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

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Abstract Does an increase in imported inputs raise exports? We provide empirical evidence on the direct and indirect channels via which importing more varieties of intermediate inputs increases export scope: (1) imported inputs may enhance productivity and thereby help the firm to overcome export fixed costs (the indirect productivity channel); (2) low-priced imported inputs may boost expected export revenue (the direct-cost channel); and (3) importing intermediate inputs may reduce export fixed costs by providing the quality/technology required in demanding export markets (the quality/technology channel). We use firm-level data on imports at the product (HS6) level provided by French Customs for the 1996–2005 period, and distinguish the origin of imported inputs (developing vs. developed countries) in order to disentangle the different productivity channels above. Regarding the indirect effect, imported inputs raise productivity, and thereby exports, both through greater complementarity of inputs and technology/quality transfer. Controlling for productivity, imports of intermediate inputs from developed and developing countries also have a direct impact on the number of exported varieties. Both quality/technology and price channels are at play. These findings are robust to specifications that explicitly deal with potential reverse causality between imported inputs and export scope.

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1 Introduction

The endogenous-growth literature has long emphasized the role of foreign inputs in enhancing efficiency and economic growth (e.g., Romer 1987 and Rivera-Batiz and Romer 1991). The recent increase in imported intermediate goods has been well-documented (e.g., Hummels et al. 2001; Yi 2003; Strauss-Kahn 2004), and micro-level analysis has found a positive effect of imported intermediate goods on firm productivity.[1] A number of key questions regarding the mechanisms through which imported inputs affect firms' productivity, the impact of greater productivity on export behavior, and the direct role of imported inputs on export scope remain however unanswered. In a context of fierce political debate over jobs lost through outsourcing (i.e., greater imported inputs), the evaluation of the affect of foreign intermediate goods on firm productivity and export behavior is not without economic and political interest.[2]

This paper investigates the role of imported inputs in enhancing firm productivity and export scope using a firm-level database of imports at the product (HS6) level provided by French customs over the 1996–2005 period. Varieties of inputs are commonly defined as a product-country pair. In order to address the simultaneity bias in the estimation of firm production functions, we appeal to semi-parametric estimation based on Olley and Pakes' (1996) methodology augmented by Ackerberg et al.'s (2007) non-collinearity strategy. We also face endogeneity issues related to potential reverse causality between imported inputs and exports when estimating the impact of imported inputs on export scope, and rely on input tariffs as an instrumental variable. We limit our sample to imported inputs from non-EU countries and exports towards EU countries. Our analysis is thus free of any endogeneity issues resulting from importer-exporter relationships.

We aim to disentangle the different channels through which imported inputs affect firm productivity and exports. The literature provides a theoretical basis. Early work by Ethier (1982) and Markusen (1989) provides a theoretical analysis of the gains obtained from imported inputs. Combining differentiated inputs results in productivity gains that are more than the "sum of the parts"; these complementarity gains result from imperfect substitution across intermediate inputs. Kasahara and Lapham (2013) recently developed a heterogeneous firms trade model also showing that importing more varieties of intermediate inputs raises firms' factor productivity.

[1] See, for example, Pavcnik (2002), Schor (2004), Amiti and Konings (2007), Kasahara and Rodrigue (2008), Andersson et al. (2008), Vogel and Wagner (2010), Bas and Ledezma (2010) and Topalova and Khandelwal (2011). For a survey see Wagner (2012).

[2] Among others, Feenstra and Hanson (1996), Hijzen et al. (2005) and Biscourp and Kramarz (2007) evaluate the contribution of imported intermediate goods to the worsening position of unskilled workers (in terms of wages and employment) in developed countries.

A second mechanism is related to technology transfer: international trade promotes economic growth through the diffusion of modern technologies embodied in imported intermediate inputs. Empirical work on aggregate cross-country data has emphasized this effect (e.g., Coe and Helpman 1995; Coe et al. 1997; Keller 2002). Technology transfer cannot however be disentangled from quality transfer, via which imports of high-quality intermediate inputs enhance productivity and lead to the export of high-quality goods at higher prices (see e.g., Kugler and Verhoogen 2012).

Our paper tests for these complementarity and technology/quality channels on firms' total factor productivity (TFP). We then explore indirect (through improved TFP) and direct channels through which imported inputs may shape export performance. If foreign inputs only affect export scope via TFP, intermediate goods should not affect export scope once we control for firm productivity. We thus investigate various direct channels conditional on TFP: (1) a price effect, whereby low-price inputs boost expected export revenue and so expand export scope; and (2) reduced export fixed costs induced by imported inputs providing the quality/technology required in export markets. We distinguish these channels via imported inputs from different countries of origin: the most developed countries produce goods with a high technology/quality content, whereas developing countries provide low-price inputs.

We find strong empirical evidence of a positive effect of imported inputs on firm productivity, with support for both the complementarity and technology channels. The average firm adds four varieties of imported inputs over the period leading to TFP 2.5 % higher. More imported input varieties also raises firm export scope. As they enhance productivity, more imported inputs make the firm more likely to bear the export fixed costs and survive in competitive export markets. Direct channels are also at play. Controlling for TFP, a 10 % increase in the number of imported inputs varieties raises export scope by 10.5 %. The average firm by importing four additional varieties of inputs increases its exports by 2.7 varieties. Both inputs from the most advanced economies and developing countries have a positive effect on the number of export varieties. We thus find evidence for the quality/technology (directly and via improved TFP) and price channels. Our findings continue to hold in a number of robustness checks. We successively consider alternative instrumental variables, definitions of imported inputs, sample selection and econometric methods.

This paper contributes to the literature in several ways. Empirical work has emphasized the positive effect of imported inputs on firm productivity (e.g., Pavcnik 2002; Schor 2004; Amiti and Konings 2007; Kasahara and Rodrigue 2008; Topalova and Khandelwal 2011). Few papers however explore the channels via which this effect pertains. Halpern et al. (2009) examine the quality and complementarity channels in a panel of Hungarian firms from 1992 to 2003. Imports are shown to lead to significant productivity gains, two thirds of which are attributed to complementarity and the remainder to quality. Using 1998–2003 Danish micro-level data, Smeets and Warzynski (2010) distinguish the cost and quality/technology effects of importing inputs on productivity by differentiating the import origin. They find that both inputs from OECD and low-wage countries yield productivity improvements. In the same spirit, Lööf and Andersson (2010) consider Swedish manufacturing firms over the period 1997–2004, and find that the distribution of imports across origin countries matters (labor productivity increases in the G7-share of total imports). We contribute to this growing literature by examining the transmission channels between imported inputs and TFP for France. We also extend the analysis by considering the impact of importing inputs on firm export patterns.

Recent papers explore the effects of an increase in imported intermediate goods on firm attributes other than TFP. Goldberg et al. (2010) examine the role of India's 1991 trade liberalization on the number of varieties produced by the firm, and find that lower input tariffs help expand the firm's product scope. Evidence is provided that the growth in the number of domestic varieties results from the improved availability of imported inputs rather than lower imported inputs prices. Similarly, using a product-level database for 25 EU countries, Colantone and Crino (2011) evaluate the impact of new imported inputs on the production of new domestic products. They find a significant positive relationship between imported inputs and product scope, stemming from the increased availability of high-quality and/or low-price imports. We depart from the above work by distinguishing the origin of imports and focusing on firms' export scope. Damijan et al. (2012) study the role of imported inputs on export performances using Slovenian firm-level data from 1994 to 2008 but focuses on imports churning. Aristei et al. (2013) show that importing firms are more likely to export. They rely on firm-level data from 27 Eastern Europe countries and interestingly find that the reverse (exporters likelihood to become importers) is not true. Bas (2012) analyzes the effects of input-trade liberalization on firm export decisions. Using firm-level data for Argentina between 1992 and 1996, reduced input tariffs are shown to lead to entry in export markets. Our work goes one step further by disentangling the channels through which imported inputs directly and indirectly (via TFP) affect export scope.

The paper is organized as follow. Section 2 presents the theoretical channels through which imported inputs might affect firm productivity and export scope. Section 3 presents the data and discusses the empirical strategy. Section 4 reports the results regarding the impact of imported inputs on firms' TFP and export scope. This focuses on the transmission channels and distinguishes the different arguments for improved export scope: enhanced productivity, price effects and technology/quality transfers. Section 5 then presents some robustness checks, and Sect. 6 concludes.

2 Theoretical motivation

This section presents the theoretical mechanisms through which importing more varieties of intermediate inputs might affect firm productivity and export performance.

