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Imported Intermediate Inputs and Firms' Productivity Growth: Evidence from the Food Industry

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Abstract

Imported goods play a central role in determining the gains from trade. Using detailed trade and firm-level data for Italy and France, we investigate the relationship between trade integration, imported intermediate inputs and firm performance in the food industry. Our main findings show that an increase in import competition spurs firm-level productivity growth. Furthermore, the productivity growth effect attributable to imported intermediate inputs is significantly stronger than the effect due to imported final products. In addition, we find that new imported inputs are of particular importance, especially for Italian food firms, though less so for the French firms. Finally, the productivity growth effect of trade integration tends to be asymmetric across firms: more productive firms gain more from trade integration. These stylised facts have interesting policy implications.

Keywords: *Firm-level TFP*; *food industry*; *import penetration*; *imported inputs*; *productivity growth*; *trade integration*.

JEL classifications: *F14, F15, F61, L66, Q17*.

1. Introduction

Does trade liberalisation in upstream sectors improve firm-level productivity in the food industry? Answering this question is crucial for the European Union (EU), as it is also related to trade liberalisation in the (upstream) agricultural sector. Whether an

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increase in imported intermediate inputs brings more benefits than costs for the agri-food sector obviously has strong policy implications. Despite the growing importance of trade in intermediate inputs, very few papers to date have investigated the relationship between imported inputs and food firms' productivity growth.

The literature on endogenous growth provides theoretical insights into the role played by imported inputs on efficiency gains at the aggregate level (Rivera-Batiz and Romer, 1991; Backus *et al.*, 1992). At the micro level, gains could be due to productivity growth realised through input complementarities, lower input costs, and/or access to new and higher quality inputs (Grossman and Helpman, 1991; Aghion and Howitt, 1998).[2] Empirically, studies based on firm-level data strongly confirm that more imported inputs lead to an increase in firm productivity growth (Amiti and Konings, 2007; Kasahara and Rodrigue, 2008; Topalova and Khandelwal, 2011; Altomonte *et al.*, 2014), in the number of new domestic products (Goldberg *et al.*, 2010; Colantone and Crinò, 2014) and in the probability of firms' entry in the export market (Bas and Strauss-Kahn, 2013; Chevassus-Lozza *et al.*, 2014).

With the notable exception of Chevassus-Lozza *et al.* (2014), who showed that lower input tariffs in agriculture may increase the export sales of high-productivity French food manufacturing firms (but at the expense of low-productivity firms), no studies to date have explicitly tested this relationship in the EU food industry.[3] A major difficulty in testing this relationship is that information on the intermediate consumption structure at the firm level is normally missing from the micro-dataset. Moreover, the lack of EU input–output (I–O) tables with a sufficient degree of industry disaggregation represents a further problem in this kind of study. As a consequence, researchers are often forced to adopt *ad hoc* solutions. For example, Chevassus-Lozza *et al.* (2014) combine trade and firm-level data to identify the imported products processed by a firm belonging to each four-digit industry.[4]

We propose an alternative strategy to identify the effect of imported intermediate inputs on firm-level productivity growth. In particular, we rely on studies that use an industry measure taken from one country, the United States, to approximate the

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[2]A growing literature focuses on the impact of import competition coming from developing countries, like China, on employment and inequality. Early studies conclude that there exists a low, or moderate, role of outsourcing in explaining jobs lost and wages decrease (see Feenstra and Hanson, 1996; Biscourp and Kramarz, 2007). However, more recent studies on the US labour market, by disentangling the trade exposure at local level, are distinctly more pessimistic about the effect on jobs lost and wages inequality (see Autor *et al.*, 2013; Acemoglu *et al.*, 2014).

[3]However, there exists a small but growing literature investigating the relationship between trade and productivity in the food industry, within the framework of firm heterogeneity trade models (see Ruan and Gopinath, 2008; Gullstrand, 2011; Chevassus-Lozza and Latouche, 2012; Curzi and Olper, 2012; Olper *et al.*, 2014; Curzi *et al.*, 2015).

[4]Chevassus-Lozza *et al.* (2014) in order to determine the set of products processed by a four-digit industry, made use of the French Customs Register, which provides information on imports of all French firms by product at the eight-digit level of the combined nomenclature. After knowing the main firm activity, namely its NACE four-digit sector, they identify all products imported by a given four-digit industry. This approach, despite having the advantage of also being based on firm-level import information, has some drawbacks. Firstly, information on the intermediate consumption structure for each firm is missing, and secondly it assumes that all French firms' imports in a given NACE four-digit are truly intermediate inputs used in the same industry, which is quite a strong assumption.

industry characteristics in other countries (see Nunn and Trefler, 2014 for a discussion).[5] More specifically, we make use of the US I–O tables, notably more detailed than those for the EU, to measure a consistent index of upstream import penetration. To the extent that technology is comparable between the US and the EU food processing industry, which is likely to be the case, this strategy offers a relatively simple and consistent solution to the lack of firm-level information on the intermediate consumption structure.

In addition, in our specific context, the proposed approach allows us to solve a subtle identification problem, stemming from the use of firm-level trade data. Many food firms are small and thus they access imported intermediate inputs only *indirectly*, through (importing) intermediaries. Thus, a firm that, according to the custom data, has not imported intermediate inputs, has probably bought (and used) foreign inputs imported by another domestic intermediary, raising a complex selection bias problem. In this paper, by using data of imported inputs at product and sector level, instead of detailed firm-level custom data, we do not encounter this kind of identification problem (see Goldberg *et al.*, 2010).

We study empirically the productivity growth effect of import competition at both industry and upstream sectors level by exploiting a large micro-dataset of more than 20,000 French and Italian food firms, observed over the 2004–2012 period. Following Acemoglu *et al.* (2014) and Altomonte *et al.* (2014), we measure an index of vertical input penetration at a very detailed level, by combining the BEC classification, which distinguishes between intermediates goods and products for final consumption, with the I–O table taken from the US Bureau of Economic Analysis (BEA). Furthermore, to shed light on the underlying mechanism through which imported intermediate inputs may affect firm-level productivity growth, the impact of upstream import penetration is split between its intensive and extensive trade margins, which account, respectively, for the growth in existing input varieties and the growth in new imported input varieties.

Our specific focus on both Italian and French food firms presents some interesting advantages. First, the two countries share a world renowned reputation for the quality of their food products, based on a strong food tradition and culture. Second, their food sectors, taken together, represent a large fraction of the EU food industry revenue. However, at the same time, the two countries have a fundamental difference in their agricultural sectors, which produce a large fraction of the intermediate inputs used in the food industry. While France is a net exporter of agricultural products, Italy is a net importer. These similarities and differences add interesting insights into the analysis of the effect of imported intermediate inputs on firms' productivity growth.

Our paper is organised as follows. In section 2, we present our measurements of productivity, horizontal and vertical import penetration, our identification strategy and our main expectations. In section 3 we report the econometric results and some robustness checks. Section 4 is devoted to investigate the mechanisms through which imported intermediates inputs affect productivity growth. Section 5 concludes.

[5]For example, Levchenko (2007) and Nunn (2007) investigated the effect of institutions on cross-country differences in comparative advantage, while Acemoglu *et al.* (2009) studied the role of financial developments on vertical integration. These and other studies used an industry measure based on the US I–O tables, as a proxy for other countries. A discussion about this approach can be found in Nunn and Trefler (2014) and Ciccone and Papaioannou (2010). Section 2.3 summarises this issue in the context of the present study.

2. Data, Measures and Empirical Strategy

We combine several different datasets to apply our empirical strategy. Firstly, we use the micro-data from Amadeus (Bureau van Dijk) to measure firm-level total factor productivity in the period 2004–2012. Secondly, detailed trade flows and production data from Eurostat, supplemented by information from the FAO for the (agricultural) raw material inputs, have been combined with the 2007 US I–O information from the US Bureau of Economic Analysis (BEA) to measure vertical import penetration.

