Does importing more inputs raise exports? Firm level evidence from France

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Abstract

Following Melitz (2003)'s seminal paper, several theoretical and empirical studies have shown that only the subset of most productive firms export. While other studies provide evidence on a positive effect of an increase in imported inputs on firms' productivity, the link between imported intermediate inputs and export scope has not been made. This paper bridges the gap by studying the impact of imported inputs on the margins of exports. We use a unique firms' level database of imports at the product (HS6) level provided by French Customs for the 1995-2005 period. Access to new varieties of inputs may increase productivity, and thereby exports, through better complementarity of inputs, transfer of technology and/or decreased inputs price index. We test for these different mechanisms by distinguishing the origin of imports (developing vs. developed countries) and constructing an exact price index a la Broda and Weinstein (2006). We find a significant impact of higher diversification and increased number of imported inputs varieties on firm's TFP and export scope. Whereas the complementarity and transfer of technology mechanisms are supported by our results, the price effect seems very limited.

Keywords: Firm heterogeneity, imported inputs, TFP, export scope, varieties, price index, firm-level data.

JEL Classification: F10, F12

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1 Introduction

The globalization process is characterized by a significant increase in world imports of intermediate goods (Hummels et al., 2001, Yi (2003) or Strauss-Kahn (2004)). The literature on endogenous growth provides theoretical grounds for the role of these foreign inputs in enhancing efficiency gains and economic growth at the aggregate level (e.g., Romer (1987, 1990) or Rivera-Batiz and Romer (1991)). Given their predominant role in international trade, the study of the effects of foreign intermediate goods on firms' performance is thus essential to understand the micro-determinants of economic growth.

At the firm level, most gain is measured in terms of productivity growth realized through, better complementarity of inputs, lower input prices, access to higher quality of inputs and access to new technologies embodied in the imported varieties (see Ethier (1982), Markusen (1989) or Grossman and Helpman (1991) for a theoretical background). Robust empirical works using micro-level data recently confirmed a positive relationship between imported inputs and firm productivity (e.g., Halpern et al. (2009) for Hungary, Kasahara and Rodrigue (2008) for Chile or Amiti and Konings (2007) for Indonesia).[1]

Another strand of literature focuses on firms' exports. In specification proposed by Melitz (2003) firms are heterogeneous in productivity levels, and only a subset of them - the most productive - become exporters. Several empirical studies confirmed this export pattern (e.g., Roberts and Tybout (1997), Clerides et al. (1998), Bernard and Jensen (1999) or Alvarez and Lopez (2005)). The underlined idea is that firms productivity level must be high enough to bear the fixed cost associated with entry in export markets. Thus, exporting status and productivity are correlated at the firm level. Since the pioneering work of Melitz (2003), most heterogeneous firms' models stayed however silent on the determinant of firms' heterogenous productivity level which is considered exogenous.[2]

This paper studies the role of imported inputs on firm's export performance. Since foreign inputs improve firms' productivity, they should also be an important asset for exporting activities. Firms boost their efficiency gains by sourcing their intermediate goods from abroad

[1] Muendler (2004) stands as an exception. He does not find a significant effect of firm productivity growth through importing inputs for Brazil.

[2] Few theoretical exceptions introduce endogenous productivity gains determined by R&D investments: Costantini and Melitz (2007), Atkeson and Burstein (2010), Aw, Roberts and Xu (2009) and Bustos (2010). The most recent literature extends the source of heterogeneity to characteristics other than just productivity; for instance, several recent papers consider the ability to deliver quality (e.g., Verhoogen 2008, Kugler and Verhoogen 2008 or Hallak and Sivadasan (2009)).

and thereby are able to bear the cost of entering and surviving in export markets. In this case, the export selection process is explained by firm productivity which is determined by the firm level of imported inputs. We thus bridges the gap between two distinct lines of literature: the first focuses on firms' export ignoring the use of imported inputs in production, the second investigates the impact of importing inputs on firms productivity but does not look at export scope. We use a unique firms' level database of imports at the product (HS6) level provided by French customs for the 1995-2005 period where varieties of inputs are defined as a product-country pair. We also aim at distinguishing the different channels through which an increase in imported inputs affects firm productivity and exports.

The first mechanism is the variety/complementarity channel. By accessing to new imported varieties of intermediate good, firms expand the set of inputs used in production and therefore reach a better complementarity. Resulting gains in productivity allow entering more export markets. We explore such eventuality by testing for the impact of an increase in the number of imported input varieties on firms' TFP and export scope. Halpern at al. (2009) examine the variety channel (imported inputs are assumed imperfect substitutes to domestic inputs) through which imports affect firm productivity. They find that imported inputs lead to significant productivity gains, of which two thirds are attributed to the complementarity argument and the remainder to a quality argument. Similarly, Goldberg et al. (2009) find that an increase in imported input varieties contribute to the expansion in firms' product scope. We depart from their works by exploring the impact of the complementarity channel on firms' export performance.

The second mechanism is related to transfert of technology embodied in imported inputs. One of the channels through which international trade promotes economic growth is indeed related to the diffusion of modern technologies embodied in imported intermediate inputs. Empirical works using aggregate cross-country data have indeed emphasized this effect (e.g., Coe and Helpman (1995), Coe and Helpman (1997) or Keller (2002)).

Finally, the last channel is related to a price effect. As shown in the love-of-variety setting of Krugman (1979) or Ethier (1982) a rise in the number of varieties imported also affects price indices. In order to assess the impact of the increase in the number of imported inputs varieties on the imported inputs price index, we rely on Feenstra (1994) methodology augmented by Broda and Weinstein's (2006) work.

Two theoretical papers, Kasahara and Lapham (2006) and Bas (2009) extend Melitz model to incorporate imported intermediate goods. In their model, productivity gains from importing intermediates goods allow some importers to start exporting. Importantly, because import and export are complementary, Kasahara and Lapham (2006) argue that import protection acts as export destruction. To the best of our knowledge, our study is the first to empirically put together the two following arguments: firms that have access to a larger variety of imported inputs increase their productivity and firms with high productivity levels export more varieties.[3]

This paper provides new insight on the role of imported inputs in shaping firms' export performance. The main results are the following. The greater the number and the diversification of imported inputs, the larger the number of varieties that firms sell in the export market. This effect is larger for inputs imported from developed countries that have a more advanced technological content. We find that the use of imported inputs from developed countries increase the export scope 20% to 60% more than a similar increase in imported inputs from less developed countries. We posit that by using more varieties of imported inputs, the firm reaches a better complementarity of inputs and therefore raises its productivity. These more productive firms are also more likely to export more products as they are able to bear the export fixed costs and survive on competitive export markets. We thus explore whether the channel through which imported inputs increase firms ability to export more varieties is associated with productivity gains. Using a semi-parametric estimation of total factor productivity based on the methodology of Olley and Pakes (1996) and Ackerberg et al. (2007), we find strong empirical evidence on firms' productivity improvements related to the use of foreign intermediate goods. We also find support for the technology argument for imports (i.e., importing inputs from developed countries improves firms TFP 57% more than importing inputs from developing countries). By contrast, we do not find strong evidence in favor of the price argument as the large increase in the number of imported inputs only modestly reduces the import price index.

The paper is organized as follow. Section 2 presents data and evidence on the increase in imported inputs for France. Section 3 develops the theoretical background. Section 4 provides the empirical methodology and the main results of the impact of increased imported inputs on

[3] Bas (2009) tests for the relationship between imported inputs and export scope for the case of Chile and Argentina. We add to her paper by looking at the countries of origin of imports and thereby distinguishing the channels trough which imported inputs impact firms TFP and export scope.

firms' export scope. Section 5 shows that firms' TFP is also affected by an increase in imported inputs and explores the complementarity and technology channels. Section 6 focuses on the price channel. Section 7 concludes.

2 Data, facts and trends

2.1 Data

Our dataset is a panel of French manufacturing firms for the period 1995-2005. It comprises firm level characteristics such as sales, employment, wages, capital, input cost as well as trade information on firms' exports and imports. This dataset was built from two sources. Trade data comes from the French Customs which provides annual imports and exports data for French manufacturing firms over the 1995-2005 period.[4] The customs data is at the product level (6-digit Harmonized System (HS6), i.e., 5349 categories) and specifies the country of origin (destination) of imports (exports). This is a unique feature of our database which allows distinguishing imported inputs from different sources, namely developed and developing countries.[5] Data on firms' level characteristics comes from the Annual French Business Surveys ("EAE") available from the INSEE (French Institute of Statistics) and includes French firms with more than 20 employees. In both databases, individual firms are assigned a specific code, the so-called "siren" code, which allows matching information from the two sources. Unfortunately, whereas the Customs data encompasses most trade flows in and out France over the period (representing trade activity of about 120,000 firms per year), the "EAE" database is quite restrictive (the number of firms is of about 20,000 per year). The "EAE" database is however of great value to us as it includes data on capital and thereby allows calcutation of total factor productivity. After merging these two databases, we work with an unbalanced panel of about 21,000 firms or 230,000 observations over the sample period. Nominal variables are in million of euros and are deflated using 2-digit industry-level prices indices provided by the INSEE.

