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Irish firms' productivity and imported inputs

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Abstract

In this paper, we empirically analyze the evolution of firms' productivity and how the efficiency changes with variations in the inputs' origin. Using firm-level information on a sample of Irish firms, we assess the importance of the imported inputs' quota for a firm's efficiency, as well as starting import activity. The main findings are that an increase in the intensive margin of imports raises firms' efficiency of domestic firms; in addition heterogeneous effects across firms are detected. Unlike the findings of most of the literature, there is weak evidence of self-selection in import activity; differently from previous research when we introduce fixed effects, the self-selection disappears. Instead, the few observed firms that start importing raise their productivity compared to non-importing firms; learning by importing is suspected. The results suggest an important policy implication: policies that favor the imports of intermediates enhance the productivity of domestic firms, making them more competitive in the international markets.

Keywords: firms' productivity, inputs, import, Ireland.

JEL Classification: F10, F14, D24, L25

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1 Introduction

In the last decade, by creating firm-level data-sets, trade economists have focused their attention on the causal relationship between trade activity and firms' efficiency; the well-established convention is that more efficient firms tend to self-select in international markets. The relation has been demonstrated both empirically (Roberts Tybout 1997; Bernard Jensen, 1999) and theoretically (Melitz, 2003; Melitz Ottaviano, 2007)[1]. In a similar framework, there is little evidence of learning-by-exporting effects[2] (i.e., export activity enhances firms' productivity). Instead more recently, firms' productivity has been put in relation with another internationalization activity: imports. Firms' decisions to use foreign inputs depend on the fact that imported inputs may show "better" characteristics compared to domestic ones; importing firms can exploit technology from abroad or use the higher quality of foreign inputs to raise their productivity (Castellani et al., 2009). Foreign inputs enhance firms' efficiency through different channels, such as learning, quality and variety. In addition, inputs with more features may need additional " internal abilities" of the firms, to use these inputs: all of these aspects have non-negligible effects on firms' efficiency. In particular, "import activity" is relevant for a small open economy such as Ireland, given that the domestic market for inputs may not provide enough "variety/quality" necessary for the production process, and at the same time the economy, being one of the most open among the developed countries (O'Toole, 2007), may suffer from the international competition.

The issue of efficiency has been widely analyzed, but productivity growth is a source of great concern for policy makers, the media and institutions. Given that productivity determines production, it is obvious that a trend of increasing national productivity brings as a consequence a positive growth rate for the gross domestic product (GDP): for example, Oliner and Sichel (2000) show that the outstanding performances in terms of GDP growth in the US during the second half of the 1990s were driven by the exceptional performance in productivity due to the introduction of IT technology in the industry. Closer to our case, there is the exceptional growth of Ireland between the 1990s and the beginning of new millennium; the great performances of Ireland are linked with an unusual growth in productivity for Europe. In Particular, the average Irish growth rate of productivity reached 2.6% per year, higher than the US (2.2%) and European (1.2%) growth rates (Sexton, 2006).

In addition, productivity and competitiveness are relevant for firms in the global

[1]Even if new findings are putting in a different lights the previous achievements, as in the case of multi-product firms.

[2]De Loecker, 2007

economy, especially in the face of competition from low-wage countries. As a result, policy makers are interested in sustaining firms' productivity to make them more competitive in the international markets.

Finally, greater efficiency makes a country more attractive as a destination for foreign investment; at the same time, foreign investment may have a positive impact on national efficiency levels (within and between sectors). The effects of FDI on efficiency are widely studied by economists (Coe Helpman, 1995; Smarzynska-Javorcik, 2003; O'Toole, 2007) even if there is not an unambiguous interpretation of spillover effects on productivity coming from FDI.

The present paper focuses on firms' importing activity, and it tries to contribute to the debate on firms' efficiency and the internationalization process[3]. The main contribution of the paper is the description of the empirical relation among the efficiency of firms located in Ireland and the use of foreign input. The central aim is to show that the variation in the intensity of imported inputs may have a positive effect on firms' productivity. More precisely, what we are going to estimate is both the effect due to an increase in the imports as well as the effect of starting imports. The productivity indicators used is not a measure of technical or physical efficiency as Olley-Pakes (1996) TFP, rather an indicator of nominal efficiency[4] (i.e. output per worker or labor output per worker).

The paper provides four main results. First, the most productive firms rely less on inputs purchased in the domestic market; as a result, as a firm's productivity increases, so does the consumption of foreign inputs (both services and material). Second, there is evidence that foreign inputs are a source of productivity growth unlike in other papers (Vogel and Wagner, 2009); the intensive margin of imports (relative amount imported) raises the productivity. Third, the response of efficiency to imports level is heterogeneous and it probably biases the average effect; Irish-owned firms, in manufacturing, benefit from a raise of imported goods, particularly if they are far away from the frontier, while foreign firms if close to the frontier. Fourth, there is weak evidence of self-selection whether we introduce in the analysis fixed effects, dynamics and we deal with the initial condition (Wooldridge, 2005); results provide weak evidence that past efficiency affects intensive margin of imports or import choice.

The paper is structured as follows. In the next section (Section 2), we briefly illustrate the past literature. Then in Section 3 we describe the data-set and its characteristics. In Section 4 we exploit the relation between efficiency and import intensity. In Section 5

[3] We will use efficiency and productivity as synonymous throughout the paper.