In Appendix 1 we present a simple partial equilibrium model of firm heterogeneity build on Melitz (2003) and Kasahara and Lapham (2013) that rationalizes these channels. Kasahara and Lapham (2013) develop a heterogeneous firms Melitz-type model including an intermediate goods sector to explain the simultaneous choices of firms regarding export of final goods and import of intermediate inputs. In their model, firms produce final goods using labor and two types of intermediate inputs, domestically produced or imported. In that framework firms importing more varieties of intermediate inputs will also have higher TFP. We rely on a similar (although simplified) setting, where firms with different initial productivity levels (φ) produce final goods (y) using labor (L), capital goods (K) and two types of imported intermediate goods from the north (N_{iN}) and the south (N_{iS}).[3] From the production function, we can derive the total factor productivity (A) of each firm as a Solow residual:

$$A = \frac{y}{L^{\eta} K^{\beta} \prod_{i=1}^{I} \overline{M}_{iF}^{\alpha_i}} = \varphi \prod_{i=1}^{I} (N_{iN}\chi_{iN})^{\frac{\alpha_i}{\sigma_i - 1}} (N_{iS})^{\frac{\alpha_i}{\sigma_i - 1}}$$

This expression is similar to that in Kasahara and Rodrigue (2008). The firm's TFP depends on the exogenous productivity draw, φ, augmented by the number of foreign inputs. This particular characteristic stems from Ethier's (1982) model where intermediate inputs are complementary in production and firms exhibit a "love for varieties". As Ethier (1982) puts it, efficiency gains thus result from a greater division of labor.[4] Firm TFP is increasing in the initial firm productivity draw, φ, the number of foreign input varieties imported from the North, N_{iN}, or the South, N_{iS}, and the foreign technology/quality parameter (χ_i). The value of this technology parameter depends on the country of origin of imports, being greater than one for inputs sourced from the North. Importing intermediate goods thus has a greater effect on productivity when the inputs come from the most developed countries. This specification allows us to disentangle two channels via which imported intermediate goods affect firm TFP: (1) the variety/complementarity channel, and (2) the technology/quality channel. Assuming an exogeneous shock which increases the number of available varieties from abroad, the larger the range of imported input varieties used in production, the greater is firm TFP. This effect is larger for firms which import their inputs from the most developed countries.

In this framework, firm export profit is decreasing in marginal costs and thereby, increasing in firm TFP. Export profits also rise as the price of imported inputs falls, which occurs if the firm sources its varieties from the South (i.e., profit rises via the price channel). Thanks to an increase in productivity or a fall in input prices, firms reduce their marginal cost. Any increase in expected export revenues may allow firms to bear the fixed cost of exporting, and thus sell on export markets. Importing intermediate good varieties may also boost export profits through its effect on export fixed costs. Acceding to foreign markets is costly: in order to produce goods that

[3] As our aim is to illustrate the main mechanisms at play between use of imported inputs, TFP and export scope at the firm level, we present a very simplified model. In contrast, Kasahara and Lapham (2013) derive important results in a more realistic framework.

[4] Feenstra's (1994) argument goes in the same direction: Varieties of imported inputs are not perfect substitutes. Input cost indices that do not consider variation in the number of input varieties are thus biased, which, for a given level of output, biases the estimation of TFP. Subsequent papers (e.g., Goldberg et al. 2010; Gopinath and Neiman 2011) do account for the role of the number of varieties in estimating the exact price index and then TFP.

suit foreign demand, firms may incur considerable investments in technology and/or quality upgrading (see e.g., Sutton 2007; Hallak and Sivadasan 2009; Kugler and Verhoogen 2012). In such context, the export fixed cost is product-market specific. Importantly, the availability of intermediate inputs with a quality and technology content may help to reduce this export fixed cost.[5] Notably, Kugler and Verhoogen (2012) combine the role of fixed cost and input quality in producing output, and state that producing high quality outputs requires high quality inputs.

To sum up, the simple theoretical framework developed in Appendix 1 shows that importing more varieties of inputs increases TFP, export revenue and ultimately export scope. Importing more varieties from both the South and the North helps to increase productivity through complementarity gains. Inputs sourced from the most advanced economies (the North) may also raise TFP and export scope thanks to improved technology/quality, whereas imports from less developed economies (the South) may increase the number of exported varieties through lower production costs. In the next section we use our French firm-level data to test whether these conjectures are empirically sound.

3 Data and empirical strategy

3.1 Data

Our dataset is a panel of French manufacturing firms for the 1996–2005 period. Importantly, service (in particular wholesale) firms are excluded from the database. We thus avoid including firms whose activity consists in importing goods in order to re-sell them on domestic or foreign markets.[6] The database comprises firm-level characteristics such as sales, employment, wages, capital and raw-material intensity, as well as trade information on firm exports and imports. This dataset was built from two sources. The trade data comes from the French Customs, which provides annual import and export data for French manufacturing firms over the 1996–2005 period.[7] The customs data are at the product level (8-digit Combined Nomenclature (CN) which we translate into the 6-digit Harmonized System (HS6), giving us 5349 categories) and specify the country of origin (destination) of imports (exports). We can thus determine the source of imported inputs. For our purposes, we differentiate

[5] In the spirit of Matsuyama (2007), the export fixed cost may also depend on foreign countries' regulations, business language, consumer culture and network accessibility. Importing inputs may help to reduce the export fixed cost by improving the firm's knowledge of foreign markets. Our empirical test does not however capture such an effect. We thus leave any test of this mechanism for further research.

[6] We may still encounter some forms of carry-along trade, as revealed by Bernard et al. (2012), where imported inputs are directly re-exported. As shown in Sect. 5, our results are robust to the exclusion, at the firm level, of all goods that are both imported and exported, suggesting that, carry-along trade does not drive our results.

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

imports from developed and developing countries.[8] The data on the firm-level characteristics come from the Annual French Business Surveys (EAE) available from the INSEE (French Institute of Statistics) and include French firms with at least 20 employees. In both databases, individual firms are assigned a specific code, called a "siren", which allows us to match information from the two data sources. Unfortunately, whereas the Customs data encompasses most trade flows in and out of France over the period (representing the trade activity of about 120,000 firms per year), the EAE database is fairly restrictive (the number of firms is around 20,000 per year). The EAE database is however of great value as it includes data on capital and allows for the calculation of TFP. After merging these two databases, we work with an unbalanced panel of about 21,000 firms or 210,000 observations over the sample period. Nominal variables are in millions of euros and are deflated using the 2-digit industry-level prices indices provided by the INSEE.[9]

Focusing on French data is relevant in our context. First, most work has examined the impact of imported inputs on productivity for developing or transition economies. Second, the political debate on the impact of imported inputs on unemployment, better known under the name of outsourcing, is fiercest in most of the developed countries, and especially in France. Understanding whether importing intermediate goods has a positive impact on productivity, export scope and ultimately employment is pertinent. Third, as we aim to capture quality/technology effects, focusing on an advanced economy seems appropriate. We make the extreme but plausible assumption that France's providers of inputs embodying technology and quality are advanced economies. This is less likely to hold for developing countries, across which technological spillovers may occur.[10] Finally, France has sufficient absorptive capacity for an efficient use of the technology/quality transfer content of imports (Augier et al. 2013 points out the role of absorptive capacities).

Imported input variety is a key variable here. In line with the literature (e.g., Feenstra 1994; 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, safety seat belts for motor vehicles (HS 870821) is a product while safety seat belts for motor vehicles from Japan is a variety. In 1996, French firms imported fourteen different varieties of safety seat belts for motor vehicles.

Our Customs dataset does not specify whether the firm's imports are final goods or intermediate inputs. In order to capture imported intermediate goods, we rely on three strategies commonly used in the literature. First, following Feenstra and Hanson (1996), we consider that imports from the same HS4 category as the firm's main sector of activity (at the HS4 level) are final goods whereas imports from any other category are intermediate inputs. Biscourp and Kramarz (2007) appeals to the same methodology in a French database very similar to ours. In order to shed more light on the measure of intermediate inputs constructed along these lines, Table 10

[8] 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.

[9] We used different specific deflators at the 2-digit level for added value, materials and capital goods.

[10] For example, Brazilian exports to Argentina may incorporate a technology transfer.

in Appendix 2 reports quite convincing examples for imported intermediate inputs and imported final goods calculated as above for two firms in different sectors.

This strategy may however have its limits when firms operate in more than one HS4 code. We thus also rely on intermediate inputs constructed using French input-output (IO) tables from INSEE. One important drawback of this alternative definition stems from the highly aggregated nomenclature of IO tables (for example, these IO tables include only about sixty manufacturing sectors). As a third definition of intermediate inputs, we eliminate all goods, at the NC8 level, that are both imported and exported by a firm. This conservative strategy successfully excludes carry-along trade. Its main drawback is that imported goods may be both exported directly and used as inputs. Such inputs thus include information that should not be omitted in our estimation of firm TFP and export scope. The main results presented in this paper rely on the first definition of intermediate goods; the robustness checks using the IO definition and the no-carry-along definition are presented in Sect. 5. Our findings are consistent across these alternative classifications.[11]

3.2 Stylized facts

Our panel of exports and imports of French manufacturing firms for the 1996–2005 period reveals a considerable increase in imported input varieties over time. The firm average number of inputs imported from developed countries rose by 15 % between 1996 and 2005 while inputs imported from developing countries grew by a striking 41 %. We also observe substantial growth (16 %) in the number of exported varieties. Whether there is a link between the increase in imported inputs and exports is what we would like to investigate.