Table 1 reports information on the number of firms by trade status. Interestingly, 70% of our French firms are exporters. This feature is at odds with previous studies which evidenced

[4]This database is quite exhaustive. Although reporting of firms with trade values below 250,000 Euros (within the EU) or 1,000 Euros (rest of the world) is not mandatory, we observe many observations below these thresholds

[5]Developing countries correspond to non high-income countries, defined by the World Bank as countries with 2007 per-capita GNIs under \$11,456 computed in U.S. dollars using the Atlas conversion factor.

the small share of firms that export (see for example, Bernard and Jensen (1995) for the US, Aw, Chung and Roberts (2000) for Korean and Taiwan or Eaton, Kortum and Kramartz (2004) for France). Eaton et al. (2004) database differs however from ours as they use an exhaustive database of French companies and thus work with more than 200,000 firms. By restricting our database to the biggest firms (i.e., firms with more than 20 employees), we also capture more exporters.[6] As our aim is to test for the impact of importing more varieties on export margins, such bias in the database does not seem inappropriate. Importantly, most exporters (i.e., 86% of them) are also importers.

Table 1: Descriptive statistics number of firms by trade status

	1995-2005	
	N	Percentage
Domestic	50737	0,22
Only exporter	23797	0,10
Only importer	19879	0,09
Exporter-importer	137576	0,59

Notes: N is the total number of observations over the period. Percentage is the fraction of firms by trade status over total firms.

Imported input variety is a key variable in this paper. As common in the literature (e.g., Feenstra (1994) or Broda and Weinstein (2006)), we define a variety as a product-country pair. A product corresponds to a 6-digit HS category and a variety to the import of a particular good from a particular country. For example, wire of silico-manganese steel (i.e., HS 722920) is a product while wire of silico-manganese steel from Italy is a variety. In 1995, french firms imported four different varieties of wire of silico-manganese steel. Our dataset does not distinguish imports of final goods from imports of intermediate inputs. Knowing that firms are classified according to their main activity at the HS4 level and following Feenstra and Hanson (1996), we consider that imports from the same HS4 category as the firm main activity are final goods whereas imports from any other category are intermediate inputs.[7]

[6] The studies cited above as well as many others (e.g., Clerides et al. (1998) or Delgado et al.(2002)) show that exporters are larger, more productive and more capital intensive. More specifically, several European based studies (e.g., Andersson et al. (2007) for Sweden, Muuls and Pisu (2007) for Belgium or Castellani et al. (2010) for Italy) found that relying on a restricted number of firms (the largest ones) increases drastically the share of exporters

[7] As firms' main activity industry code is not always available, our sample size is reduced.

Table 2 shows the average number of varieties imported as intermediate inputs (henceforth imported inputs) by a firm per year. Two broad facts emerge: First, most imported inputs come from developed countries. Second, exporters are the biggest importers.[8]

Table 2: Descriptive statistics by trade status

	Only importer	Exp-imp	Entrants	Quitters
Number of imported varieties	8 (13)	35 (68)	18 (46)	26 (59)
Number of imported varieties from DC	7 (12)	31 (57)	16 (39)	23 (47)
Number of imported varieties from LDC	1 (1.6)	4 (11)	2 (8)	3 (12)

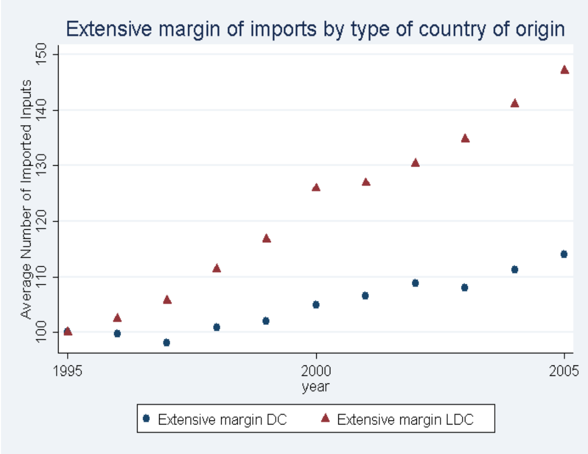
2.2 Trend in imported inputs

Imports of intermediate inputs have increased drastically over the period. This is reflected in Figure 1 which plots the extensive margins of imports over the sample period 1995-2005. Firms' average number of imported varieties from developed countries rose by 12% between 1995 and 2005. The increase is even more strinking for imported inputs from developing countries with a growth of 48% in the number of varieties. Figure 2 provides similar information for exports and reveals a consequent growth in the number of exported varieties. Fench firms have thus become more internationalized over the period by increasing both their imports and exports of varieties. Whether there is a correlation between the increase in imported inputs and exports is what we ought to investigate.

Several studies (e.g., Bernard and Jensen (1999) or more recently De Loecker (2007)) focused in firms' exports pattern and have shown that exporting firms have different characteristics than non-exporting firms. We are interested in the specificities of firms that import inputs and therefore, we run an equivalent import-premia analysis. Such preliminary analysis is given in Table 3 for the full sample and in Table 4 distinguishing for the country of origin of the inputs. Each specification gives OLS estimates of the impact of being an importer of intermediate goods on firms' characteristics such as employment, labor productivity (using

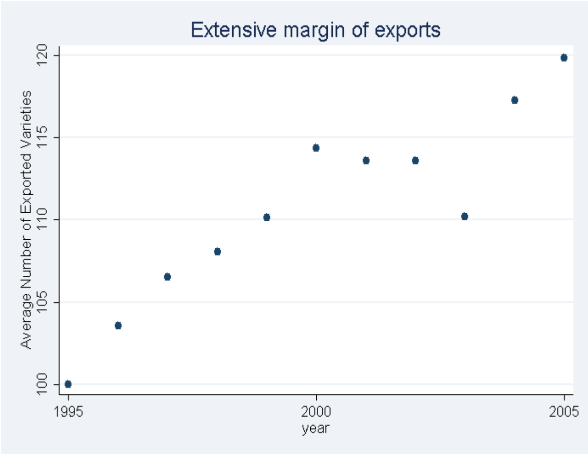
[8]All the main results of this paper have been tested for alternative definition of intermediate inputs (i.e., using the United Nations Broad Economic Categories (BEC) classification). Results are similar to the ones presented here and are available upon request

Figure 1:



Source: Authors calculations based on French firms' customs dataset.

Figure 2:



Source: Authors calculations based on French firms' customs dataset.

value-added per worker as rough measure of productivity), wages or capital and material intensity. There are substantial differences between importers and non-importers. The former are on average larger (66.4%), more productive (16.8%), pay higher wages (73.7%) and are more capital (61.6%) and materials (102.3%) intensive. In all cases, the impact of being an importer on firms' characteristics is stronger if the imports come from developed countries.

Firms that import intermediate goods also differ in their exit-entry behavior. The exit-rate of importing firms over the period is of 4% whereas for non-importing firms it reaches 8.7%. Similarly, the entry rate of importing firms is of 8.7% whereas it is of 6.8% for non-importing firms. Firms importing inputs thus exit at a lower rate and enter at a higher rate than non-importing firms. Although this discrepency may be caused by sample selection effects, it may

Table 3: **Importer premia**

	(1) Employment	(2) VA/employment	(3) Wages	(4) Capital/employment	(5) Materials/employment
importer	0.664***	0.168***	0.737***	0.616***	1.023***
	(0.003)	(0.002)	(0.004)	(0.006)	(0.006)
Year f.e.	Yes	Yes	Yes	Yes	Yes
Industry (2 digit)	Yes	Yes	Yes	Yes	Yes
Observations	228957	228954	228533	170392	225735
R^2	0.154	0.166	0.192	0.171	0.458

Notes: Standard errors are in parentheses. All coefficient are significant at the 1% level. Importers is an import dummy equals to one if the firms imported intermediate inputs and zero otherwise.

Table 4: **Importer premia by country of origin**

	(1) Employment	(2) VA/employment	(3) Wages	(4) Capital/employment	(5) Materials/employment
Importer mainly from DC	0.689***	0.165***	0.760***	0.624***	1.004***
	(0.004)	(0.002)	(0.004)	(0.006)	(0.006)
Importer mainly from LDC	0.215***	0.143***	0.278***	0.310***	0.926***
	(0.010)	(0.008)	(0.011)	(0.017)	(0.020)
Year f.e.	Yes	Yes	Yes	Yes	Yes
Industry (Ape 2 digit)	Yes	Yes	Yes	Yes	Yes
Observations	228957	228954	228533	170392	225735
R^2	0.163	0.166	0.200	0.173	0.456

Notes: Standard errors are in parentheses. All coefficient are significant at the 1% level. Importers mainly from DC is an import dummy equals to one if the firms imported more than 50% of its intermediate inputs from developed countries and zero otherwise whereas importers mainly from LDC is an import dummy equals to one if the firms imported more than 50% of its intermediate inputs from developing countries and zero otherwise .

also reflect a specificity of importing firms which might be more efficient and thereby able to survive market conditions. In any case, such exit-entry rate difference should be taken into account while turning to the empirical analysis.