2.1. Firm-level total factor productivity

In order to estimate total factor productivity (TFP) at the firm level, we consider a standard Cobb-Douglas production function $Y_{it} = A_{it}L_{it}^{\beta_l}K_{it}^{\beta_k}M_{it}^{\beta_m}$, where Y_{it} is revenue-based output of firm i in the year t; L_{it}, K_{it} and M_{it} are, respectively, labour, capital and materials inputs, and β_l, β_k and β_m are the input coefficients to be estimated; finally A_{it} represents total factor productivity (TFP).

A log-linearisation of the production function yields the equation $y_{it} = \beta_0 + \beta_l l_{it} + \beta_k k_{it} + \beta_m m_{it} + \eta_{it}$, with $lnA_{it} = \beta_0 + \eta_{it}$, where β_0 represents a measure of the mean efficiency level across firms and over time, and η_{it} is the time-firm-specific deviation from that mean. TFP is extracted from the above equation as a residual and, thus, the parameter of interest is the error term η_{it}.

To get a consistent estimator from the production function, η_{it} must be uncorrelated with the input variables. As is well known, the use of OLS to estimate the production function would lead η_{it} to be correlated with the input variables, generating simultaneity biases (see Griliches and Mairesse, 1995). For this reason, to measure consistent firm-level TFP we used the Levinsohn and Petrin (2003) approach.[6]

The method proposed by Levinsohn and Petrin (2003) (hereafter LP, for brevity), allows an unbiased estimation of the residual from a Cobb-Douglas production function, based on a semi-parametric estimation. According to this approach, the error term, η_{it}, is decomposed into two parts, $\eta_{it} = \varpi_{it} + \varepsilon_{it}$, with ϖ_{it} representing the transmitted productivity component, and ε_{it} an error term that is uncorrelated with input choices. The key difference between the two components is that ϖ_{it} is a state variable that impacts the productivity shocks and is observed by the firm but not by the econometrician.

In order to overcome this limitation, LP propose an estimation approach that uses intermediate inputs as proxies for these unobservable shocks, relying on the assumption that intermediate inputs respond more smoothly to productivity shocks.[7] LP assume that the intermediate inputs demand function depends on the two firm's state variables, k_{it} and ϖ_{it}, $m_{it} = m_{it}(k_{it}, \omega_{it})$. Next, they show that by making mild assumptions on the firm's production technology, the demand function is monotonically increasing in ω_{it}. Thus, the intermediate inputs demand function can be inverted, so that ω_{it} results as a function of m_{it} and k_{it}, namely $\omega_{it} = \omega_{it}(k_{it}, m_{it})$.

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[6]Another valuable method that overcomes this problem has been proposed by Olley and Pakes (1996). Although this method is conceptually similar to the one by Levinsohn and Petrin (2003), we chose the latter, because of data limitations. The Olley and Pakes (1996) method requires the use of investment as a proxy for productivity shocks, information only partially covered in our firm-level data.

[7]Among the different variables which could account for the use of intermediate inputs by the firms, LP suggest the use of materials or electricity costs.

Accordingly, the term accounting for the unobservable productivity, ω_{it}, can now be expressed in terms of observed inputs, $\varpi_{it} = y_{it} - \hat{\beta}_k k_{it} - \hat{\beta}_l l_{it} - \hat{\beta}_m m_{it}$, where ϖ_{it} is the (log of) TFP. Productivity levels can be obtained as the exponential of ϖ_{it}, i.e., $\Omega_{it} = \exp(\hat{\varpi}_{it})$.

We estimate firm-level TFP using balance sheet data from the Bureau van Dijk Amadeus database. In particular, we collect data for food firms of two different countries that share similar characteristics in the food sector, Italy and France. The database contains balance sheet data for more than 36,000 food firms over the 2004–2012 period, classified at the NACE four-digit industry level. In order to estimate a revenue-TFP with the LP method, we use the following variables: operating revenue (turnover) as output variable, labour cost, fixed assets and materials costs as input variables.[8] Before implementing the LP method separately for each of the two countries, we carried out an extensive data cleaning procedure. For this purpose, we firstly consider only those firms for which we have data for at least three consecutive years. Secondly, we drop firms reporting negative values for any of the considered variables in the TFP estimation. Finally, considering the same variables, in order to get rid of outliers, we drop firms with values falling below the 1st percentile and above the 99th percentile. We also compute the growth rates of each variable and drop all firms reporting growth rates smaller than the 1st or greater than the 99th percentile of the relevant distribution. After these cleaning procedures, the final database contains balance sheet data for 25,315 firms (6,692 Italians and 18,623 French).

Table 1 reports some descriptive statistics of the variables used in the Cobb-Douglas production function and the estimated TFP with the LP procedure. Firm-level TFP has been estimated separately for the sample of Italian and French Food firms, and for each of the 10 NACE Rev.2 three-digit industries. As shown in Table 1, Italian food firms show, on average, a higher TFP level than the French firms. This may reflect the relatively higher number of small firms (in terms of number of employees) in the French sample. The Italian food firms display a higher average value for all the variables considered (i.e. output, capital and material costs) with the exception of the labour cost, which is higher in the French sample. Moreover, looking at the values of TFP at three-digit sectors reported in Table S1 (see the supplementary material to this paper, available online at the publisher's website), the higher TFP level for Italian food firms holds systematically for all the three-digit food sectors that we consider.[9]

Italian food firms display a positive TFP growth during the 2004–2012 period, 0.5% per annum, an interesting result considering the concomitance of the global crisis and the trade collapse of 2008–2009. In addition, also as a reaction to declining domestic food demand, the share of firms' revenue exported abroad and the number of exporting food firms increased in Italy (see Italian Trade Agency, 2014). By contrast in the French food industry we estimated a significant reduction in the average

[8]All the variables used in the TFP estimation have been deflated using national two-digit industry deflators. Firms' operating revenues have been deflated using the GDP price index from EUROSTAT, while for labour costs we use a labour cost deflator taken from the European Central Bank. For the intermediate inputs we use the intermediate input deflators from OECD and, finally, firms' capital stock is deflated using the gross fixed capital formation deflator from EUROSTAT.

[9]Note, moreover, that the France bakery sector (NACE four-digit code 10.71), with about 10,000 firms in the dataset, could represent a potential outlier. However, the results are qualitatively and quantitatively very close when this four-digit sector is excluded from the database. These additional results are available from the author upon request.

Table 1

Descriptive statistics relative to TFP

	All			Italy			France		
	Obs.	Mean	Std. dev.	Obs.	Mean	Std. dev.	Obs.	Mean	Std. dev.
(ln) TFP	129,454	3.26	0.91	36,050	4.23	0.89	93,404	2.88	0.58
Avg. TFP growth	129,454	−2.2%	0.30	36,050	0.5%	0.38	93,404	−3.2%	0.26
(ln) Output	129,454	6.73	1.41	36,050	7.58	1.19	93,404	6.40	1.35
(ln) L	129,454	5.34	1.14	36,050	5.26	1.06	93,404	5.38	1.17
(1n) K	129,454	5.32	1.51	36,050	6.12	1.43	93,404	5.02	1.43
(ln) Materials	129,454	5.81	1.69	36,050	6.99	1.37	93,404	5.35	1.57

Notes: Avg. TFP growth refers to the average annual TFP growth in the 2004–2012 period. TFP has been estimated separately for the Italian and French sample using the Levinsohn and Petrin (2003) method. The estimated coefficients of the Cobb-Douglas production function for the Italian sample are: 0.353 for Labour, 0.062 for Capital and 0.523 for Material costs (return to scale 0.94). The estimated coefficients for the French sample are: 0.389 for Labour, 0.069 for Capital and 0.549 for Material costs (return to scale 1). All the coefficients in the two samples are precisely estimated and significant at the 1% level. ***Source*:** Figures based on data described in the text.

total factor productivity during the observed period (−3.1% per annum), that has been followed by an increasing rate of firms' bankruptcies, starting in 2007–2008 and exacerbated in 2010. Moreover, French food firms also experienced an overall deterioration in their export performance (see Aleksanyany and Huiban, 2014).

