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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 heterogeneous processing firms. Using a theoretical model with downstream firms exhibiting different levels of productivity, we show that lower input tariffs may increase the export sales of 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 export's equation in the second stage. The liberalization of agricultural trade appears to favor the reallocation of market share from low- to high-productivity agrifood firms. In addition, our results suggest that, whether lower input tariffs increase total export sales (and jobs), a large fraction of the least productive exporting firms may lose from an additional decrease in agricultural input tariffs.

1. Introduction

The impact of input trade liberalization on the domestic input sector has received much attention from researchers, but the impact on the final good sector is poorly understood (Amiti, 2000; Goldberg et al., 2009). Although standard and new trade theories disagree on the impact of liberalization on the domestic upstream sector, they predict that downstream industries will expand in response to 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 decrease 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. However, the real story is much more complex. The standard trade literature considers all downstream firms to be equally productive; however, in practice, firms differ considerably in their productivity, and a more detailed analysis is required. Under imperfect competition and product differentiation, the firms adjust their output prices differently in response to a change in the prices of a common input when they differ in productivity. Such a mechanism leads to a reallocation of market shares and, in turn, profits, among downstream firms. Thus, we do not know a priori whether all downstream firms would gain from input tariff cuts or whether the entry or the exit of exporters is favored. The effects of cuts to input tariffs on downstream firms deserve particular attention.

The effects of the reform of trade on productivity and export have been thoroughly analyzed in both theoretical and empirical studies (Pavcnik, 2002; Fernandes, 2007). Since the seminal paper by Melitz (2003), many theoretical models with heterogeneous firms have analyzed the effects of falling output tariffs, showing that it leads to a reallocation of resources and market shares from less productive to more productive firms and subsequently to a rise in the average productivity of firms. Few theoretical models have been applied to the effects of the liberalization of input trade on downstream firms, although some studies have tested whether cuts to input tariffs would improve productivity of downstream firms by increasing

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imports of intermediate inputs (Amiti and Konings, 2007; Kasahara and Rodrigue, 2008; Luong, 2011; Halpern et al., 2011). The intuition is that domestic firms can import higher-quality inputs, leading to higher productivity. Thus, cuts to input tariffs may provide a technological advantage to importing firms, increasing their productivity levels. More recently, Goldberg et al. (2010) study the impact of input tariffs on the range of products produced by domestic firms. They show that lower input tariffs led domestic importing firms to produce new goods not only because of cheaper inputs, but also, because new input goods can be introduced into the domestic market. Our objective is different because our attention is devoted to the impact of lower input tariffs on the export performance of 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 sales of downstream firms with different levels of labor productivity. To achieve our goal, we first develop a model of trade with heterogeneous firms producing a differentiated good and not only using labor, as in Melitz (2003) or Chaney (2008), but also an intermediate good. Contrary to recent trade literature with an intermediate sector (for instance, Luong, 2011, 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 assuming that labor and intermediate products are not perfectly substitutable and firms are heterogeneous, we show that the output price elasticity with respect to a change in input tariffs increases with the labor productivity of firms. These different responses lead to the reallocation of export market shares from low-productivity to high-productivity firms in response to input tariff cuts. In addition, the impact of input tariffs on the probability of exporting depends on the level of fixed export costs. Our results reveal that, when fixed export costs are high enough, a decrease in input tariffs raises the probability of exporting. Under this configuration, the export sales of all processing firms grow, but the most productive firms gain more than the less productive firms do. In contrast, when fixed export costs are sufficiently low, falling input tariffs force the least productive firms to exit foreign markets. Under these circumstances, the export sales of high-productivity firms increase at the expense of low-productivity firms.

We test the main predictions of our model using firm-level data on the French agrifood sector. We select this sector for the following reasons. First, in European and North American countries, some agrifood sectors have been substantially affected by trade reforms. Indeed, in the last two decades, the tariff barriers at European borders for agricultural products, which are primarily processed by agrifood firms, have 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, tariff barriers vary greatly across agricultural commodities. Some agricultural subsectors remain relatively protected. The input tariffs incurred by the agrifood firms differ because they process different agricultural products. Third, we can identify the main agricultural products purchased by the agrifood firms at a very disaggregated level and, in turn, calculate tariffs based on the inputs that a firm processes.

The econometric 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 French agrifood firms from foreign markets. More precisely, only the more efficient firms survive on export markets after input trade liberalization. In addition, the results suggest that more productive exporting firms profit from a decrease in input tariffs at the expense of less productive firms. More precisely, our analysis reveals that, all other things being equal, approximately 49.5% of exporting firms can potentially gain from agricultural trade liberalization. In other words, a large proportion of French agrifood exporting firms may be harmed by the liberalization of trade in agricultural goods, confirming our predictions. However, the negative effects of input trade liberalization in terms of jobs or export sales are smaller than the positive effects enjoyed by the more productive firms. Indeed, a 10% decrease in input tariffs may induce an increase in total export sales by 1% and in total employment by 0.1%. 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 agrifood 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 our analysis. In the last section, we conclude.

2. Theory

The objective of this section is to develop a static (one-period) model of trade with heterogeneous firms that capture the main effects of input tariffs on exports. We consider a home country trading with n other 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, and the mass of exporting firms is endogenous. Firms process an intermediate product and produce a differentiated product under monopolistic competition. Firms have to pay a fixed cost f_x to serve foreign markets, which are the costs to maintain a presence in foreign markets, (*i.e.* maintaining a distribution and service network, minimum freight and insurance charges, and costs of monitoring foreign customs procedures and product standards). 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 to imported intermediate inputs.

2.1. Technology

The production of any variety requires two inputs: labor and intermediate inputs. We assume for the sake of simplicity that intermediate inputs and labor are used by each firm in fixed proportions. At the end of this section we show that our results hold for different technologies.[1] Formally, we assume that 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 good. First, we assume that the downstream firms differ only in labor productivity (φ), not in the use of intermediate inputs (α). 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

$$z\alpha + w/\varphi_i$$

[1] Note that our approach differs from that of Bernard et al. (2007) and Bas (2009), who also assume that firms use two inputs. Bernard et al. (2007) consider skilled and unskilled labor in their trade model with heterogeneous firms. However, the two 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's production does not require labor, and the marginal requirement for each input does not vary across firms.

where w and z are the labor price and the prevailing domestic price of the intermediate product, respectively, 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.