Table 1 reports information on the number of firms by trade status. In our estimations, in order to limit endogeneity, we work on a restricted sample focusing on firms that import from non-EU countries and export to the EU. Table 1 also presents statistics for this restricted sample. Interestingly, 70 % (65 % for the restricted sample) of French firms are exporters. This figure is at odds with previous work emphasizing the small share of exporting firms (see for example, Bernard and Jensen 1995 for the US, Aw et al. 2000 for Korea and Taiwan, and Eaton et al. 2004 for France). By restricting our database to the largest firms (with over 20 employees), we also pick up more exporters.[12] 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. Most exporters (86, and 89 % in the restricted sample) are also

[11] As an alternative definition of intermediate inputs, we also make use of the United Nations Broad Economic Categories (BEC) classification. The results are similar to those found with other classifications and are available upon request.

[12] The work cited above, as well as many others (e.g., Clerides et al. 1998 and Delgado et al. 2002) show that exporters are larger, more productive and more capital intensive. Several studies for European countries (e.g., Andersson et al. 2008 for Sweden, Muûls and Pisu 2007 for Belgium, and Castellani et al. 2010 for Italy) have found that restricting the number of firms (to the largest ones) drastically increases the share of exporters. By contrast, Eaton et al. (2004), who use an exhaustive database of French companies and work with more than 200,000 firms, find that only a small percentage of firms export.

Table 1 Descriptive statistics number of firms by trade status 1996–2005

	Full sample		Restricted sample	
	N	Share	N	Share
Domestic	43,620	0.21	43,620	0.31
Only exporter	20,408	0.10	10,174	0.07
Only importer	18,409	0.09	7,842	0.06
Exporter-importer	124,804	0.59	80,794	0.57
Total	207,241	1	142,430	1

The restricted sample corresponds to firms that export towards the EU and import from non-EU countries. Firms that exclusively export to non-EU countries and/or exclusively import from the EU are excluded. N is the total number of observations over the period. Share is the fraction of firms by trade status over total firms

importers. In the econometric analysis carried out in the following sections (except for some robustness checks in Sect. 5), we focus only on firms that export (Table 2).

The average number of imported inputs from non EU countries is around 6 with a standard deviation of 21. When we disentangle the country of origin of imported inputs, the average number of imported varieties from a developed country (DC) is around 4 and from a less developed country (LDC) is 2, with standard deviation of 15 and 10 respectively. Table 11 in Appendix 2 shows the distribution of these variables in different sectors. This table reports the average number of imported inputs from non EU countries, DCs and LDCs at the 2-digit industry level.

A number of papers (e.g., Bernard and Jensen 1999 and, more recently, De Loecker 2007) have focused on firms' export patterns and have shown that exporting firms have different characteristics than non-exporting firms. We are interested in the particular firms that import inputs and run an equivalent import-premia analysis shown in Table 3. Each specification gives OLS estimates of the impact of being an importer of intermediate goods on firm characteristics such as employment, labor productivity (using value added per worker as a rough measure of productivity), wages and capital intensity. We report the importer premia for the restricted sample of firms (defined above) as this will be our main database in the estimations below. There are substantial differences between importers and non-importers. The former are on average larger (61.5 %), more productive (15.4 %), pay higher wages (6.6 %) and are more capital intensive (38.4 %). In all cases, the impact of being an importer on firm characteristics is larger if the imports come from developed countries (see columns (5) to (8) of Table 3). Bernard et al. (2007) compute such importer premia for 1997 U.S. firms and find similar patterns.

3.3 Empirical strategy: TFP

In order to see whether imported inputs enhance firms productivity, we estimate the production function by building on the approach in Olley and Pakes (1996) (henceforth OP), extended by Ackerberg, Caves and Frazer (2007) (henceforth ACF).

Table 2 Importer premia 1996–2005

	(1) L	(2) VA/L	(3) W	(4) K/L	(5) L	(6) VA/L	(7) W	(8) K/L
Importer	0.615***	0.154***	0.066***	0.384***				
	(0.006)	(0.004)	(0.002)	(0.010)				
Importer DC					0.613***	0.137***	0.064***	0.342***
					(0.007)	(0.004)	(0.002)	(0.010)
Importer LDC					0.299***	0.118***	0.046***	0.243***
					(0.008)	(0.005)	(0.003)	(0.011)
Size		−0.039***	0.982***	0.104***		−0.039***	0.982***	0.104***
		(0.002)	(0.001)	(0.004)		(0.002)	(0.001)	(0.004)
Exporter	0.340***	0.159***	0.098***	0.353***	0.422***	0.178***	0.106***	0.408***
	(0.006)	(0.004)	(0.002)	(0.010)	(0.006)	(0.004)	(0.002)	(0.010)
Observations	142,388	142,386	142,083	113,355	142,388	142,386	142,083	113,355
R-squared	0.313	0.255	0.943	0.307	0.318	0.255	0.943	0.306

All dependent variables are expressed in logarithmic form. *L* is total employment, *VA*/*L* is value added over total employment, *W* is wages and *K*/*L* is capital stock over total employment. All estimations include year and industry 2-digit fixed effects. Standard errors are in parentheses. *** Significant at the 1 % level. Importers mainly from DC is an import dummy equal to one if the firm imported more than 50 % of its intermediate inputs from developed countries and zero otherwise, whereas importers mainly from LDC is an import dummy equal to one if the firm imported more than 50 % of its intermediate inputs from developing countries and zero otherwise. All dependent variables are expressed in logarithmic form. Standard errors are in parentheses

Table 3 Input tariff changes and imported input varieties

Dependent variable: log of the number of imported varieties	
	(1)
Input tariffs ($t-1$)	−2.234***
	(0.110)
Firm fixed effects	Yes
Observations	80,230
R-squared	0.006

Notes: Input tariffs are computed at the firm level as an average of all tariffs on imported intermediate products at the HS6 level. Robust standard errors clustered at the firm level in parentheses. *** Significant at the 1 % level

The OP method controls for simultaneity bias in the estimation of firms' production function. Simultaneity arises because firms' variable input demands and unobserved productivity are positively correlated: the firm-specific productivity is known by the firm but not by the econometrician and firms respond to expected productivity shocks by modifying their purchases of variable inputs.

OP proposes a two-stage method to control for unobserved firm productivity. The rationale is to reveal unobserved productivity via the firm's investment behavior, which in turn depends on capital and productivity. By inverting the investment function, we obtain a expression for the productivity shock in terms of investment and capital. This expression is then substituted into the production function.[13]

ACF underlines an identification problem regarding the labor coefficient in OP models. They find evidence of significant collinearity between labor and unobserved productivity in the first stage, and propose modification of OP that avoids collinearity. The main technical difference lies in the timing of the 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 in the sub-period $t-b$ ($0<b<1$), after capital is known in $t-1$, and before investment is made in t. The labor-input decision is thus unaffected by unobserved productivity shocks between $t-b$ and t. Firms' investment decisions in the ACF methodology depend on capital and productivity, but also on labor inputs. In contrast with the OP method, this implies that the coefficients of capital and labor are estimated in the second stage.[14]

[13] Levinsohn and Petrin (2003) (henceforth LP) build upon the idea of Olley and Pakes using primary input demand instead of the investment decision to control for unobserved productivity shocks. Their rationale lies in the idea that investment data are often missing or lumpy, whereas data on raw inputs are of better quality thus guaranteeing strict monotonicity without efficiency loss. In our French database, 96.5 % of the observations report investment data. We thus rely on the OP method. For robustness, we also estimated production using the LP method. The results are very similar and are available upon request. Note that the OP specification performs better than fixed-effect specifications, as the unobserved individual effect (productivity) is not constrained to be constant over time. Moreover, approaches based on instrumental variables are limited by instrument availability. Finally, the OP methodology does not assume any parameter restrictions.

[14] Ackerberg et al. (2007) provide a detailed description of the OP, LP and ACF methodologies.

We rely on the OP/ACF method modified to account for the fact that investment decisions depend also on the input-importing behavior of the firm. As shown in Sect. 3.1, importing firms differ greatly from non-importing firms in all respects, including capital intensity and sales. Firms that import inputs from different countries face different market structures and factor prices when they make their primary input demand decisions. Modifying the OP/ACF estimation by incorporating imported input behavior is therefore of relevance. Following De Loecker (2007) and Kasahara and Rodrigue (2008), we thus include an additional state variable in the OP/ACF estimation which captures input-importing behavior.[15]

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

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

All variables are expressed in natural logs: y_{ft} is the total production of firm f at time t, l_{ft} is labor, m_{ft} is raw materials (i.e., primary inputs), k_{ft} stands for capital stock and Imp_{ft} corresponds to imported inputs, proxied by the number of imported inputs.[16] The error term can be decomposed into an intrinsic transmitted component ω_{jt} (productivity shock), which is observable to firms but not to the econometrician, and an i.i.d. component η_{ft}. Standard errors are obtained via bootstrap. Following the literature, we deflate our variables in order to proxy for physical quantities. As firm-specific price deflators are not available, we rely on industry-specific deflators.[17]

3.4 Empirical strategy: export scope

Endogeneity between the number of imported inputs, TFP and export scope is very likely in our framework. We rely on an instrumental variable (IV) estimation using input tariffs as our main instrument. We explore the effect of changes in the use of inputs originated in non-EU countries on exports towards EU countries.[18] As the supplier of the intermediate goods and the destination of final goods are not the same country, we limit endogeneity/causality issues related to the importer-exporter relationship.[19] Although they do not deal with reverse causality or omitted variable bias, we also present within estimator with robust standard errors clustered at the

[15] 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) add imported inputs status as a state variable in their analysis of the effect of imported inputs on productivity using Chilean plant-level data.