[4] These indicators are widely used as in Helpman et al.(2004) or Lileeva and Trefler (2009)

we perform robustness checks analysis. In Section 6 we describe learning by importing and we try to assess the existence of self-selection. The Section 7 concludes the paper with results and implications.

2 Past Literature

The relation between productivity and input origin has been recently explored in empirical analysis. Amiti and Konings(2008) find that reducing taxes on the imports of intermediates, Indonesian manufacturing firms' productivity increases; because the imported goods are used as inputs, a reduction of 10% percentage point in import tariff on average increases firms' productivity of 12% via learning, the variety effect and the quality effect. Using a data-set of Indonesian manufacturing firms with information about the composition of inputs, they can control the quantity (variety effect) and quality (quality effect) of imported goods used as inputs in the production process. High-quality inputs means an upgrade in quality and efficiency, while less costly inputs mean a cheaper final product (increasing competitiveness). The results are supported by Altomonte and Békés (2009); they show the existence of a "learning" effect due to the incorporation of foreign technology for a sample of Hungarian firms.

In a different paper, Kasahara and Lapham (2008) define a structural model where firms simultaneously choose to export goods and import intermediates[5]. They demonstrate that the restrictions on imports reduce the number of Chilean exporting firms; their estimations show that moving from a free-trade situation in intermediates to a no-trade situation the exporters percentage reduces from 17.2% to 12.4%. They suppose that cheaper and greater varieties of inputs increase the productivity of firms and consequently their capacity to compete on international markets. Vogel and Wagner (2009) find evidence of a positive effect of efficiency on importing activity (self-selection), whereas they do not find evidence of learning by importing. In contrast to their paper and that of Castellani et al.(2009), we do not find strong evidence of self-selection, but we illustrate the existence of benefits from increasing intensive margin of imports and some hints of learning by importing. Differently from the cited paper, we introduce the dynamics, fixed effects and we deal with the initial condition in a maximum likelihood estimation: the absence of self-selection can be partially caused by the employment of a different estimation technique. Secondly we perform additional analysis controlling for the existence of heterogeneous effects; we find that the average effect estimated is biased

[5]They modify the model of Melitz (2003) incorporating the imports of intermediates inputs and additional fixed costs.

by heterogeneous responses from importing.

Even if it is not possible to observe differences in quality among inputs,[6] an increasing variety of input used in the production process may have a positive effect on firm's efficiency. For example, Ethier(1982) demonstrates that a monopolistic competitive sector, which produces horizontally differentiated intermediate inputs for a unique consumption-good producer, causes the increase of downstream TFP with the expansion of intermediate varieties provided. Second, the potential competition in inputs market reduces prices and raises the competitiveness of firms which use intensively that inputs. Another interesting theoretical model is provided by Fugazza and Robert-Nicoud (2006). They demonstrate in a monopolistic competitive framework á la Dixit-Stigliz-Krugman, that trade liberalization in intermediate inputs decreases the productivity cut-off for the exporting activity, due to a cost reduction: when marginal cost shrinks because of cheaper input, a direct consequence is the increased competitiveness of domestic firms in all markets[7]. If importing raises productivity, this might induce firms to self-select in the export market.

Finally, it is reasonable to claim that any benefit in term of productivity may derive from MNEs and spillover effects. Ireland boosted its economic growth with foreign investment between the 1980s and 2000s. However, the evidence of positive spillovers due to FDI in the Irish economy is not straightforward. Few would doubt that the influx of FDI over the last two decades has been an important factor for Irish growth, not least because MNEs, due to their being on average more productive than domestic firms, contribute to greater productivity growth in the economy. However, there is little formal econometric evidence that links the presence of MNEs to productivity growth in domestic firms at the micro level. For example, Ruane and Ugur (2005) do not find evidence of spillovers on domestic firms' labour productivity. As long as the effects are accounted for at the sector level, it may reflect that spillovers vary substantially across a narrowly defined industry, and they cannot be detected by aggregating[8]. Gorg and Strobl (2003) present a different approach: due to the idea that spillovers raise productivity and consequently profitability, all other thing being equal, they test the effects of MNEs' presence on firms' probability of survival. They find that a multinational presence has a life-enhancing effect only on Irish firms that operate in high-technology sectors. In light of these facts, it seems relevant to investigate whether the imports of intermediates have

[6]We cannot observe quality from data, nor infer it.

[7]Moreover, if the domestic market offers cheaper and a large variety of inputs, there exists a potential aspect of attractiveness for foreign investments. As a result, input markets also affect productivity indirectly, attracting foreign capitals and knowledge.

[8]Also, Berry et al.(2005) did not find statistical evidence.

some impact on productivity growth.

3 Data Analysis

The data used come from the Annual Business Survey Economic Impact (ABSEI), and the data-set provides information for a large sample of anonymous firms that operated in Ireland from 2000 to 2006. The data-set includes both Irish and foreign-owned firms, and it covers twenty industrial sectors (manufacturing and services), according to the NACE two-digit classification. In Table A.1 in the Appendix, the composition of the data-set by sector composition and origin is provided. The majority of the observations include Irish firms; however, one quarter of the observations are related to foreign firms[9]. Foreign firms are concentrated in particular in Chemicals, Electronic and Software sectors. The Table 3.1 below shows some descriptive statistics at the sector level (Sector Nomenclature in the Appendix Table A.1).