2.2. 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 CES 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. The varieties are substitutes, which implies that $0 < \rho < 1$, and the elasticity of substitution between any two varieties is given by $\sigma = 1/(1-\rho) > 1$. The budget constraint in each foreign country is given by

$$\int_{\omega\in\Omega} p_x(\omega) y_x(\omega)\mathrm{d}\omega = R_x \tag{2}$$

where p_x is the price of a domestic variety prevailing in a foreign country and R_x is the income of the representative consumers. By maximizing Eq. (1) under the constraint (2), we obtain the demand of a foreign consumer for a variety produced by a firm with a labor productivity φ_i located in the home country, given by

$$y_x(\varphi_i) = R_x P_x^{\sigma-1}[p_x(\varphi_i)]^{-\sigma} \tag{3}$$

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 following pricing rule:

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

where $1/\rho$ is the markup. As a result, the price prevailing in a given foreign country is expressed as

$$p_x(\varphi_i) = \tau p(\varphi_i).$$

The main difference between Melitz (2003) and our approach lies in the fact we assume that the production cost function of a firm can be divided into the wage rate divided by labor productivity and the unit cost of the intermediate good, where only labor productivity varies across firms. The elasticity of the output price with respect to a change in input tariffs is then given by

$$\epsilon_{p(\varphi_i),T} = \frac{\partial p(\varphi_i)}{\partial T}\frac{T}{p(\varphi_i)} = \frac{\bar{z}\alpha T}{(1+T)\bar{z}\alpha + w/\varphi_i} \tag{5}$$

where $\epsilon_{p(\varphi_i),T}$ increases with φ_i.

In other words:

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

We obtain this result because our setup involves a share of intermediate good costs in the total production cost which increases with labor productivity (our dataset confirms this result; see Table 4 in Section 4). Thus, the most productive firms are more affected 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

We now study the effect of input tariff on export sales. Let r_i be the export sales on any foreign market of a domestic firm with a productivity φ_i, where

$$r_i = \tau p(\varphi_i) y_x(\varphi_i).$$

Using Eqs. (4) and (3), r_i can be rewritten as follows:

$$r_i = \tau^{1-\sigma} R_x \left[\frac{P_x}{p(\varphi_i)}\right]^{\sigma-1} = \tau^{1-\sigma} R_x \left[\frac{\rho P_x}{(1+T)\bar{z}\alpha + w/\varphi_i}\right]^{\sigma-1}. \tag{6}$$

The impact of T on r_i is not obvious. Indeed, the response of variety prices to changes in input tariffs differs among firms, depending on their labor productivity (see Eq. (5)). In addition, input tariffs affect not only the variety price ($p(\varphi_i)$), but also the foreign price index (P_x). Some standard calculations reveal that

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

or, equivalently, $\epsilon_{r_i,T} = (\sigma-1)\left(\epsilon_{P_x,T} - \epsilon_{p(\varphi_i),T}\right)$ where $\epsilon_{r_i,T}$ and $\epsilon_{P_x,T}$ are the elasticities of revenue and the foreign price index, respectively, to input tariffs. Note that $\epsilon_{P_x,T}$ can be viewed as the average elasticity of prices with respect to input tariffs in the foreign market. Thus, falling input tariffs raise the export sales of a firm when its output price declines to a greater extent than the "äverage" output price (the price index). Remember that the market size in each country is constant while the market share of each firm adjusts to a change in input prices. Therefore, lower input tariffs lead to a reallocation of demand from the firms with a high price elasticity to the firms exhibiting a low price elasticity.

Formally, the sign of the effect of the input tariff on export sales of firm i (characterized by labor productivity φ_i) is given by

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

where φ_x is the threshold value of labor productivity above which it is profitable for a domestic firm to serve a foreign country (see Appendix A for more details). The sign of $\partial r_i/\partial T$ depends on $p(\varphi_i)$ and, in turn, on the 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. Thus, the price set by a firm decreases more than the price index when input tariffs decline if and only if its labor productivity is high enough. Under these circumstances, the export sales of high productivity firms increase in response to lower input tariffs. By contrast, for a firm with low labor productivity, the decrease in the price of its variety is smaller than the decline in the price index. Because its own output price falls to a lesser extent than the average prices, the export sales of low productivity firms decrease with lower input tariffs.

Because $r(\varphi)$ is continuous and monotone in φ_i, there exists a unique value of labor productivity $\hat{\varphi}$ such that $\partial r(\varphi)/\partial T = 0$ when $\varphi = \hat{\varphi}$. The export revenues of a firm with labor productivity equal to $\hat{\varphi}$ do not vary when input tariffs vary. Fig. 1 illustrates the effect of a change in input tariffs on export sales, which differs according to firms' labor productivity. Two export revenue curves are plotted

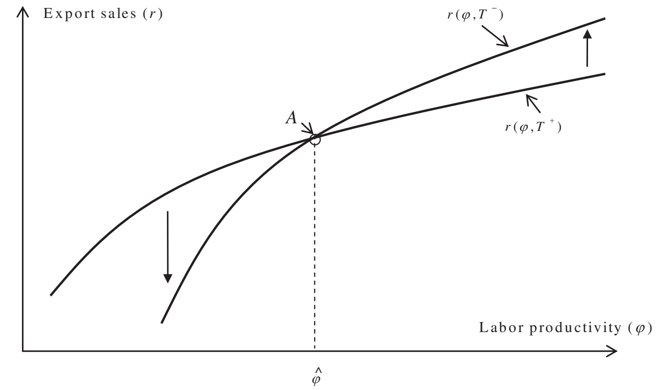

Fig. 1. Firm's export sales and labor productivity with a high input tariff (T^+) and a low input tariff (T^-).

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 $A(\hat{\varphi}, r(\hat{\varphi}))$ when input tariffs vary. In our example, export revenues increase when input tariffs shift from T^+ to T^- for the firms with labor productivity superior to $\hat{\varphi}$ ($r_i(T^-,\varphi) > r_i(T^+,\varphi)$). Conversely, export revenues decrease with a decrease in input tariffs for the firms with labor productivity inferior to $\hat{\varphi}$. Consequently, falling input prices rotate the export revenue curve counterclockwise, meaning a reallocation of export revenues from low-productivity firms to high-productivity firms. This result emerges because the prices of more productive firms decrease to a greater extent in response to lower input prices than the prices set by the less productive firms, inducing a change in relative prices in favor of more productive firms.

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

To summarize,

Proposition 1. *Lower input tariffs lead to a reallocation of export sales from low-productivity firms to high-productivity firms.*

2.4. Impact of input tariffs on export decisions

Our next task is to determine the impact of a change in T on the productivity cutoff 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 $\pi_i = r_i/\sigma - f_x$. A firm enters the foreign market as long as $\pi_i \geq 0$. The export threshold φ_x is such that $\pi(\varphi_x) = 0$ or, equivalently, $r(\varphi_x)/\sigma = f_x$. Because $\partial\, r(\varphi)/\partial\, \varphi > 0$ (see Eq. (6)), $\pi_i > 0$ if and only if $\varphi_i > \varphi_x$. Because we have $r(\varphi_x) = \sigma f_x$ at equilibrium,

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

Using $\partial\, r(\varphi)/\partial\, \varphi > 0$ and $\partial\, r(\varphi)/\partial\, T < 0$ iff $\varphi > \hat{\varphi}$, we can conclude that $\mathrm{d}\varphi_x/dT < 0$ if and only if $\varphi_x < \hat{\varphi}$. We have to determine the conditions under which $\varphi_x < \hat{\varphi}$. On the one hand, the productivity cutoff for exporting φ_x depends positively on fixed export costs f_x, as expected. More precisely, $\varphi_x = 0$ when $f_x = 0$ and increases with f_x. On the other hand, the rotation point $\hat{\varphi}$ is not affected by changes in f_x. Thus, there is a fixed level of export costs $\hat{f}_x$, which is defined as $\hat{f}_x \equiv r(\hat{\varphi})/\sigma$, so that if $f_x = \hat{f}_x$, then $\varphi_x = \hat{\varphi}$. Hence, the occurrence of $\mathrm{d}\varphi_x/dT > 0$ or $\mathrm{d}\varphi_x/dT < 0$ depends on fixed costs, f_x (see Fig. 2a and b).