[16] Our results are robust to the use of the value of imported inputs or the import status of the firm (i.e., a dummy that takes a value of one if the firm imports intermediate inputs) instead of the number of imported varieties.

[17] The OP/LP/ACF methodology thus faces the traditional concerns that productivity estimates capture differences in prices and mark-ups instead of actual physical productivity (Erdem and Tybout 2003; Katayama et al. 2009; De Loecker 2007). Following Bernard et al. (2003), we believe however that if price-costs mark-ups correlate with firms efficiency, our measure of TFP is valid.

[18] EU countries include the EU15 member states (i.e., Austria, Belgium, Luxembourg, Denmark, Finland, Germany, Greece, Italy, Ireland, The Netherlands, Portugal, Spain, Sweden and the United Kingdom).

[19] In order to be consistent across estimations, we also use this restricted database in our estimation of firm TFP.

firm level including individual firm fixed effects. Previous work has exploited trade-liberalization episodes, using input tariffs as an independent variable, in order to identify the effects of increased access to imported inputs on firms' domestic product scope (Goldberg et al. 2010) and TFP (Topalova and Khandelwal 2011). Since France did not experience trade reform over the period in question (1996–2005), we are not able to appeal to this empirical strategy.

For our instrumental variable, we select the tariffs applied by the European Union to the rest of the world and focus on French firms' imported inputs from non-European countries. Tariffs at the HS6 level come from the WITS database from 1996 to 2005. Input tariffs, at the firm level, are computed as a simple average of tariffs on inputs used in the production of final output.

Previous work (e.g., Schor 2004; Goldberg et al 2010) has used an IO matrix in order to compute the weights. This measure of input tariffs faces the drawback of being constructed using aggregate data (IO tables are not usually any more disaggregated than the HS3 level) and provides industry-level input tariffs which are then matched to the firm's sector of activity. We propose a more precise measure of input tariffs computed at the firm level. We exploit the disaggregated nature of our database by constructing an index of input tariffs which rely on output tariffs and import data at the HS6 level. This measure captures tariffs on inputs that are actually imported by the firm. In order to avoid issues related to changes in the firm imported input mix, we rely on the simple average across the firm's HS6 imported inputs.[20] As shown in Sect. 5, our findings are robust to the use of the IO-constructed measures of input tariffs.

Although there has been no drastic trade liberalization in France over the relevant period, tariffs did fall between 1996 and 2005, with considerable heterogeneity across products. While the average fall in tariffs is small at 0.5 percentage points, the maximum cut for output and input tariffs is 8 and 10 percentage points respectively. Table 3 reflects the negative and significant correlation between input tariffs and the number of imported inputs.

Using input tariffs is not without problems. Were trade policy across industries to depend on expected exports and industry lobbying, we would run into serious spurious correlation issues between changes in exports and trade policy. Tariffs being established at the EU level, it is however reasonable to think that the lobby power of French firms aiming at increasing their intra-EU exports is only limited. In order to confirm the exogeneity of input tariffs, we follow Topalova and Khandelwal (2011) and examine the correlation of tariffs changes with initial industry performance. We regress changes in input tariffs on a number of industry characteristics computed as the size-weighted average of firms' characteristics in the initial year. The results in Table 4 cover TFP, employment, wages and exports at the industry level: these reveal no statistical correlation between input tariffs and industry characteristics.

[20] Our results are robust to the use of a weighted average capturing the firm's relative use of a specific imported input in total imported input: $\tau_{jt} = \sum_i \alpha_{ij} \tau_{it}$, where α_{ij} is the weight of input i in the total input cost of output j and τ_{it} is the output tariff of sector i in t. These results are available upon request.

Table 4 Exogenous tariff changes to initial industry characteristics

	Changes in input tariffs (2005–1996)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Employment (1996)	−0.000				−0.001			
	(0.001)				(0.001)			
TFP (1996)		0.001				−0.003		
		(0.004)				(0.005)		
Wages (1996)			−0.000				−0.001	
			(0.001)				(0.001)	
Exports (1996)				−0.000				−0.000
				(0.000)				(0.000)
Industry 2-digit fixed effects	No	No	No	No	Yes	Yes	Yes	Yes
Observations	247	247	247	247	247	247	247	247
R-squared	0.001	0.000	0.002	0.001	0.183	0.179	0.183	0.180

The table presents the results of regressing changes in input tariffs between 1996 and 2005 at the 4-digit industry level on 4-digit industry characteristics in the initial year (1996). Employment (1996), TFP (1996), Wages (1996) and Exports (1996) are computed as the average employment, TFP and wages of all firms producing in the same 4-digit industry. All variables are expressed in logarithmic form. Robust standard errors in parentheses

As in Colantone and Crino (2011), we also exploit US input tariffs as instrumental variables. Changes in US tariffs are likely correlated with changes in EU tariffs; they are however less subject to endogeneity issues related to EU lobbying and trade policy.

Overall, input tariffs are a valid intrumental variable, as they are correlated with the imported input decision but are independent of firm export behavior.

4 Imported inputs, firm TFP and export patterns

We now implement the above empirical strategies to evaluate the impact of imported inputs on firm TFP. Controlling for firms' productivity, we then examine whether greater imported input availability increases export scope.

4.1 From importing inputs to increased TFP: the transmission channels

A number of recent pieces of work (e.g., Fernandes 2007; Kasahara and Rodrigue 2008; Topalova and Khandelwal 2011) have shown the positive effect of intermediate goods trade on firm productivity. Evidence on the transmission channels is however scarce (with the notable exception of Halpern et al. 2009 and Smeets and Warzynski 2010).

We explore these channels focusing on the main mechanisms pointed out in the literature: (1) access to more input varieties through imports (the complementarity/love for varieties assumption) and (2) the availability of better inputs with a greater level of technology and/or quality. Such conjectures are in line with the theoretical framework presented in Sect. 2.

Importing more varieties of inputs raises TFP no matter where the inputs are imported from (i.e. complementarity matters) with a magnified effect for imported inputs from developed countries thanks to the technology transfer (reflected in the technology parameter). We thus expect both imported inputs from developed and developing countries to positively affect TFP, with a stronger effect for the former. In order to capture the technology/quality effect, we plausibly assume that goods originated in the most advanced economies have greater technology/quality content. We thus distinguish inputs by their countries of origin (developed versus developing countries, as defined by the World Bank).

Table 5 shows the results.[21] The estimates in column (1) imply that a firm that increases the number of imported inputs from 0 to 100 % can improve its TFP by 9.6 %.[22] By way of comparison, Halpern et al. (2011), using Hungarian data, find that increasing the share of imported inputs from 0 to 100 % increases productivity by 11 %. Our average firm increased its use of imported inputs by 4 units between 1996 and 2005 equivalent to a 33 % increase, which lead to a increase in TFP of 2.5 %.[23]

In line with theoretical evidence on the impact of a imported inputs on productivity (e.g., Ethier 1982; Markusen 1989; Romer 1987, 1990; Grossman and Helpman 1991; Kasahara and Lapham 2013), as well as recent empirical results (some of which are listed above), we thus find that using more varieties of imported inputs increases TFP.

These coefficients on imported inputs from developed and developing countries are both positive and significant (see column (2) of Table 5). As the explanatory power of a variable depends on its own variability, we follow Head and Mayer (2004) in computing the impact of a variation in the expanatory variable of one standard deviation with respect to its mean. We find that a one standard deviation increase in the number of imported inputs from the most developed countries improves firm TFP by 13.2 %, while a one standard deviation increase in the number of imported inputs from developing countries increases TFP by 10 %. The impact of imported inputs on TFP is thus 30 % larger when the imported inputs come from more—rather than less—developed countries. Our results confirm the technological and quality gains induced by a rise in imported inputs from developed countries. Previous findings, for example, Coe and Helpman (1995) and Coe et al.

[21] We run the estimation on the full sample of firms. The OP/ACF semi-parametric estimation requires many lags of the data which reduces substantially the number of observations.

[22] Note that the coefficients on capital stock are small. This might be due to the fact that the OP/ACF semi-parametric estimator for the production function includes the number of imported inputs as an additional persistent variable, which is positively correlated with capital. Hence, it is difficult to assess ex-ante the direction of OLS bias on capital coefficient in this case. Kasahara and Rodrigue (2008) find similar results for Chile.