2.2. Measuring horizontal and vertical imports penetration

Before explaining how our key trade integration variables are measured, it is important to underline that horizontal import penetration deals with final product and within-sector competition. By contrast, vertical import penetration does not affect sector competition – at least directly – but instead captures the input composition of each sector by disentangling its foreign vs. domestic content.

Horizontal and vertical import penetration are measured for the period 2003–2011, for each of the 33 food manufacturing sectors, using the NACE Rev.2 classification at the four-digit level of disaggregation. Trade data are collected from Comext (Eurostat) according to the Combined Nomenclature (CN) eight-digit classification. The food sector production data come from the eight-digit Prodcom database (Eurostat), and from FAO data for all the agricultural products not included in the Prodcom database, and are strongly relevant for the analysis of intermediate inputs in the food industry.[10] Trade data and production data are both converted and aggregated at NACE four-digit industry level using the correspondence tables.

[10]Specifically, we include ten agricultural sectors, from NACE code 0111 to 0311. The correspondence between FAO and NACE is obtained merging the definition of products, as reported by the Statistical Classification of Economic Activities in the European Community for NACE-4 digit codes, with the item name reported by FAOSTAT (e.g. the NACE code 0111 final merge includes 26 FAOSTAT codes, NACE code 0113 includes 23 FAOSTAT codes, etc.). By contrast, country production value of code 0311 (marine fishing) comes from Eurostat.

The horizontal import penetration for each industry z in year t has been calculated as follows:

$$h\_\mathrm{imp}_{zt} = \frac{\mathrm{imp}_{zt}}{\mathrm{prod}_{zt} + \mathrm{imp}_{zt} - \exp_{zt}}. \tag{1}$$

where $\mathrm{imp}_{zt}(\exp_{zt})$ are the imports (exports) from (to) the World in industry z at time t, and prod_{zt} is the production value of industry z in year t. Vertical import penetration is a measure of the foreign presence in the industry z that is supplied by sector j. Following Acemoglu *et al.* (2014) and Altomonte *et al.* (2014), this vertical import penetration of industry z can be measured as the weighted average of the import penetration of its inputs:

$$v\_\mathrm{imp}_{zt} = \sum\nolimits_{j \in z} d_{jz} h\_\mathrm{imp}^{*}_{jt}, \tag{2}$$

where the weight d_{jz} represents the value share of the input used by industry z from industry j of the total inputs utilised by industry z, i.e., $d_{jz} = \mathrm{use}_{jz} / \sum_{j \in z} \mathrm{use}_{jz}$, while $h\_\mathrm{imp}^{*}_{jt}$ is the horizontal import penetration of intermediate inputs coming from industry j whose goods are used as inputs in the production processes of industry z. As in Altomonte *et al.* (2014), import penetration of intermediate inputs is measured using production and trade data considering *only* those products that, at CN and Prodcom eight-digit level, are classified as intermediate goods according to the Broad Economic – SNA Categories (BEC) classification.[11]

The weights d_{jz}, are computed from the I–O tables. However, due to the lack of I–O tables at sufficient degree of detail for both Italy and France,[12] we use the 2007 US I–O tables provided by the Bureau of Economic Analysis.[13] The US I–O tables show how industries interact with each other at a high level of disaggregation, namely at six-digit I–O industry codes. In particular, we rely on the 'Use table', which reports the value of each input of commodity j used in the production of industry z.[14] Converted into the NACE classification, there are 94 intermediate inputs involved in the 33 food NACE four-digit industries.[15]

[11]The BEC categories set out the distinctions of primary and processed goods, of capital, intermediate and consumption goods, and of durable, semi-durable and non-durable consumption goods. The SNA (System of National Account) categories distinguish between intermediate, consumption and capital goods.

[12]Eurostat, as well as national statistics, produces I–O matrices with a degree of disaggregation not higher than two-digit level, i.e., 22 manufacturing sectors of which one is the food industry.

[13]The Bureau of Economic Analysis reports I–O tables with 389 BEA industry codes, of which 237 are in manufacturing and 13 in agriculture. Detailed data used to estimate the Industry Economic Accounts of the BEA come from 2007 Economic Census and are consequently available only for year 2007 (data are available at http://www.bea.gov/industry/io_annual.htm). BEA codes are connected with the North American Industry Classification System (NAICS) code structure, that is then converted to NACE codes.

[14]The 'Use Table' shows the use of commodities by intermediate and final users. For example, for the bakery products industry, the table shows the amount (in dollars) of flour, eggs, yeast and other inputs that are necessary to produce baked goods and the secondary products of the industry, such as flour mixes and frozen foods.

[15]Most of the inputs come from agricultural and food sectors. These two industries represent on average 70% of the inputs used in the different food sectors, with an almost equal partition between them, but with strong variation among industries.

The use of US I–O tables to proxy for the relevant industry characteristics of other countries is now a rather common approach in applied studies.[16] The typical justification is that 'no matter where goods are produced, they still require the same inputs and in the same proportions' (Nunn and Trefler, 2014). For example, wherever beer is manufactured, it still requires malt, hops and water. Clearly, we are not arguing that the typical food product is produced exactly in the same way in the US as in France and Italy, and we are aware that this procedure will probably introduce some unknown bias in our results. Having said that, our justification for the approach – based on Ciccone and Papaioannou (2010) and discussed in the next section – is that in our specific context the bias introduced by using the US I–O to build proxies for the industries of other countries will lead, if anything, only to attenuation bias in our results.

Table 2 reports simple statistics of horizontal and vertical import penetrations by distinguishing among trading partners. During the observed period (2003–2011), the average measure of vertical import penetration was around 0.5 for both Italy and France. However, for Italian food firms the vertical dependency from abroad, other than increasing over time, is also significantly higher than the horizontal import penetration. By contrast, for France, the vertical index is decreasing across the observed period, and only slightly higher than the horizontal one. As discussed in the introduction, these patterns in vertical import penetration between Italy and France reflect differences in the agricultural comparative advantage.

Between the commercial partners, European Union countries represent the most important source of food industry inputs, generally followed by Emerging and OECD countries, although the largest positive changes in the vertical import penetration ratio are always observed for the New Member States of the European Union. By contrast, the two import penetration indices for developing countries (other) are, on average, decreasing over time.

Considering the variation in competition across industries, there are several differences between both sectors and countries.[17] It is worth noting that four out of eleven three-digit sectors, in both Italian and French markets, have an horizontal import penetration above the mean (fish, fruit and vegetable, oils and tobacco), and that some sectors show a relevant increase in import competition, in particular oils, dairy, mill and bakery products. Moving to the vertical import penetration, changes are less pronounced, but the average value of the index is generally higher than the horizontal one. In Italy, where only fish and tobacco sectors have a vertical index that is lower than the horizontal one, the measure ranges from a maximum of 1 (meat), to a minimum of 0.1 (tobacco) and increases over our period in many of the analysed sectors and, in particular, in the manufacture of beverage, bakery, grains mill and starch products, and in meat products. The French situation is quite different, where almost all sectors registered a decrease in the vertical import penetration that is particularly strong for dairy, fruit and vegetables and bakery products. The only exceptions are meat, fish, and animal feed products, which show a weak increase over the observed period.