In contrast, we have $\mathrm{d}\varphi_x/dT < 0$ when $\varphi_x < \hat{\varphi}$. The configuration where $\varphi_x < \hat{\varphi}$ may occur when fixed export costs are low enough ($f_x < \hat{f}_x$). In this case, lower input tariffs reduce the probability of exporting.

When fixed export costs are sufficiently high ($f_x > \hat{f}_x$), $\varphi_x > \hat{\varphi}$ is more likely to occur. This configuration corresponds to the case where all exporting firms exhibit a high labor productivity. Thus, when fixed export costs are high enough, the productivity cutoff for exporting decreases with falling input tariffs (see Fig. 2a). A reduction in input tariffs allows some non-exporting firms to enter foreign markets. In addition, when $f_x > \hat{f}_x$, export sales increase with lower input tariffs regardless of the labor productivity of exporting firms (see Fig. 2a). However, the value of export sales increases to a greater extent for more productive firms. Hence, the level of export sales and the market share of more productive firms increase with input trade liberalization.

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

The following proposition summarizes our findings.

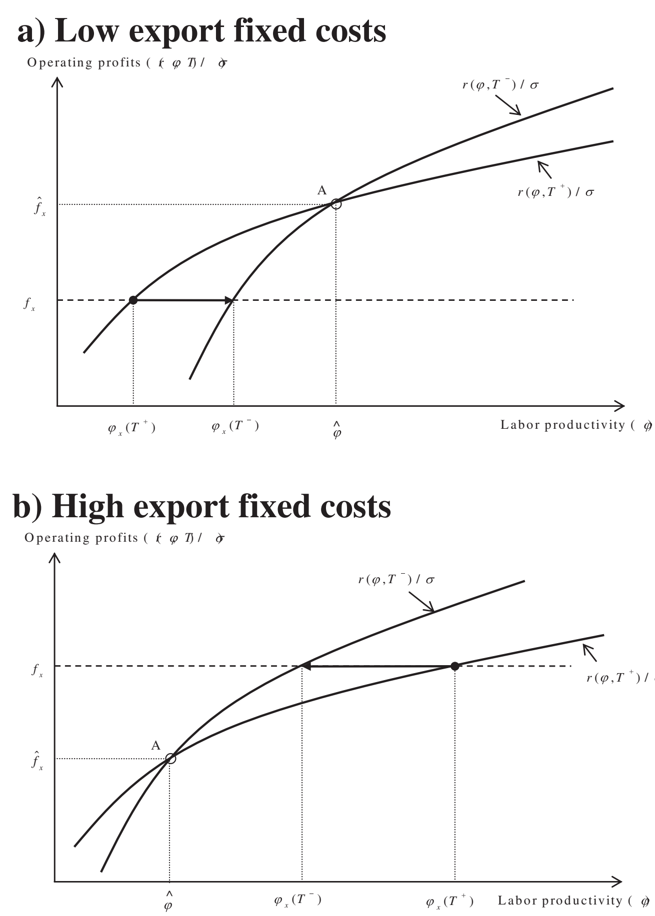

Fig. 2. The impact of lowering input tariffs ($T^+ \rightarrow T^-$) on productivity cutoff φ_x.

Proposition 2. *Falling input tariffs decrease the probability of exporting, raise average productivity, and increase the export sales of more productive producers at the expense of less productive exporting firms provided that fixed export costs are relatively low.*

2.5. Discussion

Our main results hold as long as the price set by high-productivity firms reacts more to a change in input tariffs than the price set by low-productivity firms (Lemma 1). For example, our result does not hold when labor and intermediate products are combined in a Cobb–Douglas technology.[2] For example, if they are combined according to the CES aggregator, we obtain the same result. In this case, the marginal cost is given by

$$\left\{w^{1-\zeta}\varphi^{-\zeta}+\alpha^{\zeta}[(1+T)\overline{z}]^{1-\zeta}\right\}^{1/(1-\zeta)}$$

where ζ is the elasticity of substitution between labor and the intermediate product. Then, it is easy to check that, in this case,

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

increases with labor productivity.

In addition, we could consider the case in which the intermediate products differ in quality and are not homogeneous. Under this configuration, the marginal cost could be given by

$$w/\varphi+\left\{\int_{\Lambda}a_i\left[(1+T)z_i^w\right]^{\xi-1}\mathrm{d}i\right\}^{1/(\xi-1)}$$

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 of 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 the firms to be heterogeneous in their 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 with respect to a change in input tariffs increases with labor productivity, that is, $\epsilon_{p(\varphi_1,\alpha_1),T}>\epsilon_{p(\varphi_2,\alpha_2),T}$ with $\varphi_1>\varphi_2$, provided that

$$\frac{\alpha_1}{(1+T)\overline{z}\alpha_1+w/\varphi_1}>\frac{\alpha_2}{(1+T)\overline{z}\alpha_2+w/\varphi_2} \tag{7}$$

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 intermediate input productivity $(1/\alpha)$, a sufficient condition is that the heterogeneity in labor productivity is greater than the heterogeneity in intermediate input productivity. More generally, inequality (7) means that the share of expenditures on the intermediate good in total production costs must increase with labor productivity to obtain a positive relationship between $\epsilon_{p(\varphi),T}$ and T.

Finally, we could also extend our framework by introducing fixed import costs. In this case, the more productive firms can import cheaper inputs, whereas the less productive firms purchase more expensive inputs produced domestically. Consequently, the exporting firms importing inputs gain much more from lower input tariffs when some exporters do not import.

[2] With a Cobb–Douglas technology, the output price elasticity with respect to a change in intermediate product price does not differ among firms.

3. Empirical model and estimation strategy

In this section, we describe how we test the main predictions of our model concerning the impact of input tariffs on export sales at the firm level. More precisely, we test whether lower input tariffs induce a reallocation of export sales across firms and the consequences of this change for the probability of exporting. In Section 2, we showed that 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, that accounts for the selection of firms into export markets. We check the consistency of results between the export sale equation and the probability of exporting. To do so, we proceed in two stages.

We first estimate the following system of equations:

$$\begin{cases} Pr(r_{ist}>0)=\Phi(\gamma_0+\gamma_1 lnT_{st}+\gamma_2 ln\varphi_{it}+\gamma_3 lnT_{st}ln\varphi_{it}+\gamma_4 C+\gamma_5 lnH_{ist}+\epsilon_{it}) \\ lnr_{ist}=\beta_0+\beta_1 lnT_{st}+\beta_2 ln\varphi_{it}+\beta_3 lnT_{st}ln\varphi_{it}+\beta_4 C+\nu_{it} \end{cases}$$

where the 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, 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 (e.g., time dummies, industry dummies, output tariff, and number of exporters located in the same area) and H_{ist} is a selection variable (discussed below). The parameters γ_0 to γ_5 and β_0 to β_4 are the coefficients to be estimated. From our framework, we expect firms with high labor productivity to gain (lose) more when tariffs on inputs decrease (increase), regardless of fixed costs; i.e., we expect $\beta_3<0$. It should also be noted that we expect γ_2 and β_2 to be positive in accordance with the standard literature on the relationship between productivity and exports. More productive firms are more likely to export and tend to export more.