3 Theoretical Motivation

In this section, we provide a theoretical framework which highlights the mechanisms through which imported inputs affect firms' total factor productivity (TFP) and export scope. We build a simple partial equilibrium model based on Melitz (2003) in order to rationalize the empirical facts described in the previous section and derive a set of testable predictions.

3.1 A simple model

There is a continuum of domestic firms in the economy that supply differentiated final goods under monopolistic competition. Firms differ in there initial productivity draws (φ) which are introduced as in Melitz (2003). In order to produce a variety of final good y, the firm combines three factors of production: labor (L), capital (K) and a range of differenciated intermediate goods, (M_{ij}) produced by industry i, that can be purchased in the domestic (M_{iD}) or in the foreign market (M_{iF}). The technology is represented by a Cobb Douglas production function with factor shares $\eta + \beta + \sum_{i=1}^{I} \alpha_i = 1$:

$$y = \varphi L^{\eta} K^{\beta} \prod_{i=1}^{I} (M_{ij})^{\alpha_i} \qquad \text{with } j = \{D, F\} \tag{1}$$

where $M_{ij} = \left(\sum_{v \in I_{ij}} \chi_{ij} m_{iv}^{\frac{\sigma_i - 1}{\sigma_i}} \right)^{\frac{\sigma_i}{\sigma_i - 1}}$.

The range of domestic and imported varieties of intermediate goods of industry i are aggregated by CES functions M_{iD} and M_{iF} respectively, where $I_D = \{1, ..., M_d\}$, $I_F = \{1, ..., M_f\}$ and the elasticity of substitution across varieties of industry i is $\sigma_i > 1$. In this setting, firms might increase their productivity by sourcing intermediate inputs from abroad. Importing intermediate goods imply paying a fixed importing cost (F_m) and is therefore not optimal for all firms. We make the simplifying assumption that firms either source their inputs domestically or internationally. The technology transfer parameter, χ_{ij}, captures the fact that imported inputs may enhance firm efficiency differently depending on their origin. χ_{ij} is equal to one for inputs sourced domestically and is increasing in the exporting countries' GDP for inputs sourced internationally.

Considering that intermediate inputs are symetrically produced at a level $\overline{m}$, it can be shown that

$$M_{iD} = N_{iD}^{\frac{\sigma_i}{\sigma_i - 1}} \overline{m}_D \quad \text{and} \quad M_{iF} = (N_{iF} \chi_i)^{\frac{\sigma_i}{\sigma_i - 1}} \overline{m}_F \tag{2}$$

where N_{iD} and N_{iF} are the number of domestic and imported varieties of intermediate goods. The production function for a variety of final good (equation (1)) can thus be rewriten as:

$$y = \varphi L^{\eta} K^{\beta} \prod_{i=1}^{I} M_{ij}^{\alpha_i} (N_{ij} \chi_{ij})^{\frac{\alpha_i}{\sigma_i - 1}} \qquad \text{with } j = \{D, F\} \tag{3}$$

where $M_{ij} = N_{ij} \overline{m_j}$. As common in the literature, the first-order condition is such that prices reflect a constant mark-up, $\rho = \frac{\phi - 1}{\phi}$, over marginal costs, $p = \frac{MC}{\rho}$, where the marginal cost of production is determined by:[9]

$$MC_j = \frac{p_k^{\beta} w^{\eta} \prod_{i=1}^{I} p_{ijm}^{\alpha_i}}{\varphi \prod_{i=1}^{I} \left(N_{ij}\chi_{ij}\right)^{\frac{\alpha_i}{\sigma_i - 1}}} \tag{4}$$

w is the wage, p_k is the price of capital goods and p_{ijm} is the price of inputs. Combining the demand faced by each firm, $q_j(\varphi) = \left(\frac{P}{p_j(\varphi)}\right)^{\phi} C$ - where P is the aggregate final goods price index and C is the aggregate expenditure on varieties of final goods -, and the price function, $p_j(\varphi) = \frac{MC_j}{\rho}$, revenues are given by $r_j(\varphi) = q_j(\varphi)p_j(\varphi)$:

$$r_j(\varphi) = \left(\frac{P}{p_j}\right)^{\phi-1} R,$$

where $R = PC$ is the aggregate revenue of the industry which is considered exogenous to the firm. Firm profit thus simplifies to $\pi_j = \frac{r_j}{\phi} - F$, where F is the fixed production cost.[10]

Firms' decisions: Only those firms with enough profits to afford the fixed production cost (F) will be able to survive and produce for the domestic market using only domestic intermediate inputs. The zero cutoff profit condition implies that profits of the marginal firm are equal to zero: $\pi_d\left(\varphi_d^*\right) = 0$, where the value φ_d^* represents the productivity value of the marginal firm producing for the domestic market only.

Once they have decided to stay and produce, firms may also decide to import intermediate goods to reduce their marginal costs on the basis of their profitability. Import decision is endogenously determined by the initial productivity draw (φ). Firms with a more favorable productivity draw have a higher potential payoff from sourcing their inputs from abroad and hence are more likely to find incurring the fixed importing cost worthwhile. The increase in revenues due to the use of foreign inputs enables them to pay the fixed importing cost. The indifference condition for the marginal firm to import is given by: $r_f\left(\varphi_f^*\right) - r_d\left(\varphi_f^*\right) = \phi F_m$, where the value φ_{xf}^* represents the productivity cutoff to import intermediate goods.

Finally, the most productive firms may also chose to export. The tradability condition in this case is given by: $\frac{r_x(\varphi_x^*)}{\phi} = F_x$, where φ_x^* is the productivity of the marginal firm serving

[9]Consumer preferences are represented by a standard CES utility function $C^{\frac{\phi-1}{\phi}} = \sum_{k\in\Omega_d} C_{dk}^{\frac{\phi-1}{\phi}}$ where $\phi > 1$ is the elasticity of substitution across final consumption goods. Results follow.

[10]Recall: $\pi = r - wl - p_k k - \prod_{i=1}^{I} p_{ijm} M_{ij} - F$.

the export market. While this export condition depends on the firm productivity draw, we will show that the number and quality of imported inputs also matters.

3.2 Testable predictions

3.2.1 Imported inputs and firm productivity

In this section, we derive a set of testable predictions for firms using foreign intermediate goods. From the production function in equation (3) we can derive the total factor productivity (A) of each firm as a Solow residual:

$$A = \frac{y}{L^{\eta} K^{\beta} \prod_{i=1}^{I} M_{iF}^{\alpha_i}} = \varphi \prod_{i=1}^{I} \left(N_{iF}\chi_i\right)^{\frac{\alpha_i}{\sigma_i - 1}} \tag{5}$$

Firm' TFP is an increasing function of the initial firm productivity draw - proxied by the unobserved heterogeneity shock, φ-, the number of foreign input varieties, N_{iF}, and the foreign technology transfer parameter (χ_i). As mentioned above, the value of the foreign technology parameter depends on the country of origin of imports. If the firm sources its inputs from developed countries, the effect on firm TFP is expected to be higher relative to sourcing intermediate goods from less developed countries. This specification allows us to disentangle two channels through which imported intermediate goods affect firm TFP: (1) the variety/complementarity channel and (2) the technology transfer.

Testable prediction on TFP: *The larger the range of imported input varieties, the higher firm TFP. This effect is stronger for firms sourcing their inputs from the most developed countries.*

3.2.2 Imported inputs and export patterns

Using the price and the revenue function defined in the previous section, we can derive the following expression for firms' export revenues:[11]

$$r_x = \Phi \left(\frac{\varphi \prod_{i=1}^{I} \left(N_{iF}\chi_i\right)^{\frac{\alpha_i}{\sigma_i - 1}}}{\prod_{i=1} p_{ifm}^{\alpha_i}} \right)^{\phi - 1} \tag{6}$$

[11] Note that the price set by a exporting firm is given by $p_x = p_d\,(1+\tau)$, where τ is the export variable cost.

where $\Phi = P^{\phi-1}R\left(\rho^{-1}(1+\tau)\,p_k^{\beta}w^{\eta}\right)^{1-\phi}$, with τ the variable export cost, P the aggregate price index of final goods and R aggregate revenue of the industry, all exogenous to the firm. An increase in the number of imported varieties N_{iF} or in the technology transfer embodied in imported inputs (χ_i) thus raises firms' export revenues. The increase in the expected export revenues allows the firm to bear the fixed cost of exporting and thus sell on export markets. Melitz (2003) shows that firm TFP determines export revenues. In our setting, the export selection process is thus reinforced by the different mechanisms through which importing intermediate goods determine firm TFP (the variety and technology transfer channel).