[23] If $\ln y = \alpha \ln x$, the explanatory power of variable x that changes by δx with respect to its mean is $((1 + \frac{\delta x}{\bar{x}})^{\alpha} - 1) * 100$ percent, where $\bar{x}$ is the mean of x. Due to our focus on imported inputs from non-EU countries, the average increase in the number of imported varieties is relatively small. If we include inputs imported from EU countries, the average firm increases its use of imported varieties by 7.3 units over the period.

Table 5 TFP estimation OP/ACF

Dependent variable: log of the total production of firm (*f*) in year (*t*)		
	(1)	(2)
Labor	0.276***	0.283***
	(0.010)	(0.012)
Raw materials	0.517***	0.518***
	(0.007)	(0.007)
Capital	0.074***	0.076***
	(0.003)	(0.003)
Imported inputs	0.096***	
	(0.006)	
Imported inputs DC		0.095***
		(0.003)
Imported inputs LDC		0.068***
		(0.004)
Industry fixed effects	Yes	Yes
Year fixed effects	Yes	Yes
Observations	110,811	110,811

*** Significant at the 1 % level. Robust standard errors in parentheses. All variables are expressed in logarithmic form. We also used imported input intensity, number of imported inputs and import status as alternative definitions of the imported input behavior of firms. Results using the different state variables for imported inputs are very similar to those presented here and are available upon request

(1997) also find that foreign knowledge embodied in imported inputs from countries with larger R&D stocks has a positive effect on aggregate TFP. More recently, Lööf and Andersson (2010) using a dynamic GMM approach on a database of Swedish manufacturing firms over the 1997–2004 period find that labor productivity is increasing in the G7 countries-share of total imports.

To sum up, we find strong evidence that using more varieties of imported inputs raises firm TFP. This TFP improvement occurs through a greater complementarity of inputs and the technology/quality improvement obtained due to the information embodied in inputs imported from the most developed countries. Firm productivity is enhanced, which may lead to an increase in the number of varieties exported.

4.2 Imported inputs and export patterns

We now explore the impact of an increased use of imported inputs on export scope. Access to more varieties of imported inputs may raise firm profit, not only through higher productivity but also directly via lower input prices or lower export fixed costs. This latter fall results from the ability to produce varieties which correspond adequately to foreign-market needs thanks to the improved quality/technology of inputs. By increasing the firm's expected revenue (or reducing the fixed cost), imported inputs thus allow firms to bear the cost of exporting.

We address endogeneity issues via IV estimation. Our main instruments are input tariffs for inputs originated in non-EU countries and our focus is on French exports towards EU countries. We also control for scale effects (i.e. bigger firms use more inputs and export more) by including a measure of firms' size in the estimation.

Tables 6 and 7 report the results. In contrast with Tables 6 and 7 disentangles imports from non-EU developed countries and developing countries. We distinguish the source of imports in an attempt to isolate the technology/quality channel from the price channel: inputs from developing countries are bought at low prices, thereby reducing firms' costs; inputs originating in developed economies are of better quality/technology, allowing firms to develop and export new varieties to demanding foreign markets. Standard errors are clustered by firms. First stages of the IV estimations of Tables 6 and 7 are presented in Table 12 in Appendix 2.

Columns (1) and (2) of Tables 6 and 7 encompass all firms that export. In order to take into account all exporters independently of their import status, the independent variable is the logarithm of the number of imported varieties plus one. In column (3), we restrict the sample to firms that actually import intermediate goods. Column (4) shows within estimates of a regression run on the same sample of firms as the IV estimations. We present all these specifications in order to insure that our results are not driven by a selection issue related to differences in sample size. IV estimations indeed account for much less observation than within. Reasons are twofold: the first stage of the IV estimation requires taking several lags on the explanatory variable and the lack of inputs tariffs for firms that do not import result in dropping several observations from the database.

As shown in column (5) of Table 6, the coefficient on the number of imported inputs is positive and statistically significant. As we want to capture both the indirect and direct effects via which imported inputs affect export scope, we include our measure of firm's TFP as control. Column (6) reports the results. Controlling for productivity, the coefficient is reduced thus confirming the role of TFP on the number of exported varieties. It is however still positive and highly significant: a 10 % increase in imported input varieties results in a 10.5 % expansion in firm export scope, notwithstanding the effect of imported inputs through TFP. An average firm imports 4 additional varieties of inputs from non-EU countries over the period under study resulting in an increase in its exports towards the EU of 2.7 varieties. These estimates capture the direct effect of an increased use of imported input varieties on the number of exported varieties. TFP also positively and significantly affects export scope. Our results thus reveal that importing more varieties of inputs increases the number of exported varieties not only through productivity gains (the indirect TFP channel) but also through other direct channels.[24]

Both imports from developed and developing countries have a significant positive effect on export scope, with a somewhat larger effect for imported inputs from the most advanced economies. According to column (6) of Table 7, a one

[24] Within estimates are consistently lower than IV estimates. Good instruments may actually correct for the downward bias caused by measurement errors in the explanatory variables (see Hausman 2001 and Arellano 2003).

Table 6 Export scope and imported inputs

Dependent variable: log of the number of exported varieties to EU of firm (*f*) in year (*t*)						
	(1) Within	(2) Within	(3) Within	(4) Within	(5) IV	(6) IV
Imported inputs ($t-1$)	0.070***	0.052***	0.051***	0.055***	0.161***	0.105***
	(0.005)	(0.005)	(0.005)	(0.006)	(0.018)	(0.021)
Size ($t-1$)		0.242***	0.239***	0.224***		0.201***
		(0.015)	(0.018)	(0.021)		(0.017)
TFP ($t-1$)		0.376***	0.491***	0.502***		0.477***
		(0.054)	(0.073)	(0.091)		(0.083)
Observations	87,477	87,477	60,107	44,541	44,541	44,541
R-squared	0.007	0.025	0.029	0.025		
Hansen statistic	.	.	.	.	0.737	0.916
p-value of Hansen	.	.	.	.	0.692	0.821

All specifications include firm and year fixed effects. The number of imported inputs ($t-1$) or the number of imported inputs DC ($t-1$) and LDC ($t-1$), Size ($t-1$) and TFP ($t-1$) are expressed in logarithmic form. The estimation is run on the subsample of firms importing products from non-EU countries and exporting within EU countries. In the IV estimation, the instrumental variables include lagged input tariffs and imported inputs. Variables are in $t-1$ and intrumental variables are lagged 3 periods. Input tariffs are computed at the firm level as an average of all tariffs on HS6 intermediate products that each firm imports. Robust standard errors clustered at the firm level are in parentheses. *** Significant at the 1 % level

Table 7 Export scope and imported inputs by country of origin

Dependent variable: log of the number of exported varieties to EU of firm (f) in year (t)

	(1) Within	(2) Within	(3) Within	(4) Within	(5) IV	(6) IV
Imported inputs DC ($t-1$)	0.064***	0.047***	0.053***	0.043***	0.173***	0.123***
	(0.005)	(0.005)	(0.006)	(0.007)	(0.035)	(0.038)
Imported inputs LDC ($t-1$)	0.041***	0.032***	0.036***	0.038***	0.135***	0.098***
	(0.005)	(0.005)	(0.006)	(0.006)	(0.025)	(0.027)
Size ($t-1$)		0.239***	0.234***	0.213***		0.181***
		(0.015)	(0.018)	(0.021)		(0.020)
TFP ($t-1$)		0.373***	0.486***	0.534***		0.462***
		(0.054)	(0.073)	(0.084)		(0.088)
Observations	87,477	87,477	60,107	41,755	41,755	41,755
R-squared	0.008	0.025	0.030	0.025		
Hansen statistic	.	.	.	.	7.472	5.614
p-value of Hansen	.	.	.	.	0.113	0.230

All specifications include firm and year fixed effects. The number of imported inputs ($t-1$) or the number of imported inputs DC ($t-1$) and LDC ($t-1$), Size ($t-1$) and TFP ($t-1$) are expressed in logarithmic form. The estimation is run on the subsample of firms importing products from non-EU countries and exporting within EU countries. In the IV estimation, the instrumental variables include lagged input tariffs and imported inputs. Variables are in $t-1$ and intrumental variables are lagged 3 periods. Input tariffs are computed at the firm level as an average of all tariffs on HS6 intermediate products that each firm imports. Robust standard errors clustered at the firm level are in parentheses. *** Significant at the 1 % level standard deviation increase in the number of imported inputs from the most developed countries improves export scope by 17.5 %, while a one standard deviation increase in the number of imported inputs from developing countries increases the number of exported varieties by 14.5 %.

These results suggest that both the technology/quality and price channels matter for export. Goldberg et al. (2010) focus on the impact of imported inputs on domestic production in India. They decompose imported input price indices into price and varieties effects, and do not find the former to significantly affect product scope. In contrast, Colantone and Crino (2011) use product-level data to study the impact of imported inputs on product scope in the EU, and find significant quality and price effects. Our firm-level results confirm that for developed economies the price effect plays a significant role.