Table 3.1: Descriptive statistics: Sector Averages‡

Nace	Revenues	Empl	YL	LabProd	RD	Train	Export	Ownership	Firms
10	9275.1	49.92	137.7	39.45	0.903	0.839	0.286	0.050	41
15	40445.0	139.6	241.6	52.08	1.499	1.292	0.375	0.105	620
17	5081.2	53.06	97.43	2.60	1.192	0.862	0.441	0.196	175
20	9520.7	64.60	121.1	31.93	1.530	1.180	0.354	0.051	111
22	6475.6	55.60	98.39	34.28	0.708	0.983	0.369	0.123	194
24	174391.3	158.0	549.1	194.76	2.013	1.901	0.480	0.561	259
25	6839.0	53.83	114.9	33.97	1.358	1.113	0.479	0.358	183
26	21242.9	136.9	105.5	33.56	1.050	0.998	0.324	0.151	133
27	6053.0	49.49	97.10	38.61	0.881	0.918	0.312	0.163	413
29	7243.5	56.61	108.1	38.83	1.663	1.224	0.472	0.208	272
30	93954.8	171.0	300.0	51.19	2.093	1.586	0.467	0.494	564
34	14545.7	139.2	126.2	32.07	1.583	1.481	0.490	0.418	79
36	3576.8	39.72	83.59	23.64	1.234	0.864	0.401	0.073	211
40	7019.6	72.83	106.3	20.37	0.780	0.997	0.282	0.295	65
45	26373.8	169.9	111.6	37.55	0.947	2.145	0.145	0.041	21
50	6841.5	35.10	350.4	177.59	0.644	0.722	0.300	0.119	262
65	71431.5	249.5	421.6	306.17	0.503	1.807	0.321	0.511	41
72	34033.4	66.47	191.5	88.06	1.775	1.045	0.328	0.306	929
73	1981.6	32.20	72.96	-101.62	1.394	0.81	0.239	0.114	51
74	9840.24	104.0	106.3	40.43	0.884	1.42	0.389	0.249	263
Total	37390.66	94.9668	200.3616	63.89596	1.430	1.189	0.381	0.254	4887

‡ Source: ABSEI Datset. Revenues: deflated value of revenues in Th of Euros. Empl: employment. YL: Output per worker. LabProd: value added per worker. R&D: expenditure in R&D in Th. of Euros per worker. Train: training expenditure in Th. of Euros per worker. Export: aggregate percentage of exporter. Ownership: percentage of foreign firms.

The data-set includes information about firms revenues, employment, wage expenses, material and service consumption, plus information on export status and expenditure in

[9] Forfás defines a plant as foreign owned if 50% or more of its shares are held by foreign owners.

R&D and training activities. The larger drawback of the data-set is the absence of any kind of information about capital stocks (tangible and intangible assets). It generates a methodological problem when firms efficiency has to be calculated. The absence of capital data will impede us from estimating productivity with any parametric or semi-parametric techniques as in Amiti and Konings (2007); as a result, productivity will be approximated with value added per worker[10] as in Helpman et al.(2004) and Lileeva-Trefler (2007).

In addition, the ABSEI data-set has a very important characteristic, because it includes firms that receive or demand financial support, in particular for R&D activity: firms asking any kind of support to the Enterprise Development Agency (IDA) in Ireland are required to fill a survey. It is thus not possible to assume that the sample is fully representative of the Irish economy, and it is not possible to ignore a process of self-selection in the data-set; it implies a "selection bias" so long as just "good" firms are included in the ABSEI survey[11]. This implies, in turn, that the final results will tell us which are the effects of foreign inputs on more "active" firms.

As it is possible to observe from the tables below, the firms in the sample show better performances on average. Table 3.2 and Table 3.3 illustrate efficiency growth rates (output and value added based) both for the ABSEI data-set and for the overall Irish economy (Source: EU-KLEMS)

Table 3.2: Average Growth (YL) 2001-2005‡

	YL Growth (pw) ABSEI			YL Growth (pw) EU-KLEMS
	Irish	Foreign	Total	Average
Agric.	0.026	0.259[a]	0.050	0.080
Manuf.	0.091	0.071	0.086	0.032
Services	0.301	0.134	0.252	0.089
Total	0.130	0.082	0.116	0.067

‡ Output per worker growth rates. Source: ABSEI Datset and our calculation from EU-KLEMS.
[a] Just one foreign firm in agricultural sector.

[10]Value added and revenues are deflated with sector-specific price deflators. A definition is provided in the Appendix. In Table B.3, the averages across sectors and ownership are reported

[11]The rate of response to the survey is around 60%. The very large firms are not included, i.e. firms with the 80% of market share, with market defined at Nace 3-digit level.

Table 3.3: Average Growth(LP) 2001-2005[‡]

	LP Growth(pw) ABSEI			LP Growth(pw) EU-KLEMS
	Irish	Foreign	Total	Average
Agric.	0.085	0.414^a	0.097	0.061
Manuf.	0.087	0.037	0.074	0.042
Services	0.084	0.061	0.057	0.081
Total	0.086	0.023	0.069	0.061

[‡] Value added per worker growth rates. Source: ABSEI Datset and our calculation from EU-KLEMS. .
[a] Just one foreign firm in agricultural sector.