Testable prediction on export varieties: *Importing more varieties of foreign inputs increases export profits allowing more firms to export and sell their varieties on export markets. This effect is more pronounced for firms importing intermediate goods with higher technological content from developed countries.*

4 Imported inputs and Export patterns

4.1 Empirical specification

Using more varieties of intermediate goods should thus fulfill firms needs for complementarity inputs (or love for varieties) and thereby enhance their technology. More productive and efficent firms then find it easier to enter exports markets. As a first step, we test for the impact of using more varieties of intermediate inputs on the number of exported varieties. In the next section, we also provide empirical evidence on the role of foreign inputs in enhancing productivity gains. We use several measure of imported inputs as regressors: the number of imported inputs, the value of imported inputs and the import status of the firm (i.e., a dummy that takes a value of one if the firm imports intermediate inputs). We also use a measure of imported inputs concentration, the Theil's entropy index (Theil 1972). Such measure capture the level of diversification of intermediate inputs at the firm level. For each firm, we compute the concentration in imported varieties across potential importers as given by:

$$T_i = 1/n\sum_{k=1}^{n}(x_{ik}/\mu)\ln(x_{ik}/\mu), \quad with \quad \mu = \sum_{k=1}^{n}(x_{ik}/n)$$

where x_k is the import value of variety k by firm i and n is the number of potential importer.[12]

Table 5 presents various estimators using the number of imported inputs as independent variable while Table 6 shows the results of imported inputs diversification on the number of varieties exported.[13] Specifications (1) to (3) correspond to within estimates (including firms' level fixed effects) controlled for time, while specification (4) and (5) present five period difference and GMM estimates respectively. Specifications (2) improves specification (1) by adding controls on size. Whereas it is likely that the number of exported varieties and imported inputs are size dependent, time and fixed effects do not capture firm-time specific evolutions in size. Controlling for size is therefore primordial and is carried over all other specifications. By taking five period differences, we propose an alternative specification which isolates longrun changes from business-cycle effects.[14] We do not report OLS estimates which are likely to be biased due to correlation between unobserved firms specific permanent shocks and imported inputs decisions.[15] While the within and the five period difference estimators control for correlation between inputs and permanent shocks, it does not deal with inverse causality issues between exports and imported inputs decisions. As a first step toward correcting for this issue and because it does not lack economic sense, we decided to consider the effect of past imported inputs decision on contemporaneous export pattern. The technology and complementarity gains that firms acquire through increased varieties of imported inputs are indeed likely to increase the variety of export with time lags. The inverse causality issue is however likely to still be present: Firms that aim at increasing its exported varieties in $t + 1$ increase their inputs and thereby, may import more varieties of imported inputs in t. Moreover, firms that sell goods in the export market benefit from direct linkages with foreign suppliers of intermediate inputs. In this case the error distribution of our previous specifications might not be independent of the regressors' distribution. We thus propose an alternative estimator: the difference GMM.

The GMM estimator (Arellano and Bond (1991)) corrects for causuality/simultaneity issues by treating the number of imported inputs as endogenous variables and exploiting moment

[12] We also use alternative measures of concentration such as the Herfindahl index. Results are similar and available upon request.

[13] Estimations using inputs intensity or import status as independent variables provide very similar results, we thus decided not to include them in the paper. Theses results are available upon request.

[14] Variables then correspond to annual change over the period.

[15] OLS estimates encounter endogeneity issues caused by omitted variables at the firm level. Exports decision may indeed be influenced by some firm-specific attributes or firm-specific macroeconomic aggregate shocks that also influenced imported inputs decision. We are thus facing some firm-specific variables that are carried through time and are not observed by the researcher.

conditions of exogeneity of lagged endogenous variables.[16] GMM estimators also capture dynamic effects in the dependent variable. The number of exporting varieties in t thus depends on past export experiences. In our case, such effects are likely to be important due to the presence of fixed costs of exporting. Bernard, Redding and Shott (2009) recently showed that exports fixed costs might also be product-country dependent. If the error term contains a specific time-invariant unobserved heterogeneity, the lagged value of the number of exported varieties is endogenous. Our GMM specification treats all variables as endogenous. The set of instruments is composed of large lags of endogenous variables (4 to 7 lags depending on the specification). Sargan tests validate our choice of instruments.

4.2 Results

Table 5: **Export scope and number of imported inputs**

Dependent variable:	Number of exported varieties of firm (i) in year (t)				
	(1)	(2)	(3)	(4)	(5)
Number of imported inputs (t-1)	0.146***	0.127***			0.157**
	(0.004)	(0.004)			(0.062)
Number of imported inputs (t-2)			0.064***		
			(0.004)		
Δ(5 periods) Number of imported inputs				0.084***	
				(0.009)	
Size(t-1)		0.339***	0.355***		-0.184
		(0.012)	(0.014)		(0.103)
Δ(5 periods) Size				0.047**	
				(0.020)	
Number of exported varieties(t-1)					0.362***
					(0.073)
Firm fixed effects	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes
Observations	137892	137473	117185	44801	84031
R^2	0.040	0.063	0.038	0.012	
Sargan test					
p-value of Sargan					0.726
p-value AR2					0.006
p-value AR3					0.651
p-value AR4					0.718
p-value AR5					0.399

Notes:The dependent variable is the number of exported varieties of firm i in year t. Column (5) shows the GMM estimations. The set of instruments is composed of lagged values of the number of exported varieties, the number of imported inputs, labor productivity and size. All these variables are treated as endogenous variables. Since the Arellano-Bond test of autocorrelation reveals that the disturbance might be in itself auto-correlated of order 2, but not further, we take lags between t - 4 and t -7. The Sargan test validate our instrument choice. The number of individuals relative to the number of instruments is reassuring as regards any possible bias in the test when using a large number of instruments (Windmeijer, 2005). *** p<0.01, ** p<0.05, * p<0.1. Robust standard errors in parentheses

The impact of a rise in the number of varieties of imported inputs on the number of

[16]Relative to instrumental variables method, the GMM estimation is efficient in the presence of heteroskedasticity.

Table 6: **Export scope and diversification in imported input**

Dependent variable:	Number of exported varieties of firm (i) in year (t)				
	(1)	(2)	(3)	(4)	(5)
Weighted mean of Theil index (t-1)	-0.051***	-0.041***			-0.332***
	(0.004)	(0.003)			(0.091)
Weighted mean of Theil index (t-2)			-0.017***		
			(0.004)		
Δ(5 periods) Weighted mean Theil index				-0.020***	
				(0.005)	
Size(t-1)		0.404***	0.384***		-0.032
		(0.014)	(0.015)		(0.092)
Δ(5 periods) Size				0.050**	
				(0.021)	
Number of exported varieties(t-1)					0.285***
					(0.020)
Firm fixed effects	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes
Observations	116446	116397	98566	44801	89717
R^2	0.015	0.050	0.036	0.005	
Sargan test					
p-value of Sargan					0.331
p-value AR2					0.008
p-value AR3					0.151
p-value AR4					0.688
p-value AR5					0.480

Notes: Same as Table 5

exported varieties is positif and significant in all regression (Table 5) . Firms that import intermediate inputs export in average 12.7% (specification (2)) to 15.7% (specification (5)) more varieties than non-importing firms.

The effect of the number of varieties of imported inputs on the number of exported varieties is robust to the introduction of lagged imported inputs variables. An increase in the number of imported inputs with two periods lags has a positive effect on the current number of exported varieties although this effect is smaller in magnitude. This suggests that adapting production and exports to the new set of inputs takes time.[17] Our results are robust to a five period difference specification. The coefficient on the number of imported varieties is positive and significant indicating that a growth in imported inputs varieties enhances growth in the number of exported varieties. The same results hold taking alternative period differences (i.e., three, four or more years).

Finally, Table 6 reports results of the impact of imported inputs diversification on the number of exported varieties. We look at weighted average Theil indices, where Theils are computed at the firm-product level and measure concentration across varieties. The weights

[17] We also used lag of three and four periods. The impact of imported inputs on number of exported varieties is still positive and significant with a decreasing influence.

correspond to products shares in firms production. The coefficient on the concentration index is negative and significant in all specifications, suggesting that the more diversified the firm, the higher the number of varieties it exports. If imported inputs become twice more diversified, the number of exported varieties raises by 33% (relying on our prefered GMM estimation). The use of concentration measures improve our understanding of the effect of imported inputs on exported varieties as it does not focus uniquely on numbers but also on the relative share of each input varieties in firms imports. A better distribution of imports across varieties entails an increase in exported varieties. This pushes for the complementarity argument where all inputs enter the production process.

4.3 Does the origin of imported inputs matter?

The previous section evidences the importance of importing large varieties of intermediate goods. By including a diversified set of imported inputs in the production process, firms raise their ability in entering export markets. As mentioned above, a variety is defined as a product-country pair. We may thus wonder whether all varieties impact export in a similar way. That is: Does the origin of imported inputs matter for firms export patterns?

For each measure of imported inputs, we distinguish varieties according to their country of origin. More specifically, we set apart imported inputs from developed and developing countries using the World Bank definition as mentioned above. The rationale behind this distinction is that varieties imported from more advanced countries presumably contain more technology and thereby may affect production and exports more significantly.

We use the same specification as before: Specifications (1) to (3) correspond to within estimates, while specification (4) and (5) present five period difference and GMM estimates respectively. Table 7 reports the results.