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

$$\Gamma(\varphi_{it})\equiv\frac{\mathrm{d}lnr_{ist}}{\mathrm{d}lnT_{st}}=\beta_1+\beta_3 ln\varphi_{it},$$

is consistent with the sign of γ_1 (the coefficient associated with T_{st} in the probability of exporting). 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 decrease 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 an input tariff on firms' exports is negative only for more productive firms. Therefore, if $\gamma_1>0$, we must have $\Gamma(\varphi_{it}>\hat{\varphi})<0$ and $\Gamma(\varphi_{it}<\hat{\varphi})>0$, where the critical productivity level φ is given by

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

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

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 $\gamma_1>0$. Otherwise, our model is not contradicted. Table 1 summarizes the different configurations where our predictions are rejected or not.

4. Data and variables

We use data on food processing firms located in France. In 2009, France was the top agricultural producer in Europe (with a total of €61 billion) and the second largest European producer of agrifood goods, with a total of €125 billion. France is also the world's fourth largest exporter of agrifood and agricultural products, with a total of €47.2 billion, which represents more than 6% of the world export

Table 1
Consistency of the model.

	$\alpha_1 < 0$ (High fixed cost)	$\alpha_1 > 0$ (Low fixed costs)
$\varphi_x > \hat{\varphi}$	Consistent	*Inconsistent*
$\max\varphi_{it} > \hat{\varphi} > \varphi_x$	*Inconsistent*	Consistent

market share.[3] In the last two decades, tariff barriers at European borders for agricultural products, which are mainly processed by the agrifood firms, decreased considerably. EU agricultural policies changed fundamentally due to international pressure and internal policy. Product price gaps between the EU and world market levels have declined substantially, increasing French imports of agricultural commodities (Bagoulla et al., 2010). However, agricultural tariffs vary greatly across agricultural commodities. Some agricultural subsectors remain protected, whereas tariff barriers applied to some agricultural products are now relatively low (as we will see below).

In the following, we explain the data sources we used and how we computed the input tariffs associated with each firm.

4.1. Firm data

Our main data source is the annual survey of firms (EAE) provided by the French National Institute of Statistics. This EAE 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). The dependent variable is total export sales at the firm level.

We use this database to evaluate firms' 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. To check the robustness of our results, we also calculate the TFP for each firm using Olley and Pakes' methodology (1996) and the ratio of total sales to the number of employees.

4.2. Tariffs

Tariffs come from the TARIC database (European Commission, DG Taxation and Customs Union), which includes the ad-valorem equivalent of MFN (Most Favored Nation) tariffs and tariffs of preferential agreements at the European border for agrifood and agricultural products at the 8-digit (nc8) product level over the 2001–2004 period.[4] The major issue is how 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 at the 8-digit product level and their proportions for each 4-digit industry (NACE code in the EAE survey). As a result, we can compute the tariff applied at entry to the European market associated with each bundle of intermediate products processed by a 4-digit industry. Note that the agrifood sector is divided into 41 4-digit industries.

4.2.1. Input identification

Because there is no input/output table at a disaggregated level in France and the EAE database does not give the intermediate consumption structure for each firm, we have to construct our own input–output table. We use trade data to identify the products processed by 4-digit industries. More precisely, to determine the set of products k (nc8) processed by a 4-digit industry s, denoted Ω_s^k, we use the French Customs Register, which provides information on imports of all French firms by product (at the 8-digit level of the combined nomenclature) in terms of value and quantity. Knowing the main activity of the firm (i.e., its NACE 4-digit industry) from the EAE survey, we identify all products imported by a given 4-digit industry. Note that a commodity is considered to be a potential input of the industry if at least one firm in this industry imports this product over the period. Hence, we obtain a bundle (Ω_s^k) of intermediate products associated with each agrifood firms belonging to the 4-digit industry s.[5]

4.2.2. Input tariff at the European border

Knowing all products k processed by a firm of industry s, we then calculate tariffs applied to each product k at the European border at time t, denoted by T_t^k. These tariffs are computed in two steps. In the first step, with all tariff barriers potentially applied to each country by the European Union, we compute an ad-valorem equivalent tariff at the 8-digit level per country of origin j (T_{jt}^k) and year t.[6] Accordingly, our measure not only accounts for the MFN tariff, but also preferential trade agreements between the EU and foreign countries.[7]

In the second step, we compute an average tariff at the 8-digit level at the European border T_t^k. Most existing studies use an average of tariffs weighted by the share of the country in European imports. This measure is biased because it excludes from the measure all countries that cannot export due to prohibitive tariffs Bouët et al. (2008). Our strategy is to introduce the potential effect of a decrease of tariffs even for countries that cannot 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 country j and France ($Dist_j$).[8] Hence, T_t^k is expressed 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 each 4-digit industry, we compute the tariff for each bundle of inputs (T_{st}). Note that we have to account for the fact that the weight of each input within a bundle is not equal. Thus, due to a lack of data, we assume 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 imported inputs (M_s^k) at the

[3] 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.

[4] See Gallezot (2005) for ad-valorem equivalent computation.

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

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

[7] The simplest method could be to assess the protection level on the basis of the Most Favored Nation (MFN) tariff alone. All countries belonging to the WTO are subject 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.

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

4-digit industry level. To avoid variations over the studied period, the weight used for the average is calculated from the total imports over the 2001–2004 period.[9] Thus, we have

$$T_{st} = \sum_{k \in \Omega_s^k} \left(\frac{T_t^k M_s^k}{\sum_{k \in \Omega_s^k} M_s^k} \right) \tag{8}$$

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. First, because the mean weights may be impacted by the change in input tariffs, we weight the tariffs by the share of imported inputs at the 4-digit industry level in 2001, the first year of our sample ($M_{s,2001}^k$ instead of M_s^k in 8).[10] Second, we modify our input tariff measure by using the Most Favored Nation (MFN) tariff ($T_t^{k^{MFN}}$) instead of the applied tariff T_t^k. Third, instead of the potential supply used for calculating T_t^k, we employ a measure that 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 the product k to the EU are considered.

4.3. Selection variable

We have to account for the selection of firms into export markets. To do so, we need a selection variable. Remember that, according to our model, 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 empirically know that firms incur fixed export costs before they benefit from export sales. Therefore, 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 pay fixed export costs. Thus, the higher its profit on the domestic market, the higher its ability to pay these fixed export costs. Because domestic profits decrease with the degree of competition in the domestic market, the less competition a firm faces in the domestic market, the higher its level of profits and the greater its ability to pay fixed export costs. In other words, because we do not have a proxy for fixed export costs, we use a variable measuring the ability of firms to pay these fixed costs.