The first three columns show the average productivity growth rates for the firms included in the data-set: productivity is measured both as output per worker (Tab. 3.2) and value added per worker (Tab. 3.3) with deflated values[12]. We can notice that in term of output per worker (YL) and labor productivity (VA), Irish firms in the sample grows more than the average (from EU-Klems); while manufacturing sector in data-set performs better than its average in whole economy. The gap between data-set and general growth rates widen if we consider output per worker as proxy of efficiency; however along the paper we will use labor productivity as dependent variable of our analysis. The motivation are two: labor productivity may give results closer to the real Irish economy, and as explained above, it is a more reliable and used proxy for nominal efficiency.

3.1 Import data

The paper is focused on the relationship among firms' efficiency and the origin of inputs. For this purpose, ABSEI data-set is useful because it provides information about the consumption of inputs divided by typology (services and raw materials) and also about firms' ownership (Irish and not Irish). The aim is to understand whether the introduction or the shares' variation of foreign inputs increases firms' efficiency; more precisely we are going to test the importance of importing and intensive margin of import (amount of imports) on firms' efficiency. Before we continue, it may be necessary remember that firm's efficiency is measured as value added per worker.

Regarding input use, the relevance of foreign input is assed with a ratio between the foreign input use and Irish input use: it can be considered as a measure of intensive margin for imports. Both data are reported by the data-set as values and they are

[12]Deflators are sector-specific and are collected from the EU-KLEMS data-set.

consequently deflated with a specific sector deflator, both for material and services. Then, three ratios are constructed, one of which considers aggregated inputs and other two consider material and services. The aggregated ratio as defined as follows:

$$Ratio_{it} = \frac{M(F)_{it} + S(F)_{it}}{M(I)_{it} + S(I)_{it}}, \tag{3.1}$$

where $M(j)_{it}$ and $S(j)_{it}$ are, respectively, the consumption of material and services by origin j (I=Irish; F=Foreign) for firm i at time t. Then same ratio is constructed for services($SRatio$) and material ($MRatio$)[13]. If the ratio increases, it means that firm i is more intensively using foreign inputs in the production process; the index will be equal to 0 if a firm does not import and it grows as import raises[14]. As robustness check we will use a different ratio (Section 5); we proxy the effect of foreign inputs with the share of imports on total amount of inputs used, and then we control for the total input consumption. In the Table 3.4 below, average ratios by sector are reported.

Table 3.4: Average input mix ratio

Sector	Ratio	SRatio	MRatio
Agriculture	0.443	0.136	0.851
Food Beverages & Tobacco	0.636	0.592	1.376
Textile Clothes Leather	3.637	0.741	10.01
Wood	1.040	0.289	1.916
Pulp Paper & Printing	1.414	0.123	4.757
Chemical	4.728	2.034	8.666
Rubber and Plastics	2.034	0.220	8.325
Non-Metallic Minerals	1.624	0.373	3.762
Basic Metal & Fabricated Metals	3.152	0.326	5.902
Machinery n.e.c.	1.651	0.351	4.942
Electrical and Optical Equipment	3.230	0.772	12.56
Transport Equipment	2.998	0.254	7.233
Manufacturing n.e.c.	1.165	0.229	4.007
Networks	1.435	0.742	9.560
Construction	1.061	0.133	2.123
All Other Services	63.98	63.84	2.748
Financial Intermediation	0.970	0.848	0.476
Computer and Related Activities	1.521	1.218	3.065
Research and Development	0.454	0.289	4.113
Other Business Activities	0.922	0.296	2.593
Total	4.844	3.529	5.647

[13]The inputs' import data are calculated as the difference among total input and Irish input

[14]When we take the logarithm of our index it will be calculated as Log(Ratio+1), in order to obtain a correspondence between zeros in the variable in level and its logarithmic transformation.

Clearly, the ratio is higher for material rather than for services, since it is easier to import goods rather than services; while material is tradable, services are more related with the place of provisions. However, manufacturing, the industry on which we will mainly focus, quite intensively uses imported inputs, such as textiles and chemical sectors. It is interesting to notice that the category "All Other Services" essentially uses imported inputs; within this sector, there are a large number of headquarters of multinationals, which are settled in Ireland because of lower corporate taxes.

More interesting are the next descriptive statistics concerning the manufacturing sector. Table 3.5 compares the average ratio (3.1) for total inputs and importer percentage across different class of individuals for the manufacturing sectors: exporter are more intensive importers compared to non exporters. It is interesting to note that foreign firms that do not export, import instead a large quota of inputs; probably here are included the headquarters of multinationals. Table 3.6 the efficiency levels for Irish and foreign firms in manufacturing are clustered in different classes; the rows report the export status (Domestic vs. Exporter), while the columns represent the import status (Non-Importer vs. Importers). The importers have, on average, a higher efficiency compared to non-importers; not surprisingly, exporters are also more efficient than domestic firms[15].

Table 3.5: Average ratio and importer percentage by export status and ownership (manufacturing)[‡].

Ownership \ Export		Domestic	Exporter	Total
Irish	Mean	0.99	1.36	1.27
	Import %	68.1	86.8	69.6
Foreign	Mean	8.84	4.76	4.99
	Import %	90.1	95.9	91.9
Total	Mean	1.63	2.44	2.29
	Import %	84.6	95.3	87.5

‡ Source: ABSEI Datset. Averages calculated across manufacturing sectors/year.