As expected, varieties from developed countries increase the number of exported varieties more significatively. Specification (2) and (3) shows that the impact of an increased use of imported inputs from developed countries rise the number of exported varieties 60% more than a similar increase in the use of imported inputs from developing countries. Although the difference is less significant with the GMM estimation, the impact of increased varieties of inputs from developed countries remains stronger. According to specification (5), imported inputs from developed countries increase export scope 20% more than imported inputs from developing countries. Our prior that advanced economies produce varieties embodying more of the technology and quality required for an increase in the number of exported varieties find some support. Note that the import premia analysis (Section 2.2) also suggests that firms importing mainly from developed countries are also more capital intensive. This may reflect the importance of absorptive capacities or may be a consequence of "learning by importing".[18]

As alternative specifications, we also tested for the impact of our main independent variables on the number of exported product (instead of varieties) and on the intensive margin of exports (see Table 13 and Table 14 in the Appendix). Results are in the same line as the one presented here. Thus, by and large, we find that an increase in the number of varieties and diversification of imported inputs has a robust impact on the extensive (products and varieties) margin and the intensive margin of exports. This impact is renforced if the inputs come from the most developed countries.

Table 7: **Export scope and number of imported inputs by country of origin**

Dependent variable:	Number of exported varieties of firm (i) in year (t)				
	(1)	(2)	(3)	(4)	(5)
Number of imported inputs from DC(t-1)	0.133***	0.114***			0.138**
	(0.004)	(0.004)			(0.063)
Number of imported inputs from LDC(t-1)	0.076***	0.069***			0.113*
	(0.005)	(0.005)			(0.064)
Number of imported inputs from DC(t-2)			0.056***		
			(0.004)		
Number of imported inputs from LDC(t-2)			0.033***		
			(0.005)		
Δ(5 periods) Number of imported inputs mainly from DC				0.088***	
				(0.015)	
Δ(5 periods) Number of imported inputs mainly from LDC				0.019***	
				(0.007)	
Size(t-1)		0.335***	0.355***		-0.145
		(0.012)	(0.014)		(0.103)
Δ(5 periods) Size				0.054**	
				(0.027)	
Number of exported varieties(t-1)					0.401***
					(0.072)
Firm fixed effects	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes
Observations	137892	137473	117185	11359	84031
R^2	0.041	0.064	0.038	0.021	
Sargan test					
p-value of Sargan					0.277
p-value AR2					0.001
p-value AR3					0.493
p-value AR4					0.616
p-value AR5					0.394

Notes:Same as Table 5

[18]On the same token, Serti and Tomasi (2008) finds than importers sourcing from developed countries are more capital and skilled intensive than firms buying only from developing countries.

5 Imported inputs and firm' total factor productivity

5.1 Empirical specification

Why would an increase in the number of varieties of imported inputs used in production rise the number of exported varieties? We argue that importing more intermediates inputs increases firm's productivity and thereby make the firm able to overcome the export fixed costs. In this section, we test for the validity of such argument by estimating the impact of an increase in imported inputs on total factor productivity (TFP).

We get estimates of the production function by relying and building on Olley and Pakes (1996) extended by Ackerberg, Caves and Frazer (2007). We start by giving brief insights of the Olley and Pakes (henceforth OP) and Ackerberg et al. (henceforth ACF) techniques. The OP method allows controlling for simultaneity bias and self-selection issues which are most likely to be present in our specifications. Simultaneity arises because input demand and unobserved productivity are positively correlated. Firm specific productivity is indeed known by the firm but not by the econometrician and firms respond to expected productivity shocks by modifying their purchases of inputs. OLS estimates on capital (labor) thus tend to be downwardly (upwardly) biased.[19] Selection issues are likely to be present because productivity shocks influence exit decision whereas the econometrician only observes firms that stay in the market.[20]

Olley and Pakes (1996) propose a three-stage methodology to control for the unobserved firm productivity. They deal explicitly with exit and investment behavior. The rationale is to reveal the unobserved productivity through the investment behavior of the firm in $t-1$, which in turns theoretically depends on capital and productivity. Selection issues are taken into account by inferring that firms staying in the market make their decisions in accordance with their capital stock and expectations of productivity. By the means of this theoretical exit rule, Olley and Pakes (1996) estimate survival probabilities conditional on firm's available information. These probabilities are then used in the productivity estimation. The OP estimation is further described in the appendix.[21]

[19] Coefficients that are most responsive to productivity shocks tend to be upwardly biased.

[20] Moreover, if capital is positively correlated with profits, firms with larger capital stock will decide to stay in the market even for low realizations of productivity shocks. This implies a potential source of negative correlation in the sample between productivity shocks and capital stock, which translates into a downward bias in capital elasticity estimates.

[21] Note that the OP specification performs better than fixed-effect specifications because the unobserved individual effect (productivity) is not constrained to be constant over time. Moreover, approaches based on instrumental variables can be limited by the instruments availability. Finally, OP methodology does not

Ackerberg et al. (2007) reveals indentification issues on the labor coefficient of the OP model. They evidence significant collinearity between labor and unobserved productivity in the first stage of the OP method. Ackerberg et al. (2007) proposes an alternative method that modifies OP in order to account for these collinearity problems. The main technical difference lies in the timing of labor input decision. Whereas in the OP method, labor is a freely variable input and is chosen in t, the ACF method assumes that labor is chosen at the sub-period $t-b$ ($0<b<1$), after capital is known in $t-1$, and before investment is made in t. Decision on labor input is thus unaffected by unobserved productivity shocks between $t-b$ and t . Firms' investment decision in the ACF methodology thus depends on capital and productivity but also on labor inputs. In contrast with the OP method, this implies that the coefficients of capital, the number of imported inputs and labor are all estimated in the second stage. Further explanations on the ACF method are given in the appendix.

We rely on the OP/ACF method modified to account for the fact that investment decisions depend also on the importing inputs behavior of the firm.[22] As shown in Section 1, importing firms differ greatly from non-importing firms in all means including their capital intensity, sales and exit rates. Importantly, firms that import inputs from different countries face different market structures and factor prices when they make their investment and exit decisions. Modifying the OP/ACF estimation by incorporating imported inputs behavior does not therefore lack relevance. Following De Loecker (2007) and Kasahara and Rodrigue (2008), we thus include an additional state variable in the OP/ACF estimation which captures the imported inputs behavior of firms.[23]

We estimate the following specification of a Cobb-Douglas production function:

$$y_{it} = \beta_0 + \beta_l l_{it} + \beta_k k_{it} + \beta_m m_{it} + \beta_i Imp_{it} + \omega_{it} + \eta_{it} \tag{1}$$

All variables are expressed in natural logs. y_{pt} is the total production of firm i at time t, l_{it} is labor, m_{it} is materials, k_{it} stands fo capital stock and Imp_{it} corresponds to the different proxies of imported inputs. The error term can be decomposed into an intrinsical

assume restrictions on the parameters.

[22] Like almost all previous empirical works that estimate production functions using firm level data, we do not observe prices neither physical output at the firm level. The OP/ACF methodology thus faces the traditional concerns that productivity estimates may just capture differences in prices, mark-ups and demand variations and not actual physical productivity (Erdem and Tybout (2003), Katayama et al. (2005) and De Loecker (2007).

[23] De Loecker (2007)studies learning by exporting and includes export status as a state variable in the Olley and Pakes estimation whereas Kasahara and Rodrigue (2008) adds imported inputs status as state variable of their study of the effect of imported inputs on productivity using Chilean plant level data

"transmitted" component ω_{it} (productivity shock), which is observable to firms but not to the econometrician, and an i.i.d. component η_{it} We estimate the production function using OLS, Fixed Effects and the modified OP/ACF estimator. In the last specification, standard errors are obtained by bootstrap.

5.2 From importing inputs to increased TFP: the channels of transmissions

We explore the channels throught which access to foreign inputs affects firms' TFP focusing on the three main mechanisms pointed out in the literature: (i) access to higher number of varieties of inputs through imports (the complementarity/love for varieties assumption), (ii) availability of "better" inputs with higher level of technology and (iii) availability of "cheaper" foreign inputs. We first test for the complementarity argument for an increase in TFP. By reaching a better complementarity of inputs, firms increase their productivity and consequently increase the number of varieties they export. Firms may also benefit from technologies embodied in imported inputs. Such high technology products are likely to come from developed countries. Thus, by distinguishing varieties by their country of origin and setting apart varieties coming from developed and developing countries, we aim at capturing the embodied technology gains. Finally, a decrease in the price index would also enhance firms' productivity. Such lower index prices are likely to occur if the number of available varieties increase. This last channel is analysed in Section 6.

5.2.1 The complementarity channel

Table 8 presents the results of the impact of variations in number of imported inputs on firms's TFP from the various estimators described above.[24] We rely on the OP/ACF method which we find more accurate in our context. We also estimate the production function using the OP method, results are in the same vein as the one presented here and are available upon request.