To capture the ability of firms to pay fixed export costs, we use a modified Herfindahl index as proxy for its level of profit, given by

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

where $y_d(\varphi_{ist})$ represents the domestic sales of firm i of industry s at time t. This firm-specific selection variable captures the firm's competitive environment in the domestic market. More precisely, the measure of the degree of competition faced by firm i is based on the Herfindahl index at the 4-digit industry level (H_{st}) multiplied by the square of the market share of firm i. When we only use the Herfindahl index, our proxy captures the average profit in the 4-digit industry. However, the profits are unevenly distributed between firms belonging to the same industry and, in turn, their ability to pay the fixed export costs differs. We account for this heterogeneity by weighting the Herfindahl index by the market shares of firms. A low market share means that the firm will face fierce competition and its profits are potentially low. Thus, the profit of firm i is more likely to be high when H_{st}^i is high, *i.e.* H_{st} and/or its market share are high.

4.4. Descriptive statistics

The final dataset is an unbalanced panel of 3716 exporting and non-exporting firms over the 2001–2004 period, with a total of 12,531 observations. Table 2 lists some descriptive statistics for our main variables. The first three 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. Agrifood industries also differ with respect to their labor productivity. Further, for many firms, the share of intermediate consumption in 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 quartiles at the 4-digit industry level to understand the relationship between export performance and labor productivity. The results are reported in Table 3 where Q1 (Q3) represents the labor productivity of the firm at the first (third) quartile within each 4-digit industry. Table 3 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 in average and are more likely to export, as expected.

Our dataset supports one of our main hypotheses. The more productive firms are more affected by changes in input tariffs because the share of intermediate goods in the total cost increases with an increase in labor productivity. We find that more productive firms in our sample have higher ratios of intermediate consumption to production costs. Table 4 contains two regressions showing the correlation between the ratio of intermediate consumption to production costs and labor productivity for French agrifood firms. Each regression controls for year fixed effects and 4-digit industry fixed effects. Whatever the measure of labor productivity, the ratio of expenditures for intermediate products to total cost increases with an increase in labor productivity. Our data support the idea that more productive firms should be more sensitive to a change in input prices.

5. Results

Because our data on input tariffs are calculated at the 4-digit industry level and the variation is mainly at this level, we first aggregate the firm-level data to the 4-digit industry level. We test whether lower input tariffs (measured by Eq. (8)) raises both the average labor productivity of exporting firms (due to a selection of more productive firms) and the export sales of the more productive firms at the expense of the less productive firms (due to the reallocation effect of market shares) at the 4-digit industry level. The results are reported in Table 5. In accordance with our framework, the estimations show that

Table 2
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%
Value added per employee**	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; ** in thousands of euros.

[9] Note that some inputs are not imported each year. Therefore, our tariff computation allows us to account for 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.

[10] In addition, the more productive firms are more likely to be those that import more inputs. As a consequence, the tariff measure constructed using the use of 'imported' inputs may be more reflective of the tariffs facing the more productive firms and, in turn, may induce a relatively larger effect of these tariffs on the more productive firms.

Table 3
Descriptive statistics with respect to labor productivity distribution.

4-digit industry quartile on labor productivity	Average labor productivity	Average export rate	Average number of employees	Share of exporting firms
<Q1	19.20	9.24%	90.85	39.37%
[Q1;Q2]	40.39	8.43%	112.18	41.12%
[Q2;Q3]	53.38	9.60%	123.40	45.30%
>Q3	106.22	12.83%	156.68	50.52%

Table 4
The share of intermediate consumption against productivity.

ln (intermediate consumption/total costs)		
	(a)	(b)
ln (value added/employment)	0.07***	
ln (total sales/employment)		0.18***

Significance levels: ***: 1%. Both regressions include 4-digit industry and year fixed effects.

a lower input tariff (*i*) increases average labor productivity, (*ii*) decreases the relative export sales of the bottom ten percent by labor productivity (within each 4-digit industry), and (*iii*) boosts the relative export sales of the top ten percent of firms by labor productivity. Thus, our results obtained from 4-digit industry level data suggest that a decrease in input tariffs appears to lead a reallocation of exports from low-productivity firms to high-productivity firms and seems to force low-productivity firms to exit the foreign markets. However, our estimates may be biased because we do not control for the selection effect.

In what follows, we test whether these results hold when we perform regressions *at the firm level* by correcting for the selection bias and unobserved heterogeneity bias. Following our strategy described in Section 3, we estimate the system of equations involving the probability of exporting and the level of export sales, by using a Heckman (1979) procedure where the model (system) is estimated by maximum likelihood. Then, we test the robustness of our main findings with alternative measures of the main variables. Finally, we evaluate the magnitude of the effect of lower input tariffs on total export sales, the share of firms that lose out from input trade liberalization and the potential consequences of this effect for employment.

Note that we control for year fixed effects and 4-digit industry fixed effects in all regressions, and robust standard errors are corrected for clustering at the industry-year level. Our control variables also include output tariffs and the number of exporting firms belonging to the same 4-digit industry located in the same area. In addition, 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 differ depending on whether firms import. Accordingly, we introduce a dummy variable controlling for import status in each equation.

5.1. Input tariffs, export status and exports

Table 6 reports the results associated with different systems of two equations involving the probability of exporting and the level of export sales. These estimations consider the input tariff given by Eq. (8) and different measures of labor productivity: (i) the value added per employee (column I); (ii) total sales per employee (column II); (iii) total factor productivity (column III)[11]; and (iv) the share of intermediate consumption in total production costs (column IV).[12] It is worth stressing that, from an econometric viewpoint, the two steps in modeling (selection procedure through probit and regression on exports) are interdependent (the inverse Mills ratio is statistically significant), regardless of the regressions considered which justifies the use of the Heckman procedure.

We start by commenting on the effects of some of the control variables. As in Amiti and Konings (2007), we control for the effect of output tariffs on export decisions and export revenues. 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.[13] Furthermore, as in Koenig et al. (2010), we include 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.[14] This variable captures the presence of local export spillovers. In our case, the number of exporters (local spillover) affects both the probability of exporting and the export sales. Additionally, the importing firms are more likely to export and to export more than non-importing firms (as highlighted in Bas, 2009, using data on Chile and Argentina's manufacturing sector). Thus, the results associated with the control variables are in accordance with the current literature.

We now focus our analysis on the effects of input tariffs on both export status and the level of export sales according to the labor productivity of firms. Concerning the probability of exporting, the coefficient associated with the input tariff (γ_1) is positive, whereas the marginal crossed effect (input tariff × labor productivity) on the probability of exporting is not significant. Note that we cannot directly interpret the sign or 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 regression I and test the significance for each observation. The results indicate that the crossed effect is not significant for all observations.[15] Thus, a decrease in input tariffs decreases the probability of exporting. In addition, the signs 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 the regressions considered. The higher the productivity of a food firm, the higher its probability of exporting ($\gamma_2 > 0$), as in Chevassus-Lozza and Latouche (2012).

Let us now turn to the consistency of the signs of the coefficients associated with input tariffs in the selection equation and in the export equation in light of our theoretical model. According to our theoretical predictions, the positive sign of γ_1 (a decrease in input tariffs decreases the probability of exporting) suggests that fixed export costs are relatively low in the French agrifood sector (see Section 3). Thus, we would expect the most productive firms to gain from lower input tariffs and the less productive firms to be negatively affected (see Proposition 2 and Fig. 2b).