From Table 3.5, it seems that the differences in terms of input use are greater between foreign and Irish firms (4.99 vs 1.27) than between domestic firms and exporters (1.63 vs 2.44). Foreign firms are the ones that rely more intensively on the imports of intermediate goods (service and materials together), while domestic national firms use domestic inputs more, both in terms of intensity and in terms of participation in the import market.

[15]In the Appendix, the same tables for services are reported: Tab. B.1 and Tab. B.2

However, it is not possible to claim (and it is not among the paper's objectives) that the activity of exporting is forcing firms to expand the variety of inputs used (a learning by exporting process for input use) or whether importing encourage a process of self-section in the export market. In other words, we can infer only that foreign firms use foreign inputs more intensively than Irish firms, and not a causal relation or the optimal mix.

Table 3.6: Average Log(LP) by export status, importing status and ownership (manufacturing)[‡].

Export \ Import	Non-Importer	Importer	Total
	Aggegated		
Domestic	3.26	3.34	3.32
Exporter	3.45	3.55	3.54^a
Total	3.36	3.51^a	3.50
	Irish Firms		
Domestic	3.23	3.28	3.26
Exporter	3.30	3.70	3.31^a
Total	3.30	3.30^b	3.30
	Foreign Firms		
Domestic	3.42	3.94	3.89
Exporter	3.88	4.09	4.05^a
Total	3.84	4.09^a	4.08

[‡] Source: ABSEI Datset. Log of output per worker. In parenthesis the number of observation. Averages calculated across manufacturing sectors/year. In columns import status, in rows export status. With up-script are reported significance level of mean comparison: *a* means a difference significant at 5% confidence interval, *b* means a difference not statistically significant.

Since in next sections we will focus on the analysis of manufacturing sector, in Table 3.6 are reported the average efficiency level for manufactures. Fully international firms (both exporter and importers) are generally more efficient; unlike Vogel and Wagner (2009), the non-importing firms are here as productive as importing firms (at least for Irish firms). In the Table 3.6 are also reported a test on a difference among the means: so in both rows and columns named "Total" are provided test results for the statistical difference among the two mean (Importer versus exporter in the row, and exporter vs domestic in columns). In every case exporters are significantly more efficient than domestic firms. In an ideal ranking, the most efficient firms are the ones involved both in export and import, while the less efficient are the fully domestic firms.

Finally, it is worthwhile to observe the correlation table (Tab. 3.7). Variables Log(YL) and Log(LP) are, respectively, the log of output and value added divided by the number of workers. These are positively correlated both with the import dummy (equal to one if the firm imports; otherwise zero) and with the ratios (3.1), both aggregate and for services and materials. This may suggest that there at least exists a positive correlation between importing activity and efficiency, even if it is still too early to assert the direction of a causal relation.

Table 3.7: Correlation Table‡.

	Import	Ratio	Mratio	Sratio	Log(YL)	Log(LP)
Import	1					
Ratio	0.0462*	1				
Mratio	0.1627*	0.5423*	1			
Sratio	0.0481*	0.5049*	0.0711*	1		
Log(YL)	0.0945*	0.1179*	0.1329*	0.1991*	1	
Log(LP)	0.0899*	0.1025*	0.1436*	0.2104*	0.7167*	1

‡ Source: ABSEI Datset. Manufacturing sector. All significant at 1% confidence interval.

The next sections are devoted to exploiting the potential causal relation among import activity and firms' efficiency; more precisely, we are going to control whether the imported quota (intensive margin of import) affects productivity, focusing in particular on the group of Irish-owned manufacturers.

4 Import: Extensive Margin

This section is devoted to testing the consequences of variation in the imported goods on the efficiency of manufacturing firms; we are analyzing how productivity changes as the index (3.1) increases[16]. Variation in the import level may depend on three factors:

1. The price of imported input is lower given a certain level of quality.
2. The quality of foreign input is higher for a given price.
3. The mass of foreign input used in the production process increases because of increased complexity in production process.

[16] Alternatively, it is possible to measure the importance of foreign inputs with the simple consumption level. However, in this case, we always find a positive and statistically significant relation, due probably to simultaneity bias.

When the burden of foreign input increases, it is reasonable to assume that productivity changes because of variation in the quality or new technology embedded in the inputs (Castellani et al., 2009) or because a reduction in total cost. Usually importers are more productive, more active and employ more workers compared to non-importers; in Table 4.1 are reported the import premia for different variables[17].

Table 4.1: Import Premia‡

	Log(LP)_{it}	Log(YL)_{it}	Expo_{it}	Log(Labor)_{it}	$\text{Log(R\&D)}_{it}$
Import_{it}	0.179***	0.253***	1.934***	0.496***	0.944***
	(0.027)	(0.023)	(0.071)	(0.025)	(0.051)
Ownership_i	0.652***	0.680***	3.278***	1.113***	-0.417***
	(0.024)	(0.022)	(0.059)	(0.023)	(0.054)
Cons	3.358***	4.746***	2.689***	3.007***	0.792***
	(0.070)	(0.075)	(0.275)	(0.067)	(0.160)
Obs.	14520	16130	16635	16629	16635
R^2	0.130	0.193	0.277	0.231	0.137
Time Dummy	Yes	Yes	Yes	Yes	Yes
Sector Dummy	Yes	Yes	Yes	Yes	Yes

‡ OLS regression across all individuals in the data-set. Import: import dummy. Ownership: ownership dummy, equal one if firm is foreign owned. Expo: Export dummy Standard errors in brackets are robust. Significance level: *0.10>p-value ** 0.05>p-value*** 0.01>p-value.

