firms ‡		Non-Importing Firms	
VARIABLES	Select	Reg	Select	Reg
Input Tariff	-0.0123	0.989	0.695	0.986
	(0.145)	(0.355)***	(0.215)***	(0.370)***
Labor Productivity (va)	0.150	1.681	0.593	1.389
	(0.0778)*	(0.213)***	(0.158)***	(0.335)***
Input Tariff x Labor Productivity (va)	0.0126	-0.234	-0.157	-0.315
	(0.0319)	(0.0805)***	(0.0457)***	(0.0979)***
Output tariff	0.447	1.011	0.0177	0.206
	(0.0643)***	(0.111)***	(0.101)	(0.118)*
Local Spillover	0.214	0.284	0.266	0.329
	(0.0271)***	(0.0495)***	(0.0320)***	(0.0529)***
Herfindhal	0.106		0.357	
	(0.0378)***		(0.0749)***	
Import Dummy	0.154	0.633		
	(0.0536)***	(0.102)***		
Constant	-2.302	-4.352	-2.368	2.768
	(0.497)***	(1.150)***	(0.766)***	(1.344)**
Observations		5,317		6,798
lambda		1.708		-0.830
rho		0.849		-0.507
sigma		2.012		1.638

Significance levels: $*$: 10% $**$: 5% $***$: 1%

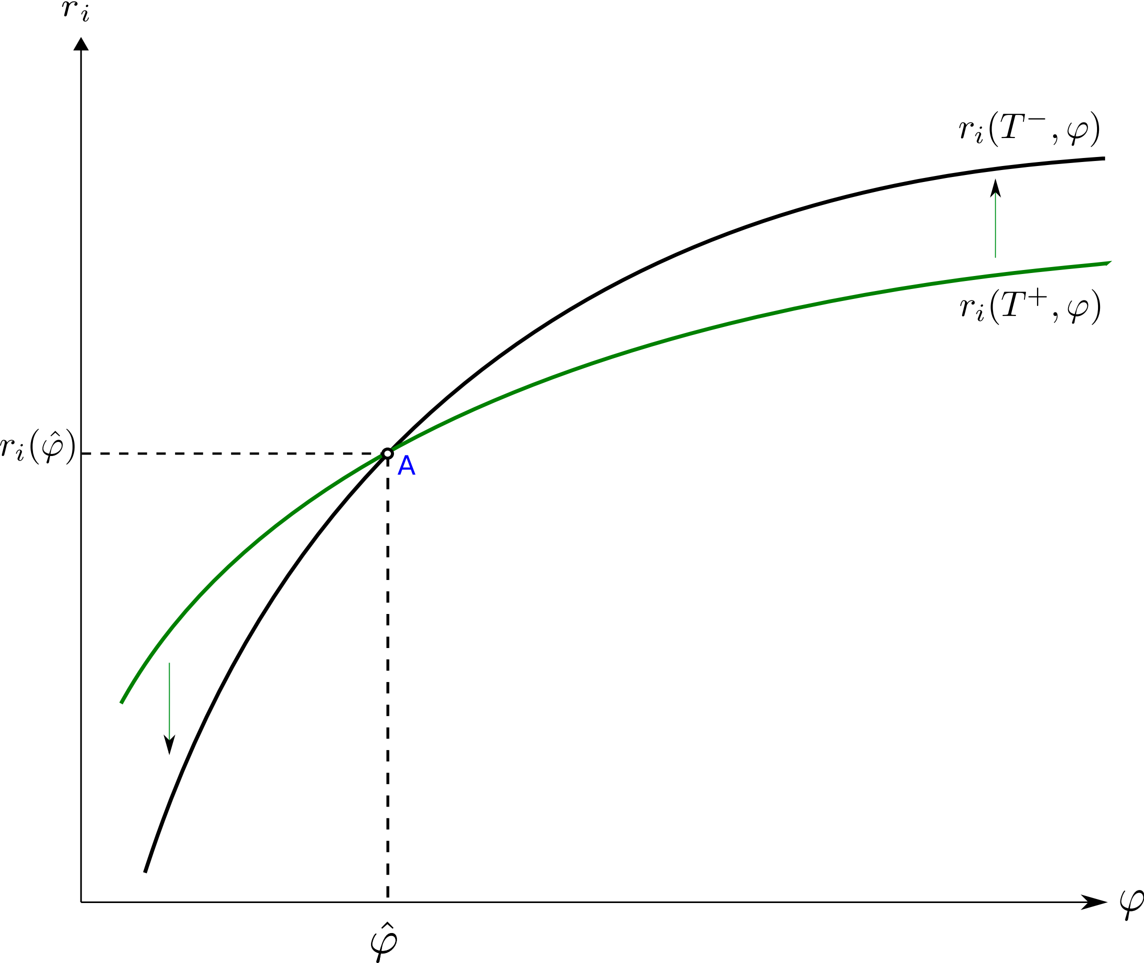
All regressions include industry fixed effects (3-digit) and year fixed effects.