We have to determine the total effect of input tariffs on exports (given by $\Gamma(\varphi_{it}) = \hat{\beta}_1 + \hat{\beta}_3 ln\varphi_{it}$) and to check whether $\Gamma(\varphi_{it})$ is positive (resp., negative) for more (resp., less) productive firms. According to the results reported in Table 6 the coefficients $\hat{\beta}_1$ (line "Input Tariff" in Table 6) are positive and significant whereas the coefficients associated with the interaction term (input tariff × labor productivity) $\hat{\beta}_3$ are negative and significant for the level of exports, whatever the measure of labor productivity. Thus, the effect of changes in input tariffs on export sales depends on labor productivity of each firm. More precisely, because estimates associated with the interaction term ($\hat{\beta}_3$) are significantly negative, input trade liberalization appears to lead to a reallocation of market share from less productive firms to more productive firms, as predicted by the theoretical model (see Proposition 1).

[11] The total factor productivity (TFP) of firms is calculated according to the method of Olley and Pakes (1996).

[12] In Section 4, we showed that the ratio of expenditures on intermediate goods to total production cost is positively correlated with labor productivity at the firm level.

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

[14] Metropolitan France is divided into 96 Départements.

[15] Details are available upon request.

Table 5
Effect of input tariff at 4-digit industry.

Variables	(a) Average prod.	(b) Market share 10% least prod.	(c) Market share 10% most prod.
Input tariff	−0.224	0.0190	−0.0450
	(0.126)*	(0.00739)**	(0.0148)***
Output tariff	0.153	0.0135	−0.0493
	(0.306)	(0.00806)*	(0.0138)***
Herfindahl Index	−0.114		
	(0.171)		
Constant	3.575	−0.0112	0.546
	(1.331)***	(0.0279)	(0.0474)***
R2	0.897	0.085	0.324
Observations	140	133	114

Effect of input tariff on (a) average productivity of exporting firms at 4-digit industry; (b) export market share of 10% least productive exporting firms in each 4-digit industry; (c) export market share of 10% most productive exporting firms in each 4-digit industry. Significance levels: *: 10% **: 5% ***: 1% All regressions include year fixed effects. Standard errors in parentheses.

We now evaluate the sign of $\Gamma(\varphi_{it})$ for all firms. From the results of the estimation in column I of Table 6 (labor productivity, measured as the ratio of value added to employment), we have $\Gamma(\varphi_{it}) = 0.807 - 0.205 ln\varphi_{it}$, which is illustrated from our data in Fig. 3 for the year 2004. We find that the rotation point $\hat{\varphi}_t$ given by $\Gamma(\varphi_{it}) = 0$ is such that $ln\hat{\varphi} = 3.936$). For the year 2004, the observations in our data are such that $max\varphi_{it} > \hat{\varphi}_t > min\varphi_{it}$ (of exporting firms). Thus, Γ is positive for less productive firms with a labor productivity inferior to $\hat{\varphi}_t$ and negative for more productive firms ($ln\varphi_{it} > 3.936$). Consequently, the coefficients associated with input tariffs in the export equation and in the selection equation are consistent ($\gamma_1 > 0$ and $max\varphi_{it} > \hat{\varphi}_t > min\varphi_{it}$). In accordance with our theoretical model (see Proposition 2), all other things being equal, a decrease in input tariffs would reduce the number of exporting firms and lead to reallocation of exports from low-productivity firms to high-productivity firms. Note that in our sample, the share of firms exhibiting a productivity inferior to $ln\hat{\varphi}_t = 3.936$ corresponds to 53.43% of exporting firms.

5.2. Robustness checks

We now check whether our results hold when we use other measures for input tariffs and export sales. The results are reported in Table 7. In column V, the measure of the input tariff is given by Eq. (1) (see Section 4.2) where the weight of input tariffs is the share of imported inputs at the 4-digit industry level in 2001. Note that the we have also considered two other measures of the input tariff variable: the tariffs of the most favored nation (i.e., preferential tariffs are excluded from our calculations) Eq. (2) and only tariffs applied to EU partners are taken into account and they are weighted by the country's share of EU imports Eq. (3). Our main conclusions hold, even if the overall impact is slightly modified.

In Table 8, the dependent variable is now the ratio of the exports of firm i to the total exports of 4-digit industry s (instead of the *level* of export sales). The results are given in column VIII. 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 do, which can lead to misspecification. The selection equation is the same as the equation reported in Table 6. All coefficients in the export share equation are significant and have the expected signs. The reallocation of the share of exports among firms at the expense of less productive firms is again observed.

Furthermore, we have considered that decreasing input tariffs lower production costs through a decline in the prices of existing imported

Table 6
Econometric results.

Variables	I		II		III		IV	
	P(EXP = 1)	Exp. sales	P(EXP = 1)	Exp. sales	P(EXP = 1)	Exp. sales	P(EXP = 1)	Exp. sales
Input tariff	0.285	0.807	0.397	1.248	0.193	0.193	0.212	1.957
	(0.114)**	(0.214)***	(0.220)*	(0.355)***	(0.0667)***	(0.186)***	(0.235)	(0.516)***
Labor productivity (value added)	0.316	1.198						
	(0.0869)***	(0.165)***						
Labor productivity (total sales)			0.419	1.271				
			(0.103)***	(0.103)***				
TFP					1.132	6.364		
					(0.311)***	(0.721)***		
Share of intermediate consumption							2.793	10.67
							(0.775)***	(1.483)***
Input tariff × labor productivity (value added)	−0.0644	−0.205						
	(0.0286)**	(0.0543)***						
Input tariff × labor productivity (total sales)			−0.0723	−0.184				
			(0.0411)*	(0.0600)***				
Input Tariff x TFP					−0.380	−0.686		
					(0.0994)***	(0.307)**		
Input tariff × share of intermediate cons.							−0.239	−1.966
							(0.266)	(0.266)
Output tariff	−0.133	−0.580	0.0865	0.182	0.150	0.457	0.457	0.225
	(0.146)	(0.337)*	(0.0607)	(0.108)*	(0.0552)***	(0.117)***	(0.0646)	(0.111)**
Local spillover	0.233	0.0903	0.228	0.0610	0.235	0.0626	0.232	0.0801
	(0.0218)***	(0.0464)*	(0.0230)***	(0.0445)	(0.0229)***	(0.0424)	(0.0244)***	(0.0467)*
Import dummy	0.544	0.725	0.502	0.650	0.603	0.580	0.458	0.687
	(0.0382)***	(0.0818)***	(0.0328)***	(0.0780)***	(0.0403)***	(0.0738)***	(0.0314)***	(0.0833)***
Selection variable	26.82		24.53		24.76		27.54	
	(10.38)***		(9.801)**		(9.986)**		(10.27)***	
Constant	−1.897	6.012	−3.613	−0.0817	−2.088	2.615	−3.712	−2.643
	(0.605)***	(1.202)***	(0.572)***	(1.105)	(0.291)***	(0.291)***	(0.672)***	(1.477)*
Observations	12,115		12,337		11,869		12,431	
Lambda		−0.819		−0.780		−0.831		−0.831
Rho		−0.508		−0.503		−0.543		−0.437
Sigma		1.612		1.549		1.532		1.561

‡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 (4-digit) and year fixed effects.
Robust standard errors corrected for clustering at industry-year level in parentheses.