We are going to assume that a firm's productivity takes the form

$$PROD_{it} = PROD_{it-1}^{\alpha} RATIO_{it-1}^{\beta} X_{it-1}^{\gamma} A_{it}. \tag{4.1}$$

Productivity is a function of its own past realization ($PROD_{it-1}$) and past values input mix[18] ($RATIO_{it-1}$) as defined in Eq. 3.1. In addition, some control variables(X_{it-1}) and a random error term ($A_{it} = \exp^{\varepsilon_{it}}$) are included. After taking the logs of (4.1), the estimated equation is

$$Prod_{it} = \alpha Prod_{it-1} + \beta Rat_{it-1} + \gamma x_{it-1} + \varepsilon_{it} \tag{4.2}$$

What we expect is a positive sign for the β coefficient; a positive and significant coefficient implies that if the intensive margin of import grows, a firm's productivity is expected to increase

First, we estimate equation 4.2 with OLS; the estimation method is very standard, but it gives us some interesting information; for example, whether there exists a statistical relation among the variables of interest. The coefficient β tells us how much

[17]It is interesting to notice that on average foreign firms have lower premia on R&D expenditure, probably caused by the data-set nature.

[18]We assume that it takes time to imported input for affecting productivity.

productivity is higher on average, as the ratio (Eq. 3.1) has increased in the past period. Some control variables are introduced; export dummy (*Expo*) defines the export status, while information on firms' R&D and training on workforce are captured either by dummies or by the log of expenditure. Finally, year fixed effects and sector dummies at Nace 2-Digit are included to control respectively for business cycle and sector characteristics. The results are shown in Table 4.2 and Log(LP) is the dependent variable.

Table 4.2: OLS Regression: Labor Productivity‡

VAR	(1) Aggr.	(2) Aggr.	(3) Manuf.	(4) Manuf.	(5) Manuf.	(6) Serv.	(7) Serv.	(8) Serv.
Log(LP)_{it-1}	0.730***	0.729***	0.726***	0.724***	0.711***	0.728***	0.727***	0.725***
	(0.012)	(0.012)	(0.014)	(0.014)	(0.015)	(0.021)	(0.021)	(0.021)
Log(Ratio)_{it-1}	0.083***	0.082***	0.077***	0.075***	0.071***	0.104***	0.104***	0.104***
	(0.011)	(0.011)	(0.012)	(0.012)	(0.012)	(0.024)	(0.024)	(0.024)
Expo_{it-1}	0.004	0.004	-0.001	-0.005	-0.028	0.020	0.025	0.006
	(0.016)	(0.017)	(0.018)	(0.018)	(0.018)	(0.035)	(0.036)	(0.036)
$\text{R\&D}_{it-1}$		-0.017		-0.019			-0.025	
		(0.014)		(0.015)			(0.030)	
Train_{it-1}		0.034**		0.055***			-0.020	
		(0.017)		(0.019)			(0.039)	
$\text{Log(R\&D)}_{it-1}$					-0.003			0.008
					(0.003)			(0.006)
Log(Train)_{it-1}					0.036***			0.017**
					(0.005)			(0.008)
Cons.	1.016***	1.006***	1.060***	1.052***	1.099***	1.011***	1.048***	0.961***
Obs	10410	10410	7602	7602	7602	2712	2712	2712
R^2	0.622	0.622	0.623	0.623	0.626	0.614	0.614	0.615
Time Dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sector Dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

‡ Standard errors in brackets are robust and clustered across individuals. Significance level: *0.10>p-value ** 0.05>p-value*** 0.01>p-value. Aggr: Aggregated industries. Manuf: Manufactures. Serv: services.

Looking at Table 4.2, it is possible to note that there exists a positive and statistically significant relation between the imported goods' burden and firm's efficiency. In other words, as imports increase by 1% (compared to domestic inputs), average firms' productivity will increase between 0.07% and 0.10% in the subsequent period.

The baseline equation confirms previous descriptive statistics; i.e., the more intensive importers are more productive than others. The relation does not vary across sector or in aggregate (Col 1 and 2) and the β is quite stable. The effect may depend on higher quality, on price, or on embedded technology. The underlying mechanism is potentially the same as that used by Amiti and Konings (2008). However, equation (4.2) may suffer from some problems. We may assume a different form for the error term ε_{it}, and it can be decomposed into a firm-specific error c_i plus an *i.i.d.* component ϵ_{it}. The presence of fixed effects (c_i) is necessary to avoid miss-specification problems, but it raises several estimations' issues.

4.1 Dynamic analysis

The estimation of Equation (4.2) may be problematic because of the presence of unobserved heterogeneity term c_i. First, the import index may be endogenous, i.e., correlated with the error term. The endogeneity is caused by a simultaneity problem[19] given that the most efficient firms may decide to use foreign inputs rather than domestic inputs, where this also follows from descriptive statistics (Table 3.6). Second, a firm's productivity is an autoregressive process, so long as the present firm efficiency can be explained with past values; the lagged values of dependent variable is endogenous, too. Finally, it is necessary to take into account a firm's heterogeneity, with unobserved effect c_i.