The results of the estimations presented in Tables 6 and 7 remain robust and stable when using labor productivity (value added per worker) as an alternative measure of firm productivity gains. These results are presented in Table 13 in Appendix 2.

Finally, we also tested the impact of imported inputs on export status and other export margins: the intensive margin and the destination margin. The intensive margin corresponds to the value of existing exports whereas the destination margin captures the number of destination countries of exports. For the destination margin, we consider all destination countries, and not just EU countries. We first test for the impact of imported inputs accessibility on firms that start exporting. Results are reported in Table 14 in Appendix 2.[25] The IV estimations reveal that most of the effect of imported inputs on export status is captured by firms' TFP. It suggests, as in a simple Melitz (2003) model, that firms need a certain amount of productivity to become an exporter. Once already exporting, accessing more markets require higher productivity but may also be eased by importing more inputs from developed and developing countries, the quality/technology effect on the export fixed cost and the price effect are at play (column (7) and (8) of Table 15 in Appendix 2). Finaly, importing more inputs from developed economies increases the intensive margin of exports whereas inputs from less advanced economies does not, reflecting the fact that higher quality/technology inputs may lead to higher valued exports (column (3) and (4) of Table 15 in Appendix 2).

5 Robustness checks

In order to check the robustness of our findings, we consider a number of alternative specifications. We first appeal to different measures of input tariffs as IV. We also explore whether our results depend on our definition of intermediate goods or imported inputs by introducing alternative measures. We then consider the role of multinational firms in explaining the link between imported inputs and exports. We also correct for potential selection effects by restricting our database to firms that are present over the whole period. Finally, we test alternative econometric

[25] Recall that in the IV estimations our sample is restricted to importing firms.

specifications: Tobit, Poisson and negative binomial methods which reflect the count-variable nature of our dependent variable.

Results across these specifications are presented in Table 8. In all regressions we use IV techniques as in Sect. 4.2. We include firm and year fixed effects and control for size and TFP. Table 8 only reports coefficients on imported inputs. Coefficients on size and TFP are always highly significant with magnitude similar to the one of Table 6. We also perform within estimations (not reported here) with consistent findings. The extended tables of results are available upon request. Table 9 provides similar information distinguishing the impact of imported inputs on export scope according to the origin of imports (i.e., developed (DC) or developing (LDC) countries).

5.1 Alternative definitions of input tariffs and intermediate goods

We first propose alternative definitions of input tariffs using IO tables. We make use of French Input-Output tables in order to calculate the weights of each input in firm output. Firm-level input tariffs are then constructed using these weights with $\tau_{jt} = \sum_i \alpha_{ij}\tau_{it}$, where α_{ij} is the weight of input i in the total input cost of output j and τ_{it} is the output tariff of sector i in t. Results are given in specification (1) in Table 8. In specification (2), input tariffs are calculated using US instead of EU tariffs data. As mentioned in Sect. 3.4, changes in US tariffs are less subject to endogeneity issues related to EU lobbying and trade policy. They are also less correlated to the increase in the EU imports of inputs. As shown in Table 8, results are not sensitive to input-tariffs measures.

We also consider three alternative measures of imported inputs. The first is constructed using French Input-Output tables at the 3-digit level, following the methodology developed in Sect. 3.1, while the second measure makes use of the BEC classification of intermediate goods. The third measure excludes all goods, at the NC8 level, which are both imported and imported by a firm (i.e., the no-carry-along trade measure). Specification (3), (4) and (5) of Table 8 report the results. They show that our findings are consistent across these alternative definitions of intermediate inputs.

5.2 Alternative imported input measures

Previous estimations exploit changes on import inputs varieties measured through the number of product-origin country pairs. This section presents additional sensitivity tests using alternative measures of imported inputs.

First, we use the share of imported inputs over total materials of the firm as a proxy of the propensity to import intermediates goods. Specification (6) of Table 8 shows that import propensity impact positively and significantly export scope, thus confirming our previous results. Second, we rely on a Herfindhal index measuring the concentration of imported inputs from countries of origin at the firm level. Specification (7) of Table 8 presents the results. This variable turns out negative and

Table 8 Robustness checks

Dependent variable: log of the number of exported varieties of firm f in year t			
	Number of imported inputs ($t-1$)	Observations	Hansen statistics (p-value)
(1) Alternative instrument: IO tariffs	0.216***	53,424	0.880
	(0.072)		(0.644)
(2) Alternative instrument: US tariffs	0.145***	40,422	0.116
	(0.045)		(0.944)
(3) IO definition of imported inputs	0.120**	39,103	2.115
	(0.054)		(0.347)
(4) BEC definition of imported inputs	0.240**	40,574	1.482
	(0.097)		(0.224)
(5) Excluding carry-along trade	0.115***	40,396	1.902
	(0.022)		(0.593)
(6) Propensity to import	0.036***	40,208	2.938
	(0.008)		(0.401)
(7) Herfindhal index	−0.438***	42,007	2.073
	(0.141)		(0.355)
(8) Excluding multinationals	0.128**	28,677	2.995
	(0.060)		(0.392)
(9) Balanced sample	0.108**	28,665	2.623
	(0.046)		(0.453)
(10) Pooled Tobit	0.613***	150,369	.
	(0.005)		
(11) Random effects Tobit	0.198***	150,369	.
	(0.004)		
(12) Fixed effects Poisson	0.088***	102,267	.
	(0.009)		
(13) Dependent variable + 1	0.067***	150,369	
	(0.005)		

For specification (1) to (7), the table reports results from IV estimations. All specifications include firm and year fixed effects as well as size and TFP as control variables. Variables are expressed in logarithmic form. The estimation is run on the subsample of firms importing products from non-EU countries and exporting within EU countries. The instrumental variables include lagged input tariffs and imported inputs. Variables are in $t-1$ and instrumental variables are lagged 3 periods. Input tariffs are computed at the firm level as an average of all tariffs on HS6 intermediate products that each firm imports. Specification (8) presents Tobit estimations with industry and year fixed effects using as the dependent variable the logarithm of the number of exported varieties, and specification (9) reports results from a random-effects Tobit. the number of left censored observations is 62,892. Specification (10) shows firm fixed effect Poisson estimations using as the dependent variable the number of exported varieties. Specification (11) runs the standard regression with firm and year fixed effects as well as size and TFP as control using the logarithm of the number of exported varieties +1 as dependent variable. Robust standard errors clustered at the firm level are in parentheses. ***, ** Significant at the 1 and 5 % level respectively

Table 9 Robustness checks: distinguishing the imports' country of origin

Dependent variable: log of the number of exported varieties of firm *f* in year *t*.	Number of imported inputs DC ($t-1$)	Number of imported inputs LDC ($t-1$)	Observations	Hansen statistics (*p*-value)
(1) Alternative instrument: IO tariffs	0.181*	0.129***	53,424	4.094
	(0.106)	(0.046)		(0.393)
(2) Alternative instrument: US tariffs	0.094**	0.062**	35,782	1.757
	(0.039)	(0.026)		(0.780)
(3) IO definition of imported inputs	0.081***	0.074***	34,368	2.228
	(0.029)	(0.017)		(0.694)
(4) BEC definition of imported inputs	0.156**	0.179*	39,899	3.468
	(0.071)	(0.090)		(0.177)
(5) Excluding carry-along trade	0.093***	0.085***	34,873	4.383
	(0.032)	(0.019)		(0.357)
(6) Propensity to import	0.036***	0.016***	40,208	3.604
	(0.008)	(0.004)		(0.462)
(7) Herfindhal index	NA	NA	.	.
	(.)	(.)		
(8) Excluding multinationals	0.107**	0.089***	28,920	4.805
	(0.048)	(0.031)		(0.308)
(9) Balanced sample	0.070*	0.064***	28,706	4.853
	(0.037)	(0.025)		(0.303)
(10) Pooled Tobit	0.507***	0.309***	150,369	.
	(0.006)	(0.006)		
(11) Random effects Tobit	0.158***	0.115***	150,369	.
	(0.005)	(0.005)		
(12) Fixed effects Poisson	0.044***	0.054***	102,267	.
	(0.008)	(0.008)		
(13) Dependent variable + 1	0.058***	0.045***	150,369	
	(0.005)	(0.006)		

For specification (1) to (7), the table reports results from IV estimations. All specifications include firm and year fixed effects as well as size and TFP as control variables. Variables are expressed in logarithmic form. The estimation is run on the subsample of firms importing products from non-EU countries and exporting within EU countries. The instrumental variables include lagged input tariffs and imported inputs. Variables are in $t-1$ and instrumental variables are lagged 3 periods. Input tariffs are computed at the firm level as an average of all tariffs on HS6 intermediate products that each firm imports. Specification (8) presents Tobit estimations with industry and year fixed effects using as the dependent variable the logarithm of the number of exported varieties, and specification (9) reports results from a random-effects Tobit. The number of left-censored observations is 62,892. Specification (10) shows firm fixed effect Poisson estimations using as the dependent variable the number of exported varieties. Specification (11) run the standard regression with firm and year fixed effects as well as size and TFP as control using the logarithm of the number of exported varieties + 1 as dependent variable. Robust standard errors clustered at the firm level are in parentheses. ***, **, * Significant at the 1, 5 and 10 % level respectively significant implying that firms importing more diversified inputs have a greater export performance in terms of number of exported varieties and destinations.