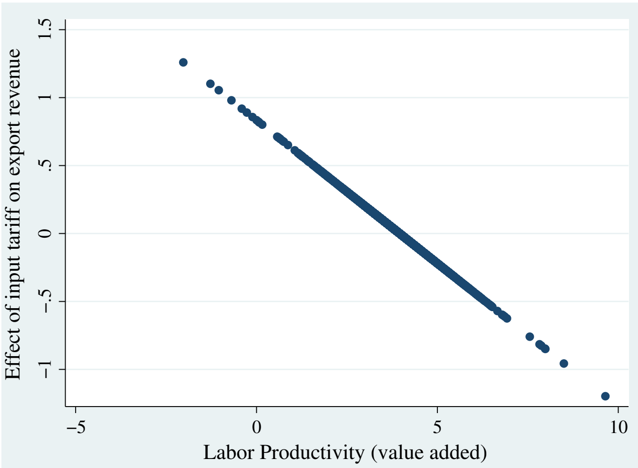

Fig. 3. Total effect of T on export level against labor productivity.

inputs. Hence, the importing firms directly enjoy lower input prices. However, input trade liberalization should also affect the 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 this case, the reallocation from less productive to more productive non-importing firms would be checked when input tariffs decline. When we perform our regressions by exclusively selecting the non-importing firms (see column IX in Table 8), the probability of exporting declines with falling input tariffs and the export sales of the more productive non-importing firms increase at the expense of the less productive non-importing firms. These results confirm that input trade liberalization also affects non-importing firms.

Table 8
Robustness checks with export market shares and non-importing firms.

Variables	VIII		IX	
	P(EXP = 1)	Exp. market share	P(EXP = 1)	Exp. sales
Input tariff	0.263 (0.115)**	0.0684 (0.0172)***	0.524 (0.171)***	1.178 (0.323)***
Labor productivity (value added)	0.311 (0.0879)***	0.0961 (0.0132)***	0.514 (0.147)***	1.304 (0.259)***
Input tariff × labor productivity (value added)	−0.0638 (0.0289)**	−0.0176 (0.00428)***	−0.131 (0.0421)***	−0.296 (0.0787)***
Output tariff	0.163 (0.0642)**	0.00520 (0.00901)	−0.453 (0.215)**	1.343 (0.491)***
Local spillover	0.233 (0.0218)***	0.00496 (0.00344)	0.232 (0.0281)***	0.309 (0.0543)***
Import dummy	0.543 (0.0383)***	0.0527 (0.00580)***		
Selection variable	29.81 (10.80)***		343.7 (125.9)***	
Constant	−2.831 (0.415)***	0.241 (0.0684)***	−1.605 (0.892)*	−1.960 (1.894)
Observations		12,115		6798
Lambda		−0.0685		−0.489
Rho		−0.555		−0.341
Sigma		0.124		1.433

Significance levels: *: 10% **: 5% ***: 1% All regressions include industry fixed effects (4-digit) and year fixed effects.
Robust standard errors corrected for clustering at industry-year level in parentheses.

The results associated with these additional regressions 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.

Table 7
Robustness checks with alternative input tariff computation.

Variables	V		VI		VII	
	P(EXP = 1)	Exp. sales	P(EXP = 1)	Exp. sales	P(EXP = 1)	Exp. sales
2001 Input bundle tariff	0.201 (0.119)*	1.103 (0.294)***				
MFN input tariff			0.274 (0.159)*	1.155 (0.405)***		
UE weighted input tariff					0.0829 (0.120)	0.570 (0.189)***
Labor productivity (value added)	0.302 (0.0860)***	1.161 (0.156)***	0.341 (0.112)***	1.189 (0.207)***	0.162 (0.0889)*	0.994 (0.133)***
2001 Input bundle tariff × labor productivity (va)	−0.0572 (0.0295)*	−0.186 (0.0527)***				
MFN input tariff × labor productivity (va)			−0.0661 (0.0336)**	−0.187 (0.0633)***		
UE input tariff × labor productivity (va)					−0.0147 (0.0306)	−0.148 (0.0450)***
Output tariff	0.145 (0.0656)**	0.561 (0.120)***	0.145 (0.0636)**	0.490 (0.148)***	0.143 (0.0648)**	0.491 (0.133)***
Local spillover	0.249 (0.0211)***	0.0835 (0.0483)*	0.233 (0.0219)***	0.0844 (0.0460)*	0.232 (0.0220)***	0.0865 (0.0468)*
Import dummy	0.548 (0.0381)***	0.702 (0.0824)***	0.543 (0.0382)***	0.716 (0.0823)***	0.540 (0.0382)***	0.716 (0.0820)***
Selection variable	26.92 (10.33)***		27.68 (10.43)***		28.50 (10.52)***	
Constant	−2.636 (0.432)***	1.001 (1.123)	−2.892 (0.568)***	0.831 (1.727)	−2.187 (0.411)***	3.229 (0.819)***
Observations		11,685‡		12,115		12,115
Lambda		−0.852		−0.841		−0.833
Rho		−0.521		−0.518		−0.514
Sigma		1.634		1.624		1.622

‡The absence of importing firms in 2001 for four very small sectors (158H, 159G,159Q and 159S) reduces the number of observations.
Significance levels: *: 10%; **: 5%; ***: 1%. Robust standard errors corrected for clustering at industry-year level in parentheses.
All regressions include 4-digit industry fixed effects and year fixed effects.

It is also worth stressing that our results also support our choice of selecting a production function other than one with Cobb–Douglas technology. Recall that, with a Cobb–Douglas function, firm productivity does not affect the relative proportions of factors that firms use and no reallocation of export sales between firms can occur when the price of the intermediate good changes (see subsection 2.5). The results reported in Table 4 and our regressions show that the Cobb–Douglas function does not fit the data well, as shown convincingly by Raval (2011).

5.3. The magnitude of the input tariff's effects on export sales

We now provide the magnitude of the effect of a lower input tariff on export sales (and on employment). To assess the magnitude of the input tariff's effects, we use the estimates reported in column I of Table 6 because this estimation can be considered as the preferred empirical method.

We simulate the impact of a ten-percent decrease 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 234,972 jobs, and the total export sales reached approximately €20 billion. Our result suggests that, all other things being equal, approximately 49.5% 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 half of employees in the sector (approximately 51%), and their export sales represent more than 74% of aggregate export value in 2004. In other words, although a large proportion (50.5%) of French agrifood exporting firms may lose from the liberalization of the agricultural goods trade, the negative effect of lower input tariffs is lower in terms of jobs than in terms of non-exporting firms.