To conclude, many of the variables in the equation are likely to be jointly endogenous (simultaneity or to two-way causality with a dependent variable), and the presence of the lagged dependent variable can bias the estimated coefficient.

In order to deal with these three issues, Equation (4.2) is estimated employing a dynamic panel technique (Arellano and Bond, 1991; Blundell and Bond, 1998), more precisely the "difference GMM" estimator[20] is employed. This estimator first differences each of the variables in order to eliminate the firm-specific effects (c_i), and then uses lagged levels of the variables as instruments. A concern arises with this GMM estimator if there is no evidence of firm-specific effects; in this case, it is more efficient to estimate the equation in levels (using lagged levels as instruments) than in first differences. For this reason, the presence of firm-specific effects is tested, estimating Equation 4.2 with OLS; the existence of unobserved heterogeneity is confirmed by a test of first-order serial correlation in the residuals[21]. The estimated equation in difference is similar to (4.2), i.e.

$$\Delta Prod_{it} = \alpha \Delta Prod_{it-1} + \beta \Delta Rat_{it-1} + \gamma \Delta x_{it-1} + \Delta \epsilon_{it}. \tag{4.3}$$

Two critical assumptions have to be satisfied for this estimator to be consistent and efficient. First, the explanatory variables must be predetermined by at least one period (instruments uncorrelated with the error). Second, the error terms cannot be serially

[19] The same issue exists for export status, as the most productive firms self-select in the export market (Bernard et al., 1999).

[20] The "system GMM" estimator is not appropriate to this case for several reasons. First, the lagged dependent variable is not a random-walk process ($\alpha < 1$). Second, the additional initial condition assumption stated by Blundell Bond (1998) is not satisfied with proper tests; the lagged differences are not valid instruments for level equations.

[21] An alternative approach is to estimate the model in levels with firm-dummy variables and then test for the joint significance of the firm-dummy variables. If the dummies are jointly significant, this is an indicator of unobserved firm heterogeneity.

correlated. More specifically, if $\mathbf{X}'_{it}$ is the vector of explanatory variables in Equation (4.3) and ϵ_{it} is the error term, then the three conditions are

$$E\left(\mathbf{X}'_{it}\Delta\epsilon_{is}\right) = 0 \text{ for all } s > t, \tag{4.4}$$

$$E\left(\mathbf{X}'_{it}\Delta\epsilon_{is}\right) = 0 \text{ for all } s \geq t \tag{4.5}$$

$$E\left(\Delta\epsilon'_{it}\Delta\epsilon_{i,t-s}\right) = 0 \text{ for all } s \geq 1 \text{ and} \tag{4.6}$$

These conditions enable the instrumentation of the variables in differences using the lagged values of levels. In this specific case, $Prod_{it-1}$ and Rat_{it-1} are considered to be endogenous, while the control variables predetermined. The first two assumptions (4.4) and (4.5) define respectively the orthogonality (validity) conditions for instrumenting purely endogenous and predetermined variables. [22] In the literature, two tests are used to control the accuracy of the estimator. The first one is the Sargan-Hansen test of over-identifying restrictions, which tests the null hypothesis of no-correlation between the instruments and the residuals (Eq.(4.4)) and (Eq.(4.5)). The second is a test for different-order serial correlation in the residuals. If this test rejects the null hypothesis (i.e. no second-order serial correlation), higher order serial correlation is detected in the error term .

We have two final remarks to make regarding the estimation techniques. First of all, the differences are calculated as "first differences" and not as orthogonal deviations (Arellano Bover, 1995): in this latter case, at the observation in time t, the mean of observation from year $t + 1$ onwards is subtracted. In this case, we lose the last year of observation but minimize the missing values in the case of no observations between two consecutive years; however, the results are also robust to transformations. Secondly, the results do not change when using a two-step estimator correcting for heterorskedasticity[23].

The estimated coefficients are shown in Table 4.3. It can be noted that the relation remains statistically significant only for manufacturing sector case (Col 2, 3, and 4) and the coefficient remains stable; then Table 4.3 shows that an increase of 1% in the import intensity generates an average increase of 0.14% in the efficiency of manufacturing firms. The other coefficients are not significant with the exclusion of lagged dependent variable:

[22] All lags are used as instruments in all the regressions. For more practical details, see Roodman (2006).

[23] Table upon request.

however export dummy maintains the expected sign (export premia) for manufacturing firms[24].