5.3 Sample selection: multinational firms and balanced panel

Multinational firms may be involved in intra-firm trade where some imported inputs are re-exported to subsidiaries with no transformation. In this case, firms' imports do not affect production and our estimates are biased. We thus test whether our results are robust to the exclusion of French multinational firms. In order to identify multinational firms, we combine our main dataset with the *Enquete Echanges Internationaux Intra-Groupe* provided by the French Office of Industrial Studies and Statistics (SESSI).[26] The result, presented in specification (8) in Table 8, is very similar to the one with the full sample. The impact of imported inputs on export scope is thus not driven by French multinational trade activities.

Finally, as we work with an unbalanced panel of French firms, we check the robustness of the results by conducting the analysis on the subsample of firms that are present during the full period (specification (9)). The results in Table 8 confirm that we are not capturing a selection effect.

5.4 Alternative econometric specifications

Our dependent variable, the number of exported varieties, enters our main regressions in logarithm form. This may lead to sample-selection bias by excluding firms that do not export from our database. To address this potential sample section issue, we first present Tobit estimates which explicitly take censoring into account. Table 8 shows the results from both a pooled Tobit in specification (10) and a random-effects Tobit in specification (11).[27]

In order to account for the discrete nature of our dependent variable, we also rely on count-data model. Specification (12) presents the results of the fixed effects Poisson estimation which takes into account unobservable firm characteristics by introducing firm fixed effects and includes robust standard errors. Our last robustness check consists on changing the dependent variable to the logarithm of the number of exported varieties plus one in order to avoid dropping the firms that do not export (specification (13)). Our results are robust to all these alternative econometric specifications.

Finally, Table 9 shows the results of the above specifications (1) to (13) distinguishing imported input according to the country they are coming from. Overall, our main results hold across these alternative specifications.

[26] This dataset is based on a firm-level survey of manufacturing firms belonging to groups with at least one affiliate in a foreign country and with international transactions totaling at least one million euros. The survey year is 1998. The data provide a good representation of the activity of international groups located in France. These data cover around 82 % of total trade flows by multinationals, and 55 and 61 % of total French imports and exports respectively.

[27] Tobit models with fixed effects have an incidental parameters problem, and are generally biased.

6 Conclusions

This paper has provided robust evidence of the significant role of imported intermediate inputs in firm productivity and export scope. By using more varieties of imported inputs, the firm attains greater complementarity of inputs and therefore increases its productivity. The impact of imported inputs on TFP is reinforced if they originate from advanced economies and embody some quality/technology content. More productive firms are likely to export more varieties as they are able to bear the export fixed cost and survive in competitive export markets. Imported inputs may also affect export scope directly through lower input prices and reduced export fixed cost (thanks to higher quality/technology inputs). Both the price and quality/technology transfer arguments matter for export scope.

Should policy then fight or promote imports of intermediate inputs? While a large literature has focussed on the impact of imported intermediate inputs on employment and inequality and concluded for a (limited) role of outsourcing in explaining job loss and lower wages, this paper show that importing intermediate inputs also contributes to productivity and export growth. The positive role of imported inputs in the economy should be acknowledged and accounted for in both the policy debate and further research.

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Appendix 1: A simple model

In this Appendix, we present a simple partial equilibrium model which sheds light on the mechanisms via which imported inputs affect firm TFP and export scope. There is a continuum of domestic firms in the economy that supply differentiated final goods under monopolistic competition. Firms differ in their 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 differentiated intermediate goods (M_{ij}) produced by industry i, that can be purchased in the domestic or foreign markets. If the firm sources its inputs internationally, it may import intermediate goods from two different sets of countries distinguished by their levels of development. As is traditionally assumed, countries in the North have higher GDP per capita than those in the South. The technology is represented by a Cobb–Douglas production function with factor shares $\eta + \beta + \sum_{i=1}^{I} \alpha_i = 1$ (for simplicity, we omit the firm subscript):

$$y = \varphi L^{\eta} K^{\beta} \prod_{j \in \{D,N,S\}} \prod_{i=1}^{I} \left(M_{ij}\right)^{\alpha_i} \tag{1}$$

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 in industry i are aggregated by CES functions M_{ij}, where i is the industry, j the country region (i.e., domestic, North or South), $I_j = \{1, \ldots, M_j\}$ and $\sigma_i > 1$ is the elasticity of substitution across the varieties in industry i. The technology/quality parameter, χ_{ij}, captures the fact that imported inputs may enhance firm efficiency differently depending on their origin. We assume that χ_{ij} is greater than one for inputs sourced from the most developed countries, i.e., $j = N$, and equal to one otherwise. In this set up, each foreign country may produce one variety of inputs per industry, we thus match our empirical framework where a variety is defined as a product-country pair.

As is common in the literature (e.g., Ethier 1982 and Markusen 1989), we consider that intermediate inputs are symetrically produced at a level $\overline{m}$. This yields $M_{iD} = N_{iD}^{\frac{\sigma_i}{\sigma_i-1}}\overline{m}_D$, $\quad M_{iS} = N_{iS}^{\frac{\sigma_i}{\sigma_i-1}}\overline{m}_S$ and $M_{iN} = (N_{iN}\chi_i)^{\frac{\sigma_i}{\sigma_i-1}}\overline{m}_N$, where N_{iD}, N_{iS} and N_{iN} are the number of domestic and imported (from the South or the North) varieties of intermediate goods. The production function for a variety of final good, equation (1), can thus be rewriten as:

$$y = \varphi L^{\eta} K^{\beta} \prod_{j\in\{D,N,S\}} \prod_{i=1}^{I} \overline{M}_{ij}^{\alpha_i} \left(N_{ij}\chi_{ij}\right)^{\frac{\alpha_i}{\sigma_i-1}} \tag{2}$$

where $\overline{M}_{ij} = N_{ij}\overline{m_j}$. Following Kasahara and Rodrigue (2008), we make the simplifying assumption that firms either source their inputs domestically or internationally (from both the North and the South). Intermediate goods imported from the North have a higher technological content whereas inputs sourced from the South have a lower price, as input prices reflect the assumed relatively lower cost of factors of production in the South. As is standard, 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 MC_D if the firm sources its inputs domestically and MC_F if it does so on foreign markets.[28]

$$MC_D = \frac{p_k^{\beta} w^{\eta} \prod_{i=1}^{I} p_{iD}^{\alpha_i}}{\varphi \prod_{i=1}^{I} N_{iD}^{\frac{\alpha_i}{\sigma_i-1}}} \tag{3}$$

$$MC_F = \frac{p_k^{\beta} w^{\eta} \prod_{j\in\{N,S\}} \prod_{i=1}^{I} p_{ij}^{\alpha_i}}{\varphi \prod_{i=1}^{I} (N_{iN}\chi_{iN})^{\frac{\alpha_i}{\sigma_i-1}} (N_{iS})^{\frac{\alpha_i}{\sigma_i-1}}} \tag{4}$$

where w is the wage, p_k is the price of capital goods and p_{ij} is the price of inputs from industry i and region j.[29] 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

[28] 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.

[29] We assume that $p_{iD} = p_{iN} > p_{iS}$, as factors of production are expected to be cheaper in the South.

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 domestic profits thus simplify to $\pi_j = \frac{r_j}{\phi} - F$, where F is the fixed production cost. Firms that import, also incur a fixed import cost, F_m. Firm export profits are given by $\pi_x = \frac{r_x}{\phi} - F_x$, where F_x includes the production fixed costs (which include the import fixed cost for importing firms), F, as well as the export fixed costs which, as explained below, fall in the technology/quality parameter, i.e., $F_x = g\left(F, \frac{f_x}{\chi_{ij}}\right)$.

Using the price and revenue functions defined in the previous section, we derive the following expression for firms' export revenues:[30]

$$r_x = \Psi \left(\frac{\varphi \prod_{i=1}^{I} (N_{iN}\chi_{iN})^{\frac{\alpha_i}{\sigma_i - 1}} (N_{iS})^{\frac{\alpha_i}{\sigma_i - 1}}}{\prod_{j \in \{N,S\}} \prod_{i=1} p_{ij}^{\alpha_i}} \right)^{\phi - 1} \tag{5}$$

where $\Psi = P^{\phi-1} R \left(\rho^{-1} (1+\tau) p_k^{\beta} w^{\eta} \right)^{1-\phi}_{,}$ with τ being the variable export cost, P the aggregate price index of final goods and R aggregate industry revenue, all of which are exogenous to the firm. The corresponding profit can thus be written as

$$\pi_x = \frac{\Psi}{\phi} \left(\frac{A}{\prod_{j \in \{N,S\}} \prod_{i=1} p_{ij}^{\alpha_i}} \right)^{\phi - 1} - F_x \tag{6}$$

The tradebility condition for export is given by: $\pi_x(\varphi_x^*) = 0$, where φ_x^* is the Melitz (2003) productivity draw of the marginal firm serving the export market.