Robust standard errors corrected for clustering at industry-year level in parentheses.

‡ Importing firms are firms that import inputs at least one time over the period.

Table B1. Ai and Norton effects of interaction term.

Variable	Obs	Mean	Std.dev	Min	Max
probit_ie	12115	-.0167609	.0031995	-.0220494	.0020266
probit_se	12115	.0094572	.0012093	.0030464	.0121439
probit_z	12115	-1.763171	.2082341	-2.442481	.3436937



r_i
$r_i(T^-, \varphi)$
$r_i(T^+, \varphi)$
$r_i(\hat{\varphi})$
A
φ
$\hat{\varphi}$

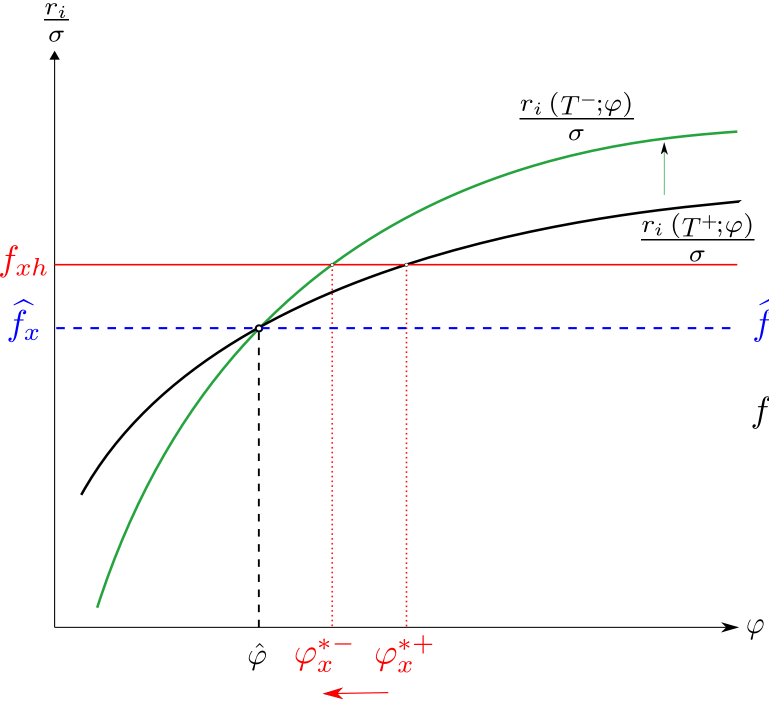


Figure 2.a : High fixed export costs

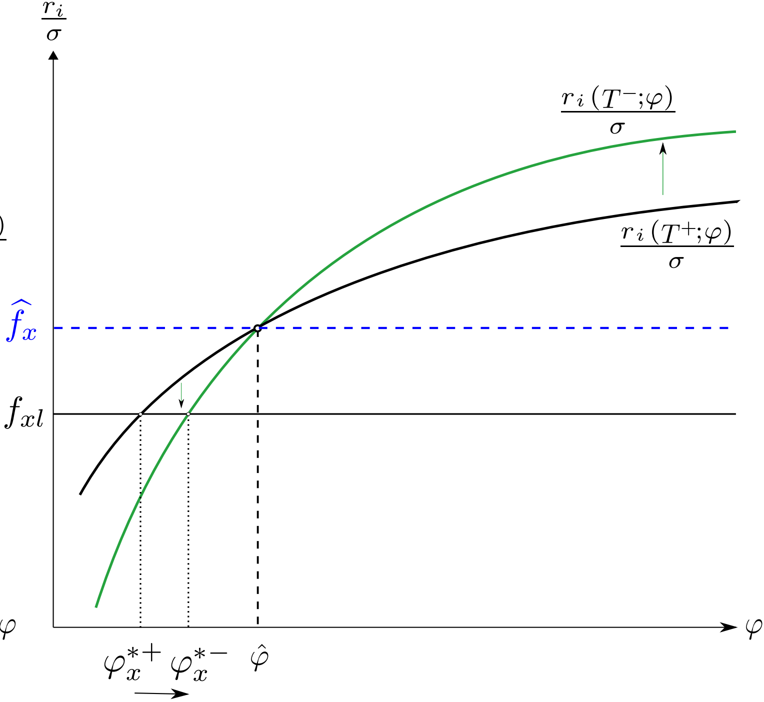
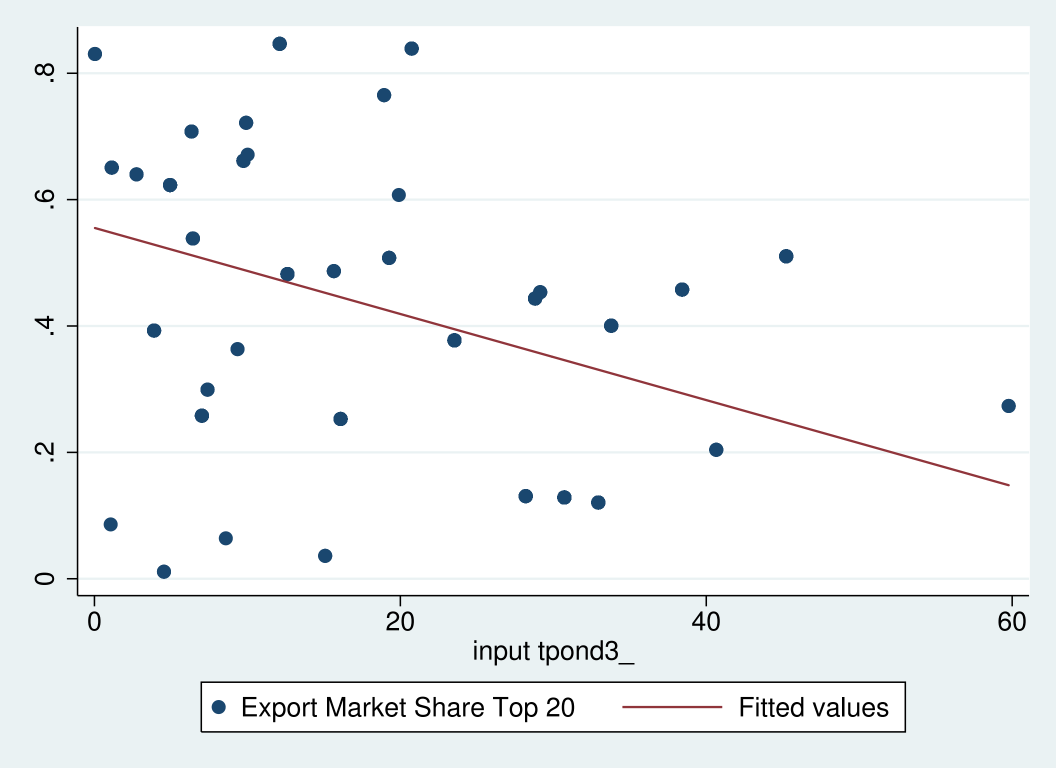
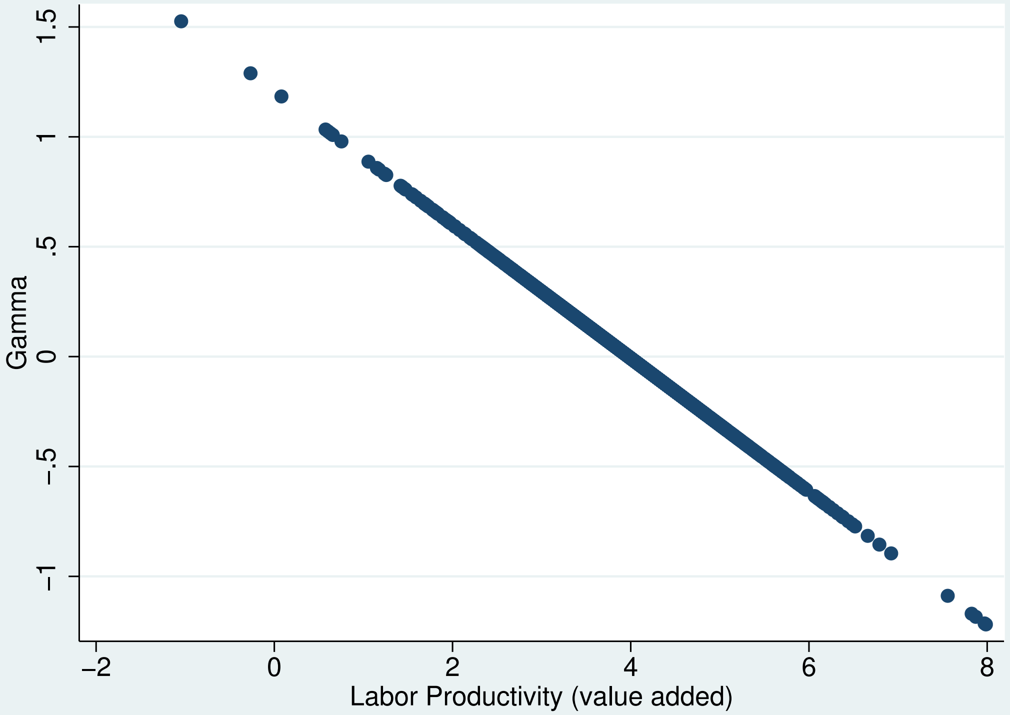