The OP/ACF estimates reported in specification (5) imply that a firm only using domestic inputs can increase its TFP by 5.7% if it starts importing its inputs. The OP/ACF estimates on the Theil index of diversification also suggests a significant impact of imported inputs diversity on productivity. In line with theoretical evidence on the impact of an increase in

[24] We use imported input intensity, number of imported inputs and import status as alternative definition of the imported inputs behavior of firms. Results using the different state variables for imported inputs are very similar to the one presented here and are available upon request.

imported inputs on productivity (e.g., Ethier (1982), Markusen (1989), Romer (1987, 1990) or Grossman and Helpman (1991)) as well as with recent empirical findings (e.g., Amiti and Konings (2007) Kasahara and Rodrigue (2008), Halpern et al. (2009)), we thus find that a larger use of imported inputs increases TFP.

Table 8: **Production function estimates and imported inputs varieties**

Dependent variable:	Total production of firm (i) in year (t)					
	(1) OLS	(2) OLS	(3) Within	(4) Within	(5) OP/ACF	(6) OP/ACF
Employment	0.198***	0.272***	0.308***	0.311***	0.274***	0.200***
	(0.005)	(0.005)	(0.010)	(0.009)	(0.014)	(0.017)
Capital	0.087***	0.069***	0.029***	0.021***	0.069***	0.069***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Materials	0.646***	0.650***	0.514***	0.537***	0.498***	0.482***
	(0.003)	(0.003)	(0.005)	(0.005)	(0.008)	(0.009)
Number of imported inputs	0.104***		0.012***		0.057***	
	(0.003)		(0.004)		(0.006)	
Weighted mean of Theil index		-0.037***		-0.009***		-0.026***
		(0.003)		(0.003)		(0.005)
Industry fixed effects	Yes	Yes			Yes	Yes
Firm fixed effects	No	No	Yes	Yes		
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	171963	122200	171963	122200	110870	79992
R^2	0.574	0.629	0.152	0.221		

Notes: *** p<0.01, ** p<0.05, * p<0.1. Robust standard errors in parentheses

One of the reasons for using the OP/ACF method is to correct for potential downward bias in the OLS capital coefficient caused by simultaneity bias between input demand and unobserved productivity. The lower value of the capital coefficient under the OP/ACF estimation is therefore unexpected. Kasahara and Rodrigue (2008) find similar results and argues that the correlation between capital and the new state variable, imported inputs, raises doubt on the direction of the OLS bias on the capital coefficient.[25]

Overall, we thus find a positive and significant effect of an increase in the number of imported inputs or of the diversification of imported inputs on firms productivity. Such increase in productivity may allow firms to access export markets and therefore explain the strong positive link found previously between the number of imported imported inputs and exported varieties.

[25]We estimate capital coefficient following the traditional OP method (i.e., excluding the imported inputs state variable) and found OP estimate of 0.105. That is a higher value than the OLS estimates (Note that the OLS estimates exluding imported inputs as variable is of 0.099).

5.2.2 The technology channel

Technological spillovers may occur as producers of final goods learn from the technology embodied in the intermediate goods through careful study of the imported product (the blueprint) (Keller 2004).

In order to test for the hypothesis that varieties from developed countries embody technology and therefore enhance productivity, we regress firm's TFP on the the number of imported inputs distinguished by their countries of origin. As explained in Section 5.1, we rely on the OP/ACF estimation but also report OLS and within estimates. Results are presented in Table 9.

Table 9: **Production function estimates and imported inputs varieties by country of origin**

Dependent variable:	Total production of firm (i) in year (t)		
	(1) OLS	(2) Within	(3) OP/ACF
Employment	0.191*** (0.005)	0.308*** (0.010)	0.271*** (0.014)
Capital	0.087*** (0.003)	0.029*** (0.003)	0.067*** (0.003)
Materials	0.643*** (0.003)	0.514*** (0.005)	0.496*** (0.008)
Number of imported inputs from DC	0.095*** (0.003)	0.014*** (0.004)	0.044*** (0.006)
Number of imported inputs from LDC	0.061*** (0.005)	-0.000 (0.005)	0.028*** (0.008)
Industry fixed effects	Yes	No	Yes
Firm fixed effects	No	Yes	
Year fixed effects	Yes	Yes	Yes
Observations	171963	171963	110870
R^2	0.574	0.152	0.339

Coefficient on imported inputs from developed and developing countries are both positive and significant. The impact of imported inputs on TFP is however larger when the inputs come from the most developed countries and this result is consistent across all specifications. According to the results of our OP/ACF estimation, importing inputs from developed countries increase firms' TFP 57% more than importing inputs from less developed economies. This results is in line with the literature. For example, Coe and Helpman (1995) and Coe et al. (1997) find that foreign knowledge embodied in imported inputs from countries with larger R&D stocks has a positive effect on aggregate total factor productivity. More recently, Loof and Anderson (2008) using a database of Swedish manufacturing firms over the 1997-2004 period finds that productivity is increasing in the G7-fraction of total import. Our results thus evidence the technological gains and learning spillovers induced by a rise in imported inputs from developed countries. Firms' productivity is enhanced which leads to an increase in the number of variety exported.

6 The imported inputs price index channel

A rise in the number of varieties imported also affects price indices. In the love-of-variety setting of Krugman (1979) or Ethier (1982), variety gains come from imperfect substitution across goods and is reflected in a decrease in the price index. Empirical work assessing the gains from trade due to an increase in the number of varieties imported through the price channel remains however scarce (with notable exceptions of Broda and Weinstein's (2006) and Goldberg et al. (2009)).

In order to assess the impact of the increase in the number of imported inputs varieties on the intermediate goods price index, we rely on Feenstra (1994) methodology augmented by Broda and Weinstein's (2006) work. As defined in section 3, the production function (equation (1)) is assumed Cobb-Douglas in capital, labor and intermediate goods. Each imported intermediate good is a CES composite of the good's varieties (recall that a variety is defined as a product-country pair). The minimum cost associated with purchasing the basket of imported intermediate goods is derived from the aggregate CES function M_{iF} (equation (2)) and yields the following minimun cost unit function for imported inputs:

$$c_m(p_{iv}, I_{iF}) = \left[\sum_{v \in I_{iF}} \chi_i \left[\tau p_{iv} \right]^{1-\sigma_i} \right]^{\frac{1}{1-\sigma_i}} \tag{7}$$

where p_{iv} is the price of variety v of good in industry i imported in t and τ represents the trade costs. By taking the ratio of this minimun cost function over two periods, we can derive the so-called conventional price index, P_{iF}^{conv}. It corresponds to the price index of imported inputs over a constant set of imported varieties and is defined as

$$P_{iFt}^{\text{conv}} = \frac{c_m(p_{iv}, \widetilde{I_{iF}})}{c_m(p_{ivt-1}, \widetilde{I_{iF}})} = \prod_{v \in \widetilde{I_{iF}}} \left(\frac{p_{ivt}}{p_{ivt-1}} \right)^{w_{ivt}}$$

where $\widetilde{I_{iF}} = I_{iFt} \cap I_{iFt-1}$ is the set of varieties imported in periods t and $t-1$. Sato-Varia log ideal weights, w_{ivt}, are given by

$$w_{ivt} = \frac{\frac{s_{ivt}-s_{ivt-1}}{lns_{ivt}-lns_{ivt-1}}}{\sum_{v\in\widetilde{I_{iF}}} \frac{s_{ivt}-s_{ivt-1}}{lns_{ivt}-lns_{ivt-1}}} \quad \text{and} \quad s_{ivt} = \frac{p_{ivt}m_{ivt}}{\sum_{v\in\widetilde{I_{iF}}} p_{ivt}m_{ivt}}$$

where $p_{ivt}m_{ivt}$ is the value of variety v of good i imported in t.

Feenstra (1994) modified the conventional price index in order to account for new and disappearing imported varieties through the lambda ratio, Λ_{iFt}. The exact price index for imported inputs thus corresponds to

$$\Pi_{iFt} = P_{iFt}^{\text{conv}}\Lambda_{iFt}. \tag{8}$$

The lambda ratio, also called variety index, is defined as:

$$\Lambda_{iFt} = \left(\frac{\lambda_{iFt}}{\lambda_{iFt-1}}\right)^{\frac{1}{\sigma_{i-1}}}$$

where σ_i is the elasticity of substitution among varieties of good i,

$$\lambda_{iFt} = \frac{\sum_{v\in\widetilde{I_{iF}}} p_{ivt}m_{ivt}}{\sum_{v\in I_{it}} p_{ivt}m_{ivt}} \quad \text{and} \quad \lambda_{iFt-1} = \frac{\sum_{v\in\widetilde{I_{iF}}} p_{ivt-1}m_{ivt-1}}{\sum_{v\in I_{it-1}} p_{ivt-1}m_{ivt-1}}.$$

When the expenditure on new varieties in t is bigger that the expenditure on disappearing varieties from $t-1$, the lambda ratio is lower than one and the exact price index is lower that the conventional one. Intuitively, the exact price index decreases (increases) with the value spent on new (disappearing) varieties. The more substituable the varieties (i.e., the higher σ_i), the lower the impact of the lambda ratio on the exact price index. In the extreme case of homogenous varieties, the availability of more or less varieties does not matter.