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[16]However, to the best of our knowledge, we were the first who applied this approach to investigate the TFP growth effect of imported intermediate inputs.

[17]Data are shown in Table S2 in the online Appendix. Note moreover that, to save space, we display these figures at three-digit level, instead of the four-digit level used in the subsequent econometric analysis.

Table 2

Horizontal and vertical import penetration by trade partners

	Italy			France		
Country groups	Mean	Std. dev.	Avg. annual growth (%)	Mean	Std. dev.	Avg. annual growth (%)
Horizontal import penetration						
World	0.324	0.278	0.30	0.427	0.326	0.84
EU 15	0.271	0.278	−0.47	0.349	0.294	0.05
Emerging	0.085	0.295	4.62	0.042	0.113	5.18
OECD	0.032	0.181	−4.59	0.024	0.049	3.61
NMS	0.055	0.219	18.83	0.015	0.051	22.28
Other countries	0.026	0.143	−1.03	0.009	0.026	−2.41
Vertical import penetration						
World	0.538	0.246	4.65	0.478	0.231	−2.20
EU 15	0.422	0.238	2.94	0.357	0.161	0.49
Emerging	0.245	0.214	6.36	0.151	0.133	−0.45
OECD	0.178	0.171	−2.39	0.310	0.310	−0.68
NMS	0.188	0.179	4.33	0.121	0.213	19.07
Other countries	0.088	0.172	−14.65	0.044	0.094	−28.73

Notes: The mean and average growth rates of import penetration indices are measured over the period 2003–2011. The country groups are defined as follows: EU-15 refers to the 14 European countries, with Belgium and Luxembourg reported as a single country; 'Emerging' considers 21 emerging countries following the MSCI classification; NMS includes the 12 New Member States of the EU; OECD considers 13 OECD countries not included in previous groups; 'Other countries' includes the remaining countries, mainly developing ones. ***Source***: Figures based on data described in the text.

2.3. *Identification strategy*

To identify the firm-level productivity gains from importing intermediate inputs we use a reduced form approach, in the spirit of Altomonte *et al.* (2014), Amiti and Konings (2007) and many others.[18] We regress firm-level estimates of TFP on our indices of import penetration at industry and upstream sector levels, respectively. As recently argued by Blaum *et al.* (2014), this reduced form approach tends to be consistent with theory. Hence, we use the following empirical specification to relate horizontal and vertical import penetration to productivity (Altomonte *et al.*, 2014):

$$y_{it} = \beta_0 + \beta_1 \log h\_\mathrm{imp}_{zt-1} + \beta_2 \log v\_\mathrm{imp}_{zt-1} + \alpha_i + \theta_t + \varepsilon_{izt}, \qquad (3)$$

where y_{it} is the log of TFP of firm i in year t and is regressed on the NACE four-digit sector lagged logs of horizontal and vertical import penetration. Moreover, α_i and θ_t are firm and time fixed effects, respectively, and ε_{izt} is an iid error term.

[18]The alternative is to follow a more structural approach, where the imported intermediate inputs are embedded directly in the estimation of the firm-level production function (see, e.g., Halpern *et al.*, 2015). However, this approach needs direct information on the firm-level share of imported inputs, information that is missing in our dataset. Moreover, as recently discussed in Blaum *et al.* (2014), this apparently more structural approach is not exempt from problems.

By including firm (and time) fixed effects, equation (3) identifies the impact of import penetration variables, measured at four-digit industry level, on firm-level TFP by exploiting the within-firm variation in productivity, hence controlling for time invariant observed and unobserved firm-level heterogeneity. Moreover, note that the import penetration variables enter the equation lagged by 1 year, because we are assuming that a firm needs some time to adapt to the new situation, and to reduce the potential bias induced by a spurious correlation due to shocks simultaneously affecting imports and productivity.

A critical issue of our identification strategy is endogeneity concerns due to both measurement errors, induced by the use of the US I–O tables to measure vertical import penetration, and by possible simultaneity bias between import penetration and TFP. Starting from the measurement error problem, as discussed in Ciccone and Papaioannou (2010), the properties of OLS estimations when the industry measure from one country is an imperfect proxy for the other countries, have two main sources of bias. One is a standard attenuation bias, according to which if there exists a random measurement error associated with the industry measure, then the estimated coefficient will be biased downward. A second bias can arise when the measure used is systematically a better proxy for certain countries than others, often referred to as an amplification bias. However, note that in our specific context this amplification bias should be nearly irrelevant, because the Italian and French food industry technologies tend to be very close to each other. For this reason the attenuation bias overwhelms the measurement error problem, making our estimation of the vertical import penetration effect, if anything, downward biased.

Concerning the issue of the simultaneity bias, it is worth noting that when estimating equation (3) we regress firm-level TFP on four-digit industry import penetration indices, a situation that, at least partially, reduces endogeneity concerns. However, to account more formally for the potential endogeneity bias, as a robustness check we also estimate equation (3) in a dynamic fashion, by using the Arellano and Bond (1991) first difference GMM estimator, and by treating import penetration indices as endogenous.

2.4. Expectations

Several theoretical arguments and empirical evidence suggest that an increase in trade integration – at both the output and input levels – should translate into firm-level productivity growth (e.g. Aghion and Howitt, 1998; Bernard *et al.*, 2003; Grossman and Helpman, 1991; Melitz, 2003 etc.). However, the effect of an increase in import competition at the output level is expected to be different from the effect induced by an increase in imported intermediate inputs.

In particular, our first expectations from the estimation of equation (3) are that $\beta_1 > 0$ and $\beta_2 > 0$, meaning that an increase in both horizontal and vertical import penetrations should translate into an increase in firm-level TFP, *ceteris paribus*. Secondly, we expect that $\beta_2 > \beta_1$, and thus that the magnitude of the effect of vertical import penetration on firms' TFP growth should be higher than that of horizontal import penetration. Two key reasons are at the root of this expectation. Firstly, standard TFP measures include both information on firms 'physical productivity' and 'markup' (see De Loecker, 2011).[19]

[19]Indeed, when we allow for both output and input price variation across firms, as in standard monopolistic competition models, then the lack of firm-level (inputs/outputs) deflators makes the estimation of (physical) TFP very difficult. See De Loecker (2011) for an in-depth discussion.

Secondly, as graphically showed below, trade liberalisation in final and intermediate goods impacts differently firms' markup. Hence, the estimated TFP elasticity to vertical import penetration should be higher in magnitude than the TFP elasticity of horizontal import penetration, because the markup component of the TFP measure would positively (negatively) contribute to the effect of vertical (horizontal) import penetration on TFP growth, *ceteris paribus*.

In order to investigate the reason behind the different impact of trade liberalisation in final or intermediate goods on firms' markup, consider a market characterised by monopolistic competition and linear demand (Figure 1), as in De Loecker and Goldberg (2014). Note that horizontal import penetration involves products for the final consumption (*output*), while vertical import penetration involves intermediate goods (*input*).

Panel A of Figure 1 presents the case of an *output* tariff liberalisation. The equilibrium in the domestic market is defined by the interaction of the marginal revenue curve mr_0 and the marginal cost mc_0, which leads firms to produce the quantity q_0 at the price p_0, and to get the markup η_0. After the output tariff liberalisation, the resulting increase in horizontal import penetration leads domestic firms to face a tougher competition. This leads the marginal revenue curve to move inward (mr_1). Assuming that the marginal cost remains constant, at the new equilibrium firms produce a lower quantity q_1 at a lower price p_1, which translates into a lower markup ($\eta_1 < \eta_0$). Hence, a tougher horizontal competition should translate into a lower markup, *ceteris paribus*.