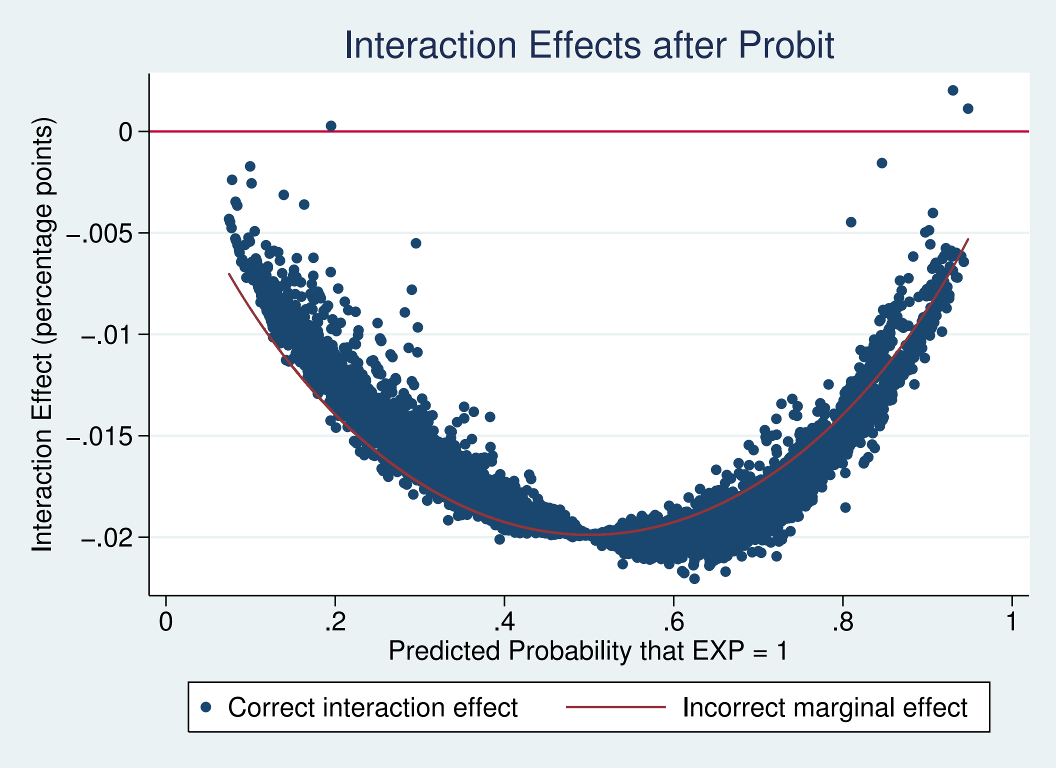
Figure 2.b : Low fixed export costs

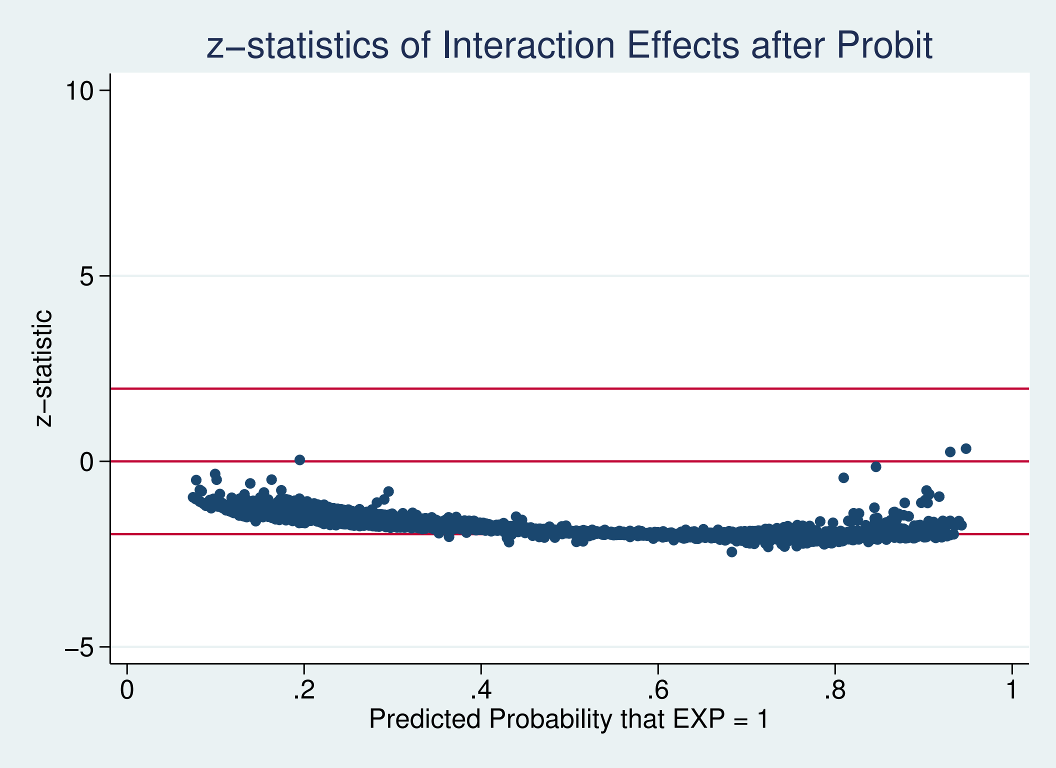


0
.2
.4
.6
.8
0
20
40
60
input tpond3_
Export Market Share Top 20
Fitted values



Gamma
1.5
1
.5
0
−.5
−1
−2
0
2
4
6
8
Labor Productivity (value added)


Interaction Effects after Probit
Interaction Effect (percentage points)
0
−.005
−.01
−.015
−.02
0
.2
.4
.6
.8
1
Predicted Probability that EXP = 1
Correct interaction effect
Incorrect marginal effect


z–statistics of Interaction Effects after Probit
z–statistic
10
5
0
–5
0
.2
.4
.6
.8
1
Predicted Probability that EXP = 1