Broda and Weinstein (2006) show that the exact price index can be aggregate across goods into the so-called aggregate exact import price index. Such index gives the overall effect of a increase in imported varieties on the import price index and is therefore of great interest for our work. By calculating the aggregate import price index, we aim at capturing the effect of the aggregate lambda ratio (variety index) on the aggregate conventional price index. Said differently, an increase in the number of new varieties of imported inputs is expected to decrease the aggregate conventional price index through the aggregate variety index. The aggregate exact import price index is given by

$$\Pi_{iFt}^{aggregate} = \prod_{i \in G} (P_{iFt}^{\text{conv}} \Lambda_{iFt})^{w_{it}}$$

where G is the number of goods and the weights, w_{it}, are Sato-Varia ideal log-change at the good level.

In order to compute the aggregate variety index, we first need to aggregate our imported inputs data to the product level. We thus work at the HS6-level of aggregation. Table 10 presents some statistics of the transformed database. Both the total number of imported varieties and the average number of varieties per product increase by 20% over the period which is quite significant.

Feenstra (2004) methodology do not allow computing lambda ratios for codes (at the product level) that do not exist over the entire period. New or disappearing products are extremely rare at the HS6-level for France over the 1995-2005 period (i.e., HS6 code 854219 which corresponds to some type of monolithic digital integrated circuits did not exist in 1995). When it occurs, we follow Goldberg et al. (2009) strategy of assigning a conservative value of one to the lambda ratio. More frequently, we run into the issue of an undefined lambda ratio caused by a lack of common varieties imported over the period. In such case we follow the now standard strategy of assigning average values of coarser HS codes.[26] The elasticities of substitution come from Broda et al. (2006) which estimates such elaticities for France at the HS3-level.[27]

Table 10: Variety in French Imports 1995-2005

Year	Total number of varieties	Number of HS6 cathegories	Average number of origin countries
1995	51763	4366	11.85
2005	61881	4367	14.17

We find an aggregate variety index of 0.983 over the 1995-2005 period.[28] Accounting for the net creation of varieties (i.e., new varieties less disappearing ones) thus lowers the conventional

[26]If there are no overlapping varieties at the HS6 level, then we rely on lambda ratio calculated at the corresponding HS4 level.

[27]By relying on HS3-level elasticities we are losing precision. Comparing their U.S. results for different periods and levels of aggregation, Broda et al. (2006) however argue that higher level of aggregation does not produce major differences in the main estimates.

[28]This result is obtained without imposing any major cleaning on the database. By dropping data that are at the tail of the distribution (potential aberrant data) with unit values of imports three time larger or lower than the average, we obtain an aggregate variety index of 0.979.

import price index by 1.7% over the period or about 0.2% per annum. This corresponds to a modest downward adjustment of the import price index. The net contribution of new varieties to the import price index is much smaller than the ones found by Goldberg et al. (2009) for India or Broda and Weinstein (2006) for the United States. In both of these studies, countries however experienced important changes in their trade patterns over the period examined. The Indian trade liberalization in 1991 entailed a drastic increase in new imported varieties with almost no loss of existing ones, while the U.S. experienced an important increase in trade with East Asia prior to 1990. Our results are clother to Arkolakis et al. (2008)'s which finds an aggregate variety index of 0.997 for Costa Rica over the 1986-1992 period.

The substantial increase in the number of imported varieties evidenced in Table 10 has therefore a limited impact on the aggregate import price index. The explanation lies in the definition of the variety index which provides information of the importance of net variety creation. If new varieties are imported in small quantities while dissapearing varities corresponds to large amount, the net effect on the aggregate price index is small. The discrepancy in the conventional price index or the variety index across sectors is however very large. The impact of a change in price indices on firm's performance may thus be still consequent if the firm uses mainly those inputs that have a specially low variety index.

In order to investigate how new imported input varieties affect firm performance, we derive the minimun cost function. From the production function, (equation (1)), it yields:

$$\text{Cost} = \frac{1}{\varphi}\left(\frac{w}{\eta}\right)^{\eta}\left(\frac{p_k}{\beta}\right)^{\beta}\prod_{i=1}^{I}\left(\frac{P_{iM}}{\alpha_i}\right)^{\alpha_i} \tag{9}$$

where P_{iM} is the foreign input price index for industry i. Substituting the exact price index (equation (8)) into the minimun cost function (equation (9)), and taking logs yields:

$$\ln \text{Cost} = \sum_{i=1}^{I}\alpha_i \ln P_{iF}^{conv} + \sum_{i=1}^{I}\alpha_i \ln \Lambda_{iF} + \epsilon \tag{10}$$

where $\epsilon \equiv \ln(\eta^{-\eta}\beta^{-\beta}\prod_{i=1}^{I}\alpha_i^{-\alpha_i}) - \eta \ln w - \beta \ln k - \ln \varphi$.

This expression allows us to study how importing new varieties of foreign intermediate goods affect firm efficiency. This implies analyzing how the value of Λ_{iF} determines firm's minimun cost function. The result is stated in the following testable prediction:

Testable prediction on TFP and export scope through price indices: *The higher the number of new imported inputs varieties, the lower the firm's minimun cost and the greater its efficiency. An increase in the number of imported inputs varieties (reflected by a low lambda ratio) affects positively firm TFP growth and export scope.*

As in Goldberg et al. (2009), our approach is semi-structural. We test for the impact of new imported inputs varieties on firm TFP and export scope through changes in prices indices in the firm's minimum cost function.

$$\Delta \ln \mathrm{X} = \alpha + \beta_1 \ln P^{inp,conv} + \beta_2 \ln \Lambda^{inp,conv} + \epsilon \tag{11}$$

where X stands for TFP or number of exported varieties, $P^{inp,conv} = \sum_{i=1} \alpha_i \ln P_{iF}^{conv}$ and $\ln \Lambda^{inp,conv} = \sum_{i=1} \alpha_i \ln \Lambda_{iF}$.

The sectorial shares of imported inputs used in production (i.e, the Cobb-Douglas shares), α_i, are obtained from our "EAE" and French Custom databases. The "EAE" provides the share of inputs in production,γ_{i1}. In order to obtain a measure of imported inputs, we compute the absorption ratio of the firm (i.e., share of imports in consumption),γ_{i2}, using data from the World Bank at the HS4 industry level. Finally, custom data gives the share of sector i in the firm's total imports, γ_{i3}. Thus the Cobb-Douglas shares are computed as $\alpha_i = \gamma_{i1}\gamma_{i2}\gamma_{i3}$.

We expect both the conventional and the variety price indices to be negative. The former because higher conventional price indices are equivalent to an increase in inputs prices which decrease efficiency, the latter because higher lambda ratios reflect the small impact of new varieties in decreasing production costs.

Equation (11) is likely to carry several endogeneity issues mainly linked with reverse causality. A technology or demand shock leading to an increase in TFP or export scope may entail an increase in imported inputs which in turn affects the price indices. As we do not observe any structural, exogeneous changes over the period, we cannot use instrumental variable strategies in order to correct for the endogeneity and we thus rely on GMM estimates. Table 11 and Table 12 provide within and GMM estimates of equation (11) using TFP and number of exported varieties as dependent variables, respectively. TFP data are obtained using the OP/ACF as described above. Both the conventional and the variety indices have the expected sign, they are not however always significant. More specifically, the significancy of these explanatory variables fade away under the GMM estimation. These results suggest that, once corrected for the endogeneity bias, the increase in the number of imported varieties does not affect firms TFP and export scope through the price channel. Note that such results were somewhat expected from the relatively low level of the aggregate variety index computed above.

Table 11: **Table Price index and firm TFP**

Dependent variable:	Δ TFP of firm (i)			
	(1) Within	(2) Within	(3) Within	(4) GMM
Δ TFP(t-1)				0.514**
				(0.239)
Conventional index(t-1)	-0.015***		-0.015***	-0.954
	(0.005)		(0.005)	(0.718)
Variety index(t-1)		-0.063**	-0.065**	-0.440
		(0.030)	(0.030)	(7.633)
Observations	78654	78654	78654	53086
R^2	0.460	0.460	0.460	.
p-value of Sargan				0.955
p-value AR2				0.053
p-value AR3				0.362
p-value AR4				0.100
p-value AR5				0.177

Notes: *** p<0.01, ** p<0.05, * p<0.1. Robust standard errors in parentheses

Table 12: **Table Price index and export scope**

Dependent variable:	Δ Number of exported varieties of firm (i)			
	(1) Within	(2) Within	(3) Within	(4) GMM
Δ Number of exported varieties(t-1)				0.079*
				(0.046)
Conventional index(t-1)	-0.052		-0.054	-3.939
	(0.041)		(0.041)	(2.671)
Variety index(t-1)		-0.498*	-0.504*	-3.282
		(0.276)	(0.276)	(5.029)
Observations	80628	80628	80628	52573
R^2	0.008	0.008	0.008	.
p-value of Sargan				0.195
p-value AR2				0.001
p-value AR3				0.879
p-value AR4				0.491
p-value AR5				0.190

Notes: *** p<0.01, ** p<0.05, * p<0.1. Robust standard errors in parentheses

7 Conclusions

This paper provides robust evidence of the role of imported intermediate inputs on export scope. An increase in the set of input varieties imported by the firm increases significantly the number of varieties it exports. We posit and show that such positive link between imported inputs and exported varieties occurs through an increase in firms' TFP. By using more varieties of imported inputs, the firm reaches a better complementarity of inputs and therefore raises its productivity. More productive firms are also more likely to export more varieties as they are able to bear the export fixed cost and survive on competitive export markets. Importing inputs from developed countries carries the advantage of capturing new embodied technologies. An increase in imported inputs from developed countries has a larger impact on firms' TFP and exports than a similar increase in imported inputs from developing countries. This result plays in favor of the technology argument for imports. By contrast, we do not find strong evidence in favor of the price argument as the large increase in the number of imported inputs only modestly reduces the import price index.