Panel B of Figure 1 presents the case of *input* tariffs liberalisation. In this case, an increase in imported intermediate inputs does not affect the competitive environment faced by (downstream) domestic firms, but it leads to a reduction of firms' input cost. As a consequence, the marginal cost curve shifts downwards (from mc_0 to mc_1). Thus, in the new scenario, domestic firms will produce a higher quantity (q_1) at a lower price (p_1), that however allows firms to have a higher markup ($\eta_1 > \eta_0$).

Thus, the expectation that $\beta_2 > \beta_1$ is the result of both the different impact of vertical vs. horizontal import competition on firms' markup, and the fact that standard TFP measures include also information on firms markup.

There is a final interesting point to be considered. As shown by Goldberg *et al.* (2010), both theoretically and empirically, the reduction of input costs induced by input tariffs liberalisation could be the result of two main mechanisms: firstly, a reduction of the average input price as an effect of tariff liberalisation; secondly, the use of *new* imported inputs due to an expansion of imported varieties (increase of the extensive trade margin).[20] In order to identify the importance of these two mechanisms, in the final section of this paper we provide a decomposition of the vertical import penetration effect in its intensive and extensive trade margin components.

3. Results

We first present the main empirical results on the relationship between output and input trade integration and firm-level TFP growth. We then provide some robustness checks to test whether the endogeneity concern over trade integration indices affects

[20]Note that, in the first case (input price reduction) we have only 'static gain' from trade. By contrast, in the second case (expansion of imported varieties) there should be also 'dynamic gain' for trade due to the expansion of new domestic products.

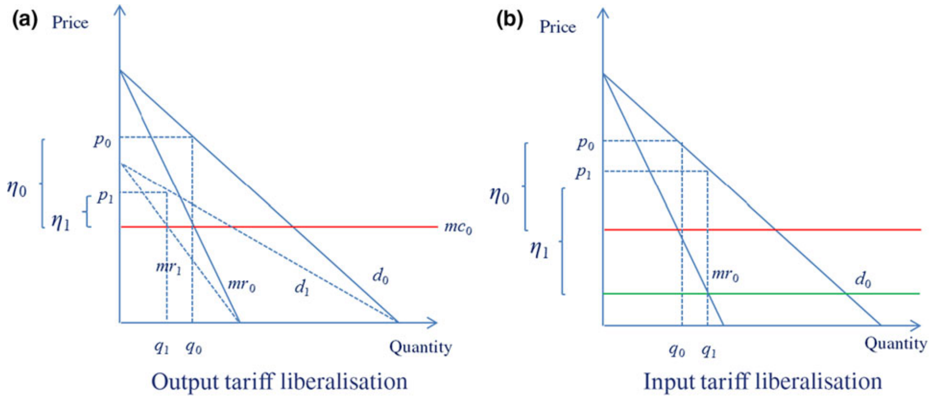

Figure 1. Effect of output and input tariffs liberalisation on firms' markup
***Source*:** Adapted from De Loecker and Goldberg (2014).

our main results. Section 4 presents a decomposition of the effect of imported intermediate inputs on TFP growth to study the main mechanisms at work.

3.1. Baseline results

Table 3 reports the baseline results of the regression of the log of firm-level total factor productivity on our two industry indicators of horizontal and vertical import penetration, plus a full set of firm and time fixed effects.[21] In column (1), we pooled both French and Italian food firms, thus assuming that they are similarly affected by import penetration indices. Column (2) relaxes this assumption.

For both countries combined (column (1)), the 1 year lagged horizontal import penetration positively affects productivity. However, although the coefficient is estimated with high precision ($P < 0.01$), the magnitude of the economic effect is quite small. A 10% increase in import penetration is associated with a TFP growth of only 0.07%, all other things being equal.[22]

Moving to the effect of vertical import penetration, its estimated coefficient also displays a statistically significant positive sign ($P < 0.01$). Thus, consistent with the expectations and previous evidence, an increase in imports in the upstream intermediate inputs contributes to firm-level productivity growth. Moreover, and interestingly, the economic effect of vertical import penetration is of two order of magnitude higher than the one of horizontal import penetration. A 10% increase in upstream integration would result in a 2.1% increase in productivity, *ceteris paribus*. This represents a large economic effect and its order of magnitude is similar to previous findings (see e.g. Amiti and Konings, 2007). Thus, the results show that the productivity gains from increasing integration in upstream sectors are much higher than those from increasing integration in output, a finding that is consistent with the mechanism highlighted by

[21]The Hausman test systematically identified fixed effects estimator as preferable to the alternative random effects estimator.

[22]Interestingly, running a specification that includes only horizontal import penetration, the estimated coefficient doubles in magnitude, suggesting that omitting vertical import penetration from the model induces an omitted variable bias.

Table 3
Import penetration and productivity: Baseline regression results

Dependent variable: Log of TFP	(1) Whole sample	(2) Italy	France
Log Horizontal IP ($t-1$)	0.007***	0.028*	0.007***
	(0.003)	(0.015)	(0.0025)
Log Vertical IP ($t-1$)	0.213***	0.062***	0.330***
	(0.009)	(0.018)	(0.013)
Firm FE	Yes	Yes	
Time FE	Yes	Yes	
Observations	129,454	129,454	
R^2	0.92	0.92	

Notes: Robust standard errors clustered at firm level in parentheses under the coefficients; $*P < 0.1$, $**P < 0.05$, $***P < 0.01$. ***Source*:** Figures based on data described in the text.

De Loecker and Goldberg (2014) and summarised above, according to which an increase in vertical inputs penetration tends to translate into an increase in firms' markups.

In column (2) of Table 3, the effect of horizontal and vertical import penetrations is analysed separately for French and Italian firms. The overall pattern is quite similar, namely both indices tend to positively affect productivity, and import penetration in upstream sectors systematically exerts a stronger effect on both Italian and French food firms. However, some interesting differences emerge which are worth noting.

Considering horizontal import penetration, the overall productivity growth effect is significantly positive for French and Italian firms, although for the latter it is only barely significant (10% level). Moving to vertical import penetration, both the coefficients for Italy and France are positive, statistically significant and higher in magnitude than the respective coefficients of horizontal import penetration. Moreover, the TFP elasticity of imported inputs of France is higher than that of Italy (0.33 vs. 0.06).

In Table 4 we address an important question: is the impact of horizontal and vertical import penetration conditional on the (initial) level of firms' productivity? Indeed, standard firm heterogeneity trade models predict that an increase in horizontal import competition should induce a market share reallocation from low- to high-productivity firms (see Melitz, 2003; Melitz and Ottaviano, 2008). A similar prediction, although based on a different mechanism, has been recently highlighted by Chevassus-Lozza *et al*. (2014) for trade liberalisation in upstream sectors. These authors showed that the output price elasticity of downstream firms, with respect to a change in input tariffs, increases with firms' productivity.

To test these predictions we run our baseline regression by interacting both horizontal and vertical integration indices with four dummies that identify the different quartiles of the TFP distribution, using the TFP sample distribution of the initial year to attenuate possible endogeneity biases.[23] The results are interesting and, for both import penetration indices, the magnitude of the TFP growth tends to be significantly

[23]Because our panel is unbalanced, by using the initial year to identify the quartiles of the TFP distribution we lose about 25% of the observations.