Let r_i^e be the expected export sales of firm i following a ten-percent decrease in input tariffs (ceteris paribus), with

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

where r_{i0} is the level of export sales of firm i in 2004. To evaluate the impact on employment, we assume that the ratio of total sales (domestic and exports) to employees is constant when export sales vary. Knowing the number of employees per firm in 2004 (denoted by l_{i0}) and the ratio of total sales to employment at the firm level, we can evaluate the expected number of jobs for each firm (l_i^e with $l_i^e = r_i^e l_{i0}/r_{i0}$). Obviously, the effects of a decrease in input tariffs on employment represent an approximation and must be interpreted with caution. Our results are reported in Table 9. A ten-percent decrease in input tariffs would induce an increase in total export sales of 1.1% and in employment of 0.1% if no firms exit the export markets.[16] For the winning firms, export sales would increase by 1.7% and employment by 0.4%.

In summary, even if lower input tariffs induce an increase 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 of export sales but hire a non-negligible share of workers due to their low labor productivity.

6. Conclusion

We have studied the impact of input tariffs on export status and export performance. Using a theoretical model with heterogeneous firms, we show that changes in input tariffs do not have a clear impact on the export level or export decisions of food processing firms. The sign of the effect depends on the fixed export costs and labor productivities of firms. When fixed export costs are low enough, falling input tariffs decreases the probability of entering foreign markets and leads to the reallocation of exports from low-productivity firms to high-productivity firms. The export sales of high productivity firms increase, whereas export sales of low productivity firms decrease. When fixed export costs are sufficiently high, 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. Even if the liberalization of agricultural trade increases total export sales of food firms, its effects vary between firms. More precisely, lower tariffs in the agricultural sector favored the exit of French food firms from foreign markets and increased the export sales of more productive firms at the expense of less productive firms. These exporting firms losing out from lower input tariffs represent a low share of export sales but hire a non-negligible share of workers due to their low labor productivity.

In our approach, we consider the total mass of firms to be 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 analyze the impact of input trade liberalization on the entry and exit decisions of domestic firms both theoretically and empirically.

Finally, it should be mentioned that falling input tariffs can also allow firms to import additional input varieties (Goldberg et al., 2010) or may cause innovation and new varieties of domestically produced inputs. Our theoretical approach focuses on the price effect, whereas Goldberg et al. (2010) highlight the role played by the variety effect. Unfortunately, our data do not enable us to disentangle the two effects. Note that the recent literature on the effect of input tariffs uses data in developing countries. It is not surprising that the variety effect is strong in the developing countries because the growth of new imported varieties (products that had not been imported prior to the trade reforms) is substantial (see, for example, Goldberg et al., 2010). In more developed countries, the price effect should be larger. 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.

Table 9
The expect levels of export sales and jobs due to a fall by 10% in input tariffs.

	Nb of firms	$\sum_i r_{i0}$	$\sum_i (r_{is}^e - r_{i0})$	$\sum_i l_{i0}$	$\sum_i (l_{is}^e - l_{i0})$
Winning firms	660	14,400,629	254,076	119,653	446
Losing firms	672	4,884,098	−43368	115,319	−196
Total	1332	19,284,727	210,708	234,972	250

Appendix A. The impact of T on r_i

The price index in a foreign country is given by:

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

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

[16] A decrease of 10% in the input tariff does not lead to negative export sales for any firm. However, some firms may exit if their operating profits become lower than their fixed export costs.

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:

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

References

Ai, C.R., Norton, E.C., 2003. Interaction terms in logit and probit models. Economics Letters 80 (1), 123–129.

Amiti, M., 2000. Trade liberalisation of intermediate inputs. The Australian Economic Review 33, 299–302.

Amiti, M., Konings, J., 2007. Trade liberalization, intermediate inputs, and productivity: evidence from Indonesia. American Economic Review 97, 1611–1638.

Auer, R.A., Fischer, A.M., 2010. The effect of low wage import competition on U.S. inflationary pressure. Journal of Monetary Economics 57 (4), 491–503.

Auer, R.A., Degen, K., Fischer, A.M., 2010. Globalization and Inflation in Europe Mimeo Swiss National Bank.

Bagoulla, C., Chevassus-Lozza, E., Daniel, K., Gaigné, C., 2010. Regional production adjustment to import competition: evidence from the French agro-industry. American Journal of Agricultural Economics 92 (4), 1040–1050.

Bas, M., 2009. Trade, foreign inputs and firms' decisions: theory and evidence. CEPII Working Paper, 2009-35.

Bernard, A.B., Redding, S.J., Schott, P.K., 2007. Comparative advantage and heterogeneous firms. Review of Economic Studies 14 (1), 31–66.

Bouët, A., Decreux, Y., Fontagné, L., Jean, S., Laborde, D., 2008. Assessing applied protection across the world. Review of International Economics 16, 850–863.

Chaney, T., 2008. Distorted gravity: the intensive and extensive margins of international trade. American Economic Review 98, 1707–1721.

Chevassus-Lozza, E., Latouche, K., 2012. Heterogeneity of firms, heterogeneity of markets, and trade costs: access of French exporters to European agrifood markets. European Review of Agricultural Economics 93 (2), 257–288.

Fernandes, A.M., 2007. Trade policy, trade volumes and plant-level productivity in Colombian manufacturing industries. Journal of International Economics 71, 52–71.

Gallezot, J., 2005. Database on European Agricultural Tariffs DBTAR. TRADEAG Working Paper 05/07 (http://ageconsearch.umn.edu/bitstream/18851/1/wp050007.pdf).

Goldberg, P., Khandelwal, A., Pavcnik, N., Topalova, P., 2009. Trade liberalization and new imported inputs. American Economic Review 99 (2), 494–500.

Goldberg, P.K., et al., 2010. Imported intermediate inputs and domestic product growth: evidence from India. Quarterly Journal of Economics 125 (4), 1727–1767.

Halpern, L., Koren, M., Szeidl, A., 2011. Imported Inputs and Productivity. CeFiG Working Papers 8, Center for Firms in the Global Economy, revised 16 Sep 2011.

Heckman, J., 1979. Sample selection bias as a specification error. Econometrica 47, 153–161.

Kasahara, H., Rodrigue, J., 2008. Does the use of imported intermediates increase productivity? Plant-level evidence. Journal of Development Economics 87, 106–118.

Koenig, P., Mayneris, F., Poncet, S., 2010. Local export spillovers in France. European Economic Review 54 (4), 622–641.

Kugler, M., Verhoogen, E., 2009. Plants and imported inputs: new facts and an interpretation. American Economic Review Papers and Proceedings 99 (2), 494–500.

Luong, T.A., 2011. The impact of input and output tariffs on firms' productivity: theory and evidence. Review of International Economics 19 (5), 821–835.

Melitz, M.J., 2003. The impact of trade on intra-industry reallocations and aggregate industry productivity. Econometrica 71 (6), 1695–1725.

Olley, G., Pakes, A., 1996. The dynamics of productivity in the telecommunications equipment industry. Econometrica 64 (6), 1263–1297.

Pavcnik, N., 2002. Trade liberalisation, exit and productivity improvements: evidence from Chilean plants. Review of Economic Studies 69, 245–276.

Raval, D., 2011. Estimation of a CES Production Function with Factor Augmenting Technology, mimeo University of Chicago.