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8 Appendix

8.1 Estimation Algorithm: Identification of Productivity Gains from Importing intermediate goods

8.1.1 The OP method

Olley and Pakes (OP) (1996) develop a dynamic model of firm behavior and a semi parametric algorithm estimator in order to address the simultaneity and selection issues that arise when estimating production functions using firm level data.

The dynamic model is based on productivity heterogeneity among firms which is modeled as an idiosyncratic shock. In this model, based on Ericson and Pakes (1995), factor prices evolve according to an exogenous first order Markov process, while productivity and investment functions are determined as part of the Markov perfect Nash equilibrium.

Firms maximize their expected value of both current and future profits. Current profits are a function of two state variables: capital (k) and unobserved productivity (ω). The OP algorithm estimator of the production function parameters is based on two assumptions. First, the unobserved productivity is the only state variable that creates differences in firm behavior (e.g., firm productivity determines firms' entry and exit decisions). Second, conditional on the values of all the observed state variables, investment is an increasing function of productivity. Thereby, OP methodology consists in inverting the investment function to determine the unobserved productivity variable as a function of the observables variables such as investment or capital.

As argued in the text, we modify the OP estimator to take into account firms' import behavior. We estimate the following production function:

$$y_{it} = \beta_0 + \beta_l l_{it} + \beta_k k_{it} + \beta_m m_{it} + \beta_i Imp_{it} + \omega_{it} + \eta_{it} \tag{1}$$

All variables are expressed in natural logarithms. y_{it} is gross output, k_{it} is capital, m_{it} is materials and l_{it} is labor. Imp_{it} represents the imported input behavior of firms. It could take the value of (i) imported input intensity over wages, (ii) the number of imported input varieties by country of origin or (iii) import status. ω_{it} is the productivity shock that is observable to firms when they make their production choices but not to the econometrician, while η_{it} is unobservable to both the firm and the econometrician.

Relative to the standard OP estimator, in this model imported inputs enter as an additional state variable like capital stock. Thereby, the investment function will depend on firms imported inputs choices. The investment function (i_{it}) is given by:

$$i_{it} = f_{it}\left(\omega_{it}, k_{it}, Imp_{it}\right) \Leftrightarrow \omega_{it} = h_{it}(i_{it}, k_{it}, Imp_{it}) \tag{2}$$

The investment function is then inverted to express the unobserved productivity shock (ω_{it}). The coefficients of the polynomial h_{it} are different depending of the imported input behavior of firms. As in OP, the first stage of the estimation algorithm consists in plugging the productivity function (ω_{it}) in the production function to consistently estimate the coefficient of the labor factor.

$$y_{it} = \beta_0 + \beta_l l_{it} + \beta_m m_{it} + \widetilde{\phi}(i_{it}, k_{it}, Imp_{it}) + \eta_{it} \tag{3}$$

where $\widetilde{\phi}(i_{it}, k_{it}, Imp_{it}) = \beta_k k_{it} + h_{it}(i_{it}, k_{it}, Imp_{it})$. The variable inputs, labor and materials, are consistently estimated in this stage dealing with simultaneity issues. This estimation, however, does not allow us to separate the effect of capital and imported inputs on investment decision from their effect on output.

The second stage consists in taking into account exit decisions of firms to deal with selection issues. The probability of exiting is written as:

$$\Pr(\chi_{i,t+1} = 1 | I_t) = \Pr(\chi_{i,t+1} = 1 | \omega_{it}, \underline{\omega}_{i,t+1}(k_{i,t+1})) = \widehat{\rho}_{it}(i_{it}, k_{it}, Imp_{it}) \tag{4}$$

The final step consists in plugging the labor coefficient, the productivity function and the probability of survival into the production function equation, to obtain the capital and imported inputs coefficients. This last stage consists in a non linear least square estimation (NNLS) on:

$$y_{i,t+1} - \beta_l l_{i,t+1} - \beta_m m_{i,t+1} = \beta_0 + \beta_k k_{i,t+1} + g((\widehat{\widetilde{\phi}} - \beta_k k_{it}), \widehat{\rho}_{i,t+1}) + \upsilon_{i,t+1} \tag{5}$$

This semi parametric estimation gives consistent estimates of the capital coefficient. Since we introduce the imported intermediate goods as an input in the production function, its coefficient is also identified in this last stage. As in Olley and Pakes (1996), the productivity shock follows a first order Markov process (ξ), which implies that $\omega_{t+1} = E(\omega_{t+1}|\omega_t) + \xi_{t+1}$. Thus, the error term ($\upsilon$) is decomposed into the i.i.d. shock (η) and the news term in the Markov process (ξ).

8.1.2 The ACF method

The main difference between the ACF and OP methods is that in the former the labor input coefficient is not estimated in the first stage of the estimation. As in the OP estimation, k_{it} is chosen in $t-1$. In order to account for the collinearity between labor and unobserved productivity, ACF assumes that labor, l_{it}, is chosen in $t-b$ with $0 < b < 1$ instead of t. In this case the firm investissement at t also depends on labor and i_{it} can be re-written as

$$i_{it} = f_{it}\left(\omega_{it}, k_{it}, l_{it}, Imp_{it}\right) \Leftrightarrow \omega_{it} = h_{it}(i_{it}, k_{it}, Imp_{it}) \tag{6}$$

Inverting the investment function and substituting into the production function yields:

$$y_{it} = \beta_0 + \beta_l l_{it} + \beta_m m_{it} + \widetilde{\phi}(i_{it}, k_{it}, l_{it}, Imp_{it}) + \eta_{it} \tag{7}$$

where $\widetilde{\phi}(i_{it}, k_{it}, k_{it}, Imp_{it}) = \beta_k k_{it} + \beta_l l_{it} + h_{it}(i_{it}, k_{it}, l_{it}, Imp_{it})$. The estimation then follows the OP methodology.

8.2 Alternative Specifications

Table 13: **Number of exported products**

Dependent variable:	Number of exported products of firm(i) in year(t)					
	(1)	(2)	(3)	(4)	(5)	(6)
Imported inputs from DC(t-1)	0.010***	0.008***				
	(0.001)	(0.001)				
Imported inputs from LDC(t-1)	0.009***	0.007***				
	(0.001)	(0.001)				
Number of imported inputs from DC(t-1)			0.111***	0.090***		
			(0.004)	(0.004)		
Number of imported inputs from LDC(t-1)			0.082***	0.074***		
			(0.004)	(0.004)		
Weighted mean of Theil index (t-1)					-0.035***	-0.027***
					(0.004)	(0.004)
Labor productivity(t-1)		0.081***		0.073***		0.077***
		(0.007)		(0.007)		(0.009)
Size(t-1)		0.303***		0.264***		0.334***
		(0.011)		(0.011)		(0.014)
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	132665	132607	132665	132607	84040	84019
R^2	0.013	0.033	0.030	0.044	0.009	0.031

Notes: Same as Table 5

Table 14: **Intensive margin of exports**

Dependent variable:	Intensive margin of exports of firm(i) in year(t)					
	(1)	(2)	(3)	(4)	(5)	(6)
Imported inputs from DC(t-1)	0.020***	0.015***				
	(0.002)	(0.002)				
Imported inputs from LDC(t-1)	0.011***	0.008***				
	(0.001)	(0.001)				
Number of imported inputs from DC(t-1)			0.147***	0.103***		
			(0.008)	(0.008)		
Number of imported inputs from LDC(t-1)			0.069***	0.052***		
			(0.008)	(0.008)		
Weighted mean of Theil index (t-1)					-0.078***	-0.063***
					(0.009)	(0.009)
Labor productivity(t-1)		0.237***		0.230***		0.221***
		(0.014)		(0.014)		(0.019)
Size(t-1)		0.577***		0.544***		0.619***
		(0.021)		(0.021)		(0.028)
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	132663	132605	132663	132605	84039	84018
R^2	0.021	0.043	0.026	0.045	0.019	0.041

Notes: Same as Table 5