Table 4

Import penetration and productivity: Results split by initial level of TFP

Dependent variable: Log of TFP	Horizontal	Vertical
Log IP ($t-1$) first quartile of TFP	−0.001	0.128***
	(0.003)	(0.014)
Log IP ($t-1$) second quartile of TFP	0.013***	0.163***
	(0.004)	(0.013)
Log IP ($t-1$) third quartile of TFP	0.020***	0.227***
	(0.006)	(0.013)
Log IP ($t-1$) fourth quartile of TFP	0.021**	0.325***
	(0.010)	(0.019)
Firm FE	Yes	
Time FE	Yes	
Observations	98,221	
R^2	0.918	

Notes: Robust standard errors clustered at firm level in parentheses under the coefficients; *, ** and *** indicate statistical significance at 10%, 5% and 1% level, respectively. ***Source*:** Figures based on data described in the text.

higher for firms with higher initial level of productivity, *ceteris paribus* (see Table 4).[24]

When considering horizontal import penetration, the estimated effect for the lower quartile is negative, although insignificant, and it progressively increases as we move to the higher quartiles of TFP distribution. This pattern is consistent with the within-industry market share reallocation from small to large firms predicted by Melitz-type firm heterogeneity models (e.g. Melitz and Ottaviano, 2008). The only unexpected result is the one related to the upper quartile, where the estimated TFP growth effect induced by horizontal import competition is not significantly different from the adjacent third quartile. Different reasons can justify this finding. For example, one can argue that more efficient firms, being often multinationals in nature, use a different strategy and, thus, they can be less affected by the increasing competitive environment (see Colantone *et al.*, 2015).

Interestingly, the effect is even starker for vertical import penetration, where the estimated coefficients tend to grow progressively as we move from the lower to the upper quartiles of the TFP distribution. Here, the most efficient firms show a TFP growth effect induced by an increase in imported intermediate inputs that is 2.5 times stronger than the least efficient firms. However, it is important to stress that less productive firms also significantly benefit from trade liberalisation in intermediate inputs. Taken together, these findings are interesting for different reasons. Firstly because they confirm that importer firms, which are concentrated in the upper tail of the distribution (see Bernard *et al.*, 2012), gain proportionally more from trade liberalisation in upstream sectors, a result fully consistent with the predictions of Chevassus-Lozza

[24]We conducted a battery of *F*-tests for assessing whether the estimated coefficients of horizontal and vertical import penetration reported in Table 4 are significantly different across the quartiles. These *F*-tests reject the equality of the coefficients in all cases but the one between the third and upper quartiles of horizontal import penetration. The outcomes of the tests are available upon request.

et al. (2014). Secondly, and perhaps more interestingly, these effects are also sizeable for the less efficient firms of the sample, suggesting that the benefits of having more competitive upstream sectors are also spread to firms that do not import directly.

3.2. *Robustness check: Dynamic panel model*

As discussed in the identification section, one potential shortcoming of the results presented above is the possible simultaneity bias between TFP and import penetration indices. To investigate this issue, we apply the Arellano and Bond (1991) first difference generalised method of moment (GMM) estimator.

The results from dynamic panel models are reported in Table 5. For comparative purpose, column (1) displays the regression (1) of Table 3. Column (2) reports the results from a dynamic fixed effects model, while columns (3) and (4) show the results of the first difference GMM estimators. The only difference between the two GMM estimators is the lag structure used for the import penetration instruments: AB2 in column (3) starts from the second lag, while AB3 in column (4) from the third lag.

All the results from the dynamic panel models strongly confirm our previous findings, showing that simultaneity bias between import penetration and TFP does not seem to be a major problem of our static fixed effects results. Indeed, all the standard GMM endogeneity tests reported at the bottom of the table (AR2 and Hansen) are insignificant, suggesting that the GMM specifications do not suffer from serious correlation problems between the residual and the import penetration indices.

Table 5
Robustness checks: Dynamic panel model

	(1)	(2)	(3)	(4)
		Dynamic panel model		
	Static fixed effects	LSDV	AB2	AB3
Log Horizontal IP ($t-1$)	0.007***	0.009***	0.040***	0.042***
	(0.003)	(0.002)	(0.007)	(0.008)
Log Vertical IP ($t-1$)	0.213***	0.102***	0.152***	0.122***
	(0.009)	(0.008)	(0.022)	(0.035)
Log TFP ($t-1$)		0.444***	0.424***	0.387***
		(0.006)	(0.036)	(0.037)
AR1 (P-value)			0.084	0.086
AR2 (P-value)			0.372	0.394
Hansen test (P-value)			0.179	0.191
Observations	129,454	129,454	104,802	104,802

Notes: Column (1) reproduces the results reported in column (1) of Table 3; Column (2) reports results based on a last square with dummy (LSDV) variables dynamic panel model; Columns (3)–(4) report dynamic panel first difference GMM two-step estimator implemented in STATA, using the xtabond2 routine; lagged dependent variable instrumented with its $t-2$ and longer lag levels; import penetration indices instrumented with their $t-2$ ($t-3$) and longer lags levels in the AB2 (AB3) columns, respectively; Year fixed effects are included in each regression; Windmeijer-corrected cluster-robust standard errors in parentheses; *, ** and *** indicate statistical significance at 10%, 5% and 1% level, respectively. ***Source***: Figures based on data described in the text.

Furthermore, when vertical import penetration is considered, we find a remarkable consistency across estimators of the magnitude of the estimated effect. For example, the long-run TFP elasticity of the LSDV, AB2 and AB3 estimators, respectively 0.183, 0.264 and 0.199, are all close to the elasticity of the static model, 0.213.[25] However, some differences in the GMM model lie in the magnitude of the estimated elasticity of horizontal import penetration, which is now significantly higher in comparison with the static model, suggesting that in this specific case, endogeneity bias could be at work in the static model. Yet, the elasticity of the imported intermediate inputs is still about three times higher than that of horizontal import penetration, thus giving a broad confirmation of our *a priori* expectations.

4. Mechanisms

In the previous sections we documented a strong positive effect of vertical import penetration on firms' TFP growth. Hence, a natural question arises, namely which kind of mechanism is driving the result? As discussed above, an increase of imported intermediate inputs due to trade integration reduces the firm-level marginal costs. On one hand this effect can be driven by a simple substitution effect between domestic and foreign inputs that are now cheaper. On the other hand, however, the effect could be the result of *new* imported inputs that increase the ability of firms to *upgrade* the existing products, or to produce completely new products. Which of the two effects prevails is relevant because in the first case it would lead mainly to 'static gain' from trade, whereas in the second case 'dynamic gains' from trade would also be at work (Goldberg *et al*., 2010).

We try to shed some light on the relevance of the two mechanisms through a decomposition of the vertical import penetration index. Because the growth of imported inputs may be the results of growth in the intensive or the extensive trade margin, we decompose the vertical import penetration into these components. Considering the horizontal import penetration of each input, the first component includes only the CN eight-digit inputs imported both in the first and in all the other subsequent years. After aggregation through equation (2), we call this component *existing imported inputs* or *vertical intensive margin*. By contrast, the second component or *vertical extensive margin* is based on the aggregation through equation (2) of all the other imported input codes, mostly driven by *new imported inputs*, because very few products ceased to be imported over the analysed period.[26]

Table 6 reports summary statistics of the decomposition of vertical import penetration. As is evident, the two countries display a very different pattern. In Italy, the (average) level of trade integration in imported inputs, 0.54, is due to 60% at the extensive margin (0.32) and to 40% at the intensive margin (0.22). In addition, considering the growth rate over the period, trade integration due to new input varieties

[25]Note that in the dynamic specifications reported in Table 5, the estimated import penetration coefficients are lower in magnitude, because they are measuring short-term elasticities. To obtain long-run elasticities comparable with the static specification reported in column (1), it is necessary to divide the estimated coefficient of import penetration for one minus the coefficient of the lagged depend variable.

[26]Note that, because official nomenclatures change over time, we construct a correspondence table of the CN codes that changed over the period. This procedure avoids considering imported inputs whose eight-digit number changed over time as a 'new' product.