Appendix 2: Empirical results

(See Tables 10, 11, 12, 13, 14 and 15)

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

Table 10 Intermediate inputs

Firm sector HS4	Bodies, for specific motor vehicles (8707)	Footwear, outer sole rub, plastic or leather (6403)
Intermediate inputs	Other Polyethers (390720)	Woven Labels, Badges and Similar Articles, Not Embroidered (580710)
	Other Articles of Vulcanized Rubber (401699)	Other Textile Products and Articles, for Technical Use (591190)
	Other Hollow profiles of Aluminium Alloys (760429)	Other Articles of Leather or of Composition Leather (420500)
	Other Parts and Accessories of Bodies for the Motor Vehicles (870829)	Woven Fabrics of Metal Thread, of Metallized Yarn (580900)
		Coniferous-Air (470421)
		Other Whole Skins (Tanned or Dressed) (430219)
		Textile Fabrics Impregnated, Coated, Covered With Polyurethane (590320)
Final products	Other Bodies, for the Other Motor Vehicles (870790)	Other Footwear With Uppers of Leather or Composition Leather (640510)
		Other Footwear With Uppers of Leather (640399)
		Outer Soles and Heels, of Rubber or Plastics (640620)
		Other Footwear With Uppers of Textile Materials (640520)

Table 11 Distribution of imported inputs by sector

Industry	Average number of imported varieties non EU	Average number of imported varieties DC	Average number of imported varieties LDC
17	6	2	3
18	17	4	13
19	4	2	3
20	2	1	1
21	4	3	1
22	1	1	0
24	10	7	3
25	3	2	1
26	3	2	1
27	5	3	2
28	2	1	0
29	6	4	1
30	36	28	8
31	10	7	3
32	20	14	6
33	11	9	2
34	7	6	2
35	18	16	3
36	5	2	3

Table 12 First stage of the IV estimations of Tables 6 and 7

Dependent variable	(1) # Imported inputs ($t-1$)	(2) # Imported inputs DC ($t-1$)	(3) # Imported inputs LDC ($t-1$)
Imported inputs ($t-3$)	0.134***		
	(0.006)		
Imported inputs DC ($t-3$)		0.075***	
		(0.006)	
Imported inputs LDC ($t-3$)			0.105***
			(0.005)
Input tariffs ($t-3$)	−0.453***	−0.355***	−0.593***
	(0.132)	(0.133)	(0.138)
Firm fixed effects	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes
Observations	46,539	46,539	46,539
R-squared	0.048	0.012	0.110

The instrumental variables include lagged input tariffs and imported inputs. Dependent variables are in $t-1$ and intrumental variables are lagged 3 periods. Input tariffs are computed at the firm level as an average of all tariffs on HS6 intermediate products that each firm imports. Robust standard errors clustered at the firm level are in parentheses. *** Significant at the 1 % level

Table 13 Alternative productivity measure

Dependent variable: Log of the number of exported varieties to EU of firm (*f*) in year (*t*)

	(1) Within	(2) Within	(3) Within	(4) IV	(5) Within	(6) Within	(7) Within	(8) IV
Imported inputs ($t-1$)	0.051***	0.051***	0.055***	0.105***				
	(0.005)	(0.005)	(0.006)	(0.020)				
Imported inputs DC ($t-1$)					0.046***	0.052***	0.043***	0.123***
					(0.005)	(0.006)	(0.007)	(0.038)
Imported inputs LDC ($t-1$)					0.032***	0.036***	0.038***	0.100***
					(0.005)	(0.006)	(0.006)	(0.027)
Labor productivity ($t-1$)	0.098***	0.109***	0.089***	0.089***	0.098***	0.108***	0.090***	0.081***
	(0.009)	(0.011)	(0.012)	(0.011)	(0.009)	(0.011)	(0.012)	(0.011)
Size ($t-1$)	0.302***	0.308***	0.290***	0.264***	0.298***	0.303***	0.283***	0.241***
	(0.015)	(0.017)	(0.020)	(0.017)	(0.015)	(0.017)	(0.019)	(0.022)
Observations	87,477	60,107	46,539	40,314	87,477	60,107	48,063	41,755
R-squared	0.027	0.031	0.027	0.024	0.027	0.032	0.026	0.013
p-value of Hansen	.	.	.	0.892	.	.	.	0.187

All specifications include firm and year fixed effects. Robust standard errors clustered at the firm level are in parentheses. *** Significant at the 1 % level

Table 14 Export status and imported inputs

Dependent variable: export status of firm (f) in year (t)								
	(1) Within	(2) Within	(3) IV	(4) IV	(5) Within	(6) Within	(7) IV	(8) IV
Imported inputs ($t-1$)	0.017***	0.013***	0.021***	0.012*				
	(0.002)	(0.002)	(0.006)	(0.006)				
Imported inputs DC ($t-1$)					0.017***	0.013***	0.015**	0.004
					(0.002)	(0.002)	(0.007)	(0.007)
Imported inputs LDC ($t-1$)					0.007***	0.005***	0.007	0.005
					(0.002)	(0.002)	(0.005)	(0.005)
Size ($t-1$)		0.043***		0.020***		0.043***		0.018***
		(0.005)		(0.006)		(0.005)		(0.005)
TFP ($t-1$)		0.126***		0.219***		0.126***		0.250***
		(0.014)		(0.031)		(0.014)		(0.028)
Observations	150,369	150,369	55,274	55,274	150,369	150,369	66,766	66,766
R-squared	0.002	0.006			0.002	0.006		
Hansen statistic	.	.	0.911	0.635	.	.	6.331	6.419
p-value of Hansen	.	.	0.634	0.728	.	.	0.176	0.170

All specifications include firm and year fixed effects. The number of imported inputs, DC and LDC ($t-1$), Size ($t-1$) and TFP ($t-1$) are expressed in logarithmic form. Columns (1), (2), (5) and (6) show the effect of the number of imported inputs on the probability to become an exporter. All the other columns present the IV estimations of the probability that importing firms become exporters. In the IV estimation, the instrumental variables include lagged input tariffs and imported inputs. Variables are in $t-1$ and intrumental variables are lagged 3 periods. Input tariffs are computed at the firm level as an average of all tariffs on HS6 intermediate products that each firm imports. Robust standard errors clustered at the firm level are in parentheses. ***, **, * Significant at the 1, 5 and 10 % level respectivly

Table 15 Intensive margin and destination of export and imported inputs

	Dependent variable:							
	Log of the export value of firm (f) in year (t)				Log of the export destinations of firm (f) in year (t)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Within	IV	Within	IV	Within	IV	Within	IV
Imported inputs ($t-1$)	0.038***	0.206*			0.050***	0.116***		
	(0.009)	(0.111)			(0.004)	(0.032)		
Imported inputs DC ($t-1$)			0.052***	0.203**			0.046***	0.089***
			(0.009)	(0.102)			(0.004)	(0.016)
Imported inputs LDC ($t-1$)			0.005	0.170			0.030***	0.035***
			(0.009)	(0.104)			(0.004)	(0.013)
Size ($t-1$)	0.378***	0.182***	0.374***	0.157***	0.236***	0.189***	0.234***	0.186***
	(0.027)	(0.044)	(0.027)	(0.046)	(0.012)	(0.014)	(0.012)	(0.012)
TFP ($t-1$)	1.134***	1.196***	1.131***	1.078***	0.448***	0.566***	0.446***	0.605***
	(0.118)	(0.208)	(0.118)	(0.203)	(0.046)	(0.068)	(0.046)	(0.061)
Observations	87,477	23,940	87,477	24,011	107,919	52,684	107,919	52,991
R-squared	0.029		0.029		0.040		0.040	
p-value of Hansen	.	0.387	.	0.304	.	0.317	.	0.173

All specifications include firm and year fixed effects. The number of imported inputs, DC and LDC ($t-1$), Size ($t-1$) and TFP ($t-1$) are expressed in logarithmic form. In columns (1) to (4) the estimation is run on the subsample of firms importing products from non-EU countries and exporting within EU countries, while in columns (5) to (8) the estimation is run on the subsample of firms exporting toward all destination countries. In the IV estimation, the instrumental variables include lagged input tariffs and imported inputs. Variables are in $t-1$ and intrumental variables are lagged 3 periods. Input tariffs are computed at the firm level as an average of all tariffs on HS6 intermediate products that each firm imports. Robust standard errors clustered at the firm level are in parentheses. ***, **, * Significant at the 1, 5 and 10 % level respectivly

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