Table 6
Decomposition of vertical IP in its extensive and intensive trade margins

	Italy			France		
	Mean	Std. dev.	Annual growth (%)	Mean	Std. dev.	Annual growth (%)
Vertical import penetration	0.538	0.246	4.65	0.478	0.231	−2.20
Due to						
New imported inputs	0.320	0.192	6.44	0.166	0.125	−1.73
Existing imported inputs	0.224	0.115	2.33	0.337	0.172	−3.94

Notes: The table reports a decomposition of vertical import penetration in its extensive (new imported inputs) and intensive (existing imported inputs) trade margins. The intensive margin is defined as the volume of imported inputs due to tariff lines always present in the considered period. The remaining trade volume is considered as the extensive margin, and thus it represents the net contribution of new and ceased imported varieties. By definition, the sum of the contribution of the intensive and the extensive margins equals total trade. In our specific case, however, we lose the mathematical identity due to aggregation problems when computing the import penetration using equation (2). ***Source***: Figures based on data described in the text.

(6.4% per annum) largely dominates the growth rate due to existing input varieties (2.3% per annum). Hence for Italy, the contribution of *new* imported inputs largely dominates the process of trade integration over our data period.

In France the situation is in stark contrast. Indeed, first of all, we observe an overall *reduction* of trade integration due to imported intermediate inputs. Secondly, considering the period average, the contribution to vertical integration due to *existing* imported inputs largely dominates the one of *new* imported inputs, although the latter displays better growth performance than the former.

How do these overall patterns translate into estimated TFP growth elasticities? Being a 'simple' decomposition of vertical import penetration, the econometric results should quite closely follow the summary statistics discussed above. In fact, as shown by the econometric results in Table 7, in the case of France the positive TFP growth effect of vertical import penetration is largely dominated by the contribution of existing imported inputs, although the new imported inputs display a positive and significant elasticity. However, note that the overall (positive) TFP growth effect of new imported inputs for French firms is driven by the positive correlation between a strong *reduction* in new imported inputs from the 'Other countries' group and the *negative* TFP growth rate. Indeed, in France the negative growth rate in the extensive margin of vertical import penetration is totally driven by an extraordinary drop of imported input lines coming from the least developing countries (−34%). By contrast, the growth of new input varieties is systematically positive when considering the other sources, such as New Member States (18.4%), OECDs (4.2%), Emerging (0.21%) or the EU-15 (1.47%).

In the case of Italy the econometric results show that, overall, what matters is the effect of new imported inputs, while the existing imported inputs display an insignificant negative effect on TFP growth. In particular, this is due to the contribution of the extensive margin growth coming from the EU-15 (4.6%), Emerging countries (5.9%) and New Member States (5.1%). Note moreover that the magnitude of the new imported inputs elasticity for Italian food firms is 2.5 times greater than that for French firms.

Table 7

Decomposition of vertical import penetration (IP) effects on firms TFP growth

	(1)		(2)	
Dependent variable: Log of TFP	Italy	France	Italy	France
Log Horizontal IP ($t-1$)	0.028*	0.007***	0.025*	0.020***
	(0.015)	(0.002)	(0.015)	(0.003)
Log Vertical IP ($t-1$)	0.062***	0.330***		
Due to:	(0.018)	(0.013)		
Existing imported inputs			−0.029	0.287***
			(0.022)	(0.014)
New imported inputs			0.066***	0.026**
			(0.018)	(0.013)
Firm FE	Yes		Yes	
Time FE	Yes		Yes	
Observations	129,454		129,454	
R^2	0.923		0.923	

Notes: The table reports the TFP growth effects of vertical import penetration split into its extensive (new imported inputs) and intensive (existing imported inputs) trade margins. The intensive margin is defined as the volume of imported inputs due to tariff lines always present in the considered period. The remaining trade volume is considered as the extensive margin, and thus it represents the net contribution of new and ceased imported varieties. Robust standard errors clustered at firm level under the coefficients; *, ** and *** indicate statistical significance at 10%, 5% and 1% level, respectively. ***Source*:** Figures based on data described in the text.

One way of interpreting these findings is that the adaptation of the food firms in the two countries to the new market conditions has been quite different. Contrary to French food firms, Italian ones have exploited the new opportunities offered by trade integration especially with the EU New Member States, by expanding their domestic product scope, exploiting the introduction of new imported varieties.

It is beyond our present scope to understand the different behaviour of Italian vs. French food firms. However, as noted above, differences in agricultural comparative advantage between France and Italy, exacerbated by the food price shocks and the trade collapse induced by the global crisis (see Curzi *et al*., 2013) could be at work here.

5. Discussion and Conclusions

Our results strongly support the idea that an increase in firms' exposure to international trade leads to a growth of firms' productivity. This view emerged from the recent theoretical models of international trade allowing for firm heterogeneity (e.g. Bernard *et al*., 2003; Melitz, 2003), and has been supported by a number of empirical studies, which have found that trade liberalisation in intermediate inputs significantly contributes to firm productivity growth, particularly in developing countries (Amiti and Konings, 2007; Kasahara and Rodrigue, 2008; Goldberg *et al*., 2010; Topalova and Khandelwal, 2011; Halpern *et al*., 2015).

By exploiting the US I–O table to measure a consistent index of vertical import penetration for the French and Italian food sectors, we contribute to the existing literature by showing that the productivity growth effect of upstream trade liberalisation holds true for the food industry, and is significantly greater than a similar effect induced by horizontal import competition. In particular, we find that trade liberalisation in intermediate inputs induces a productivity growth effect that is from three to five times stronger (depending on the specification) than import competition coming from the same industry. In addition, we find that *new* imported inputs are of particular importance, especially for Italian food firms, though less so for the French firms, where the effect of imported inputs seems to work mainly through the growth of the intensive trade margin. Furthermore, and consistent with theory, we also show that the magnitude of the TFP growth effect increases with the initial level of firms' productivity, meaning that not all imports affect all firms to the same extent.

These findings have important implications for the EU trade policy. If the objective of European institutions is to spur productivity growth in the food industry, further trade liberalisation, in particular in the upstream sectors, would be a potential valuable strategy.

Yet, in evaluating these policy implications some caveats are in order. This is because this article focused exclusively on the positive side effect of trade liberalisation as captured by TFP growth, disregarding the adjustment costs related to the possible employment effects. Indeed, the findings of asymmetric growth effects of trade liberalisation on firms of different size and productivity calls for a careful investigation of the employment effects. This could be done, for example, along the line of the recent literature that focused on the US labour markets (see Autor *et al*., 2013; Acemoglu *et al*., 2014), showing how import competition from China explains about one-quarter of the contemporaneous aggregate decline in US manufacturing employment.

Finally, our approach, in addition to the US I–O relations, is based on detailed trade and production information. Because similar data are normally available for many countries, a similar approach can be applied to study the effects of trade integration and imported inputs on other (developed) countries. Moreover, although our approach presents some advantages in comparison to the use of firm-level input trade data, the additional use of firm-level information may shed new light on the mechanisms at work, an issue which we only partially address. For example, by matching firm-level data with customs information on imported inputs and exported products, both by source and destination, our understanding of food firms' behaviour in the international markets could significantly increase.

Supporting Information

Additional Supporting Information may be found in the online version of this article:

Table S1. Descriptive statistics of TFP level at NACE 3-digit level.

Table S2. Horizontal and vertical import penetration at NACE 3-digit level.

References

Acemoglu, D., Johnson, S. and Mitton, T. 'Determinants of vertical integration: Financial development and contracting costs', *Journal of Finance*, Vol. 63, (2009) pp. 1251–1290.

Acemoglu, D., Autor, D., Dorn, D., Hanson, G. H. and Price, B. *Import Competition and the Great U.S. Employment Sag of the 2000s*, Working Paper No. 20395 (The National Bureau of Economic Research, 2014).

Aghion, P. and Howitt, P. *Endogenous Growth Theory* (Cambridge MA: MIT Press, 1998).

Aleksanyany, L. and Huiban, J.-P. *Economic and Financial Determinants of Firm Bankruptcy: Evidence from the French Food Industry*, Working Paper (Mimeo, 2014).

Altomonte, C., Barattieri, A. and Rungi, A. 'Import penetration, intermediate inputs and productivity: Evidence from Italian firms', *Rivista Italiana degli Economisti*, Vol. 19, (2014) pp. 45–66.

Amiti, M. and Konings, J. 'Trade liberalization, intermediate inputs and productivity: Evidence from Indonesia', *American Economic Review*, Vol. 97, (2007) pp. 1611–1638.

Arellano, M. and Bond, S. 'Some tests of specification for panel data: Monte Carlo evidence and application to employment equations', *Review of Economic Studies*, Vol. 58, (1991) pp. 227–297.

Autor, D. H., Dorn, G. and Hanson, G. H. 'The China Syndrome: Local labor market effects of import competition in the United States', *American Economic Review*, Vol. 103, (2013) pp. 2121–2168.

Backus, D. K., Kehoe, P. J. and Kehoe, T. J. 'In search of scale effects in trade and growth', *Journal of Economic Theory*, Vol. 58, (1992) pp. 377–409.

Bas, M. and Strauss-Kahn, V. 'Does importing more inputs raise exports? Firm level evidence from France', *Review of World Economics*, Vol. 150, (2013) pp. 241–275.

Bernard, A. B., Eaton, J., Jensen, J. B. and Kortum, S. S. 'Plants and productivity in international trade', *American Economic Review*, Vol. 93, (2003) pp. 1268–1290.

Bernard, A. B., Redding, S. J. and Schott, P. K. 'The empirics of firm heterogeneity and international trade', *Annual Review of Economics*, Vol. 4, (2012) pp. 283–313.

Biscourp, P. and Kramarz, F. 'Employment, skill structure and international trade: Firm-level evidence for France', *Journal of International Economics*, Vol. 72, (2007) pp. 22–51.

Blaum, J., Lelarge, C. and Peters, M. *The Gains from Input Trade in Firm-Based Models of Importing*, Working Paper No. 21504 (The National Bureau of Economic Research, 2014).

Chevassus-Lozza, E. and Latouche, K. 'Firms, markets and trade costs: Access of French exporters to European agri-food markets', *European Review of Agricultural Economics*, Vol. 79, (2012) pp. 257–288.

Chevassus-Lozza, E., Gaigné, C. and Le Mener, L. 'Does input trade liberalization boost downstream firms' exports? Theory and firm-level evidence', *Journal of International Economics*, Vol. 90, (2014) pp. 391–402.

Ciccone, A. and Papaioannou, E. *Estimating Cross-Industry Cross-Country Models Using Benchmark Industry Characteristics*, Working Paper No. 1235 (Universitat Pompeu Fabra, 2010).

Colantone, I. and Crinò, R. 'New imported inputs, new domestic products', *Journal of International Economics*, Vol. 92, (2014) pp. 147–165.

Colantone, I., Coucke, K. and Sleuwaegen, L. 'Low-cost import competition and firm exit: Evidence from the EU', *Industrial and Corporate Change*, Vol. 24, (2015) pp. 131–161.

Curzi, D. and Olper, A. 'Export behavior of Italian food firms: Does product quality matter?', *Food Policy*, Vol. 37, (2012) pp. 493–503.

Curzi, D., Pacca, L. and Olper, A. 'Trade collapse, quality and food exports', *Applied Economics Letters*, Vol. 20, (2013) pp. 1614–1617.

Curzi, D., Raimondi, V. and Olper, A. 'Quality upgrading, competition and trade policy: Evidence from the agri-food sector', *European Review of Agricultural Economics*, Vol. 42, (2015) pp. 239–267.

De Loecker, J. 'Product differentiation, multiproduct firms, and estimating the impact of trade liberalization on productivity', *Econometrica*, Vol. 79, (2011) pp. 1407–1451.

De Loecker, J. and Goldberg, P. 'Firm performance in a global market', *The Annual Review of Economics*, Vol. 6, (2014) pp. 201–227.

Feenstra, R. and Hanson, G. H. Foreign investment, outsourcing and relative wages, in R. C. Feenstra, G. M. Grossman and D. A. Irwin (eds.), *The Political Economy of Trade Policy: Papers in Honor of Jagdish Bhagwati* (Cambridge: MIT Press, 1996, pp. 89–127).

Goldberg, P. K., Khandelwal, A. K., Pavcnik, N. and Topalova, P. 'Imported intermediate inputs and domestic product growth: Evidence from India', *Quarterly Journal of Economics*, Vol. 125, (2010) pp. 1727–1767.

Griliches, Z. and Mairesse, J. *Production Functions: The Search for Identification*, Working Paper No. 5067 (The National Bureau of Economic Research, 1995).

Grossman, G. and Helpman, E. *Innovation and Growth in The Global Economy* (Cambridge, MA: MIT Press, 1991).

Gullstrand, J. 'Firm and destination-specific export costs: The case of the Swedish food sector', *Food Policy*, Vol. 36, (2011) pp. 204–213.

Halpern, L., Koren, M. and Szeidl, A. 'Imported inputs and productivity', *American Economic Review*, Vol. 105, (2015) pp. 3660–3703.

Italian Trade Agency (ITA), L'Italia nell'Economia Internazionale. Rapporto ICE 2013-2014, Istituto per il Commercio Estero, Roma, 2014.

Kasahara, H. and Rodrigue, J. 'Does the use of imported intermediates increase productivity? Plant-level evidence', *Journal of Development Economics*, Vol. 87, (2008) pp. 106–118.

Levchenko, A. A. 'Institutional quality and international trade', *Review of Economic Studies*, Vol. 74, (2007) pp. 791–819.

Levinsohn, J. and Petrin, A. 'Estimating production functions using inputs to control for unobservables', *Review of Economic Studies*, Vol. 70, (2003) pp. 317–342.

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

Melitz, M. J. and Ottaviano, G. I. P. 'Market size, trade, and productivity', *Review of Economic Studies*, Vol. 75, (2008) pp. 295–316.

Nunn, N. 'Relationship-specificity, incomplete contracts, and the pattern of trade', *Quarterly Journal of Economics*, Vol. 122, (2007) pp. 569–600.

Nunn, N. and Trefler, D. 'Domestic Institutions as a Source of Comparative Advantage' *in* G. Gopinath E. Helpman and K. Rogoff (eds.), *Handbook of International Economics: Vol. 4* (Amsterdam: Elsevier, 2014 pp. 263–315).

Olley, S. and Pakes, A. 'The dynamics of productivity in the telecommunications equipment industry', *Econometrica*, Vol. 64, (1996) pp. 1263–1298.

Olper, A., Pacca, L. and Curzi, D. 'Trade, import competition and productivity growth in the food industry', *Food Policy*, Vol. 49, (2014) pp. 71–83.

Rivera-Batiz, L. and Romer, P. 'International trade with endogenous technological change', *European Economic Review*, Vol. 35, (1991) pp. 971–1001.

Ruan, J. and Gopinath, M. 'Global productivity distribution and trade liberalization: Evidence from processed food industries', *European Review of Agricultural Economics*, Vol. 35, (2008) pp. 439–460.

Topalova, P. and Khandelwal, A. 'Trade liberalization and firm productivity: The case of India', *Review of Economics and Statistics*, Vol. 93, (2011) pp. 995–1009.