Table 4.3: Difference-GMM: Labor Productivity‡

	(1) Aggr.	(2) Manuf.	(3) Manuf.	(4) Manuf.	(5) Serv.	(6) Serv.	(7) Serv.
$Log(LP)_{it-1}$	0.243***	0.214***	0.202***	0.207***	0.262***	0.252***	0.247***
	(0.032)	(0.038)	(0.037)	(0.037)	(0.055)	(0.053)	(0.053)
$Log(Ratio)_{it-1}$	0.060	0.149**	0.145**	0.149**	-0.011	-0.026	-0.014
	(0.048)	(0.060)	(0.059)	(0.059)	(0.059)	(0.056)	(0.058)
$Expo_{it-1}$	0.015	0.085	0.057	0.102	-0.109	-0.120	-0.094
	(0.101)	(0.124)	(0.122)	(0.122)	(0.163)	(0.160)	(0.158)
$R\&D_{it-1}$				-0.055			-0.143
				(0.071)			(0.148)
$Train_{it-1}$				0.001			0.002
				(0.060)			(0.137)
$Log(R\&D)_{it-1}$			-0.009			-0.009	
			(0.021)			(0.032)	
$Log(Train)_{it-1}$			0.042			0.062	
			(0.026)			(0.045)	
Obs.	7223	5378	5378	5378	1784	1784	1784
Firms	2264	1625	1625	1625	616	616	616
Instr.	50	50	80	80	50	80	80
Hansen Test	0.511	0.475	0.534	0.146	0.615	0.764	0.637
AR2 Test	0.112	0.173	0.240	0.188	0.828	0.954	0.818

‡ Dynamic panel-data estimation, Difference GMM. For Hansen Test and AR2 Test P-Values are shown. Aggr: Aggregated industries. Manuf: Manufactures. Serv: services. Significance level: *0.10>p-value ** 0.05>p-value*** 0.01>p-value. Year dummies included

Next we perform an additional experiment. Given that the relation is significant only for manufacturing sector we go deeper in its analysis: more precisely we split the sample of manufacturing firms across Irish owned and foreign owned firms. The results are shown in Table 4.4. The coefficient of Ratio (Eq. 3.1) is significant both in aggregate and for Irish firms; in comparison with Table 4.3 the magnitude of coefficient does not change, suggesting us that the statistical relation is driven on average by national firms[25]. It seems that Irish firms become more productive as they are more intensive importers.

[24] The evaluation of export in services may be misleading (Lipsey, (2006).

[25] We will see in Section 5 that the relation is more complex according to initial level of efficiency.

Table 4.4: Difference-GMM: Labor Productivity in Manufactures‡

	(1) Irish	(2) Irish	(3) Irish	(4) Foreign	(5) Foreign	(6) Foreign
Log(LP)_{it-1}	0.159***	0.154***	0.154***	0.198**	0.149*	0.165**
	(0.037)	(0.037)	(0.037)	(0.082)	(0.079)	(0.080)
Log(Ratio)_{it-1}	0.135**	0.136**	0.140**	0.018	0.022	0.019
	(0.066)	(0.065)	(0.065)	(0.087)	(0.087)	(0.085)
Expo_{it-1}	0.082	0.089	0.104	-0.138	-0.182	-0.168
	(0.123)	(0.121)	(0.121)	(0.480)	(0.489)	(0.443)
$\text{R\&D}_{it-1}$			-0.058			-0.035
			(0.076)			(0.140)
Train_{it-1}			-0.044			0.069
			(0.059)			(0.221)
$\text{Log(R\&D)}_{it-1}$		-0.011			-0.011	
		(0.024)			(0.031)	
Log(Train)_{it-1}		-0.002			0.062	
		(0.024)			(0.061)	
Obs	3845	3845	3845	1533	1533	1533
Firms	1187	1187	1187	438	438	438
Instr.	50	80	80	50	80	80
Hansen Test	0.590	0.747	0.257	0.232	0.339	0.268
AR2 Test	0.223	0.231	0.211	0.830	0.573	0.665

‡ Dynamic panel-data estimation, Difference GMM. For Hansen Test and AR2 Test P-Values are shown. Aggr: Irish and Foreign firms. Significance level: *0.10>p-value ** 0.05>p-value*** 0.01>p-value. Year dummies included

A third exercise consists in adding non linearities in the estimation of Eq. (4.3) with the introduction of a quadratic term for Ratio index: the idea is to control for potential non linear effects arising from imports. We can hypothesize that there exists an optimal input mix among foreign and domestic inputs, that maximizes the level of productivity growth; then if the imports' intensity reaches a certain threshold the positive effect from an additional imported input turns to be negative. The results are in Table 4.5. We can note that the quadratic term (Ratio^2) changes sign compared with its value in level; both variables are statistically significant, again in the group of manufacturing firms. If we calculate an hypothetical threshold we obtain a value for variable Ratio by around 8.10; it means that when import intensity passes this threshold, any further expansion in the import reduces efficiency, on average for manufacturing firms. However we can notice from Table 3.4 that in any case the average value of Ratio is below the threshold, in manufacturing sectors.

Table 4.5: Difference-GMM: Labor Productivity - Quadratic Term‡

	(1) Aggr.	(2) Manuf.	(3) Manuf.	(4) Manuf.	(5) Serv.	(6) Serv.	(7) Serv.
Log(LP)_{it-1}	0.231***	0.205***	0.195***	0.200***	0.245***	0.238***	0.235***
	(0.032)	(0.039)	(0.039)	(0.039)	(0.053)	(0.051)	(0.051)
Log(Ratio)_{it-1}	0.046	0.229***	0.214***	0.231***	-0.144	-0.153	-0.117
	(0.071)	(0.083)	(0.081)	(0.081)	(0.134)	(0.130)	(0.133)
$\text{Log(Ratio)}^2_{it-1}$	-0.002	-0.028**	-0.025*	-0.028**	0.012	0.012	0.010
	(0.006)	(0.014)	(0.014)	(0.014)	(0.010)	(0.010)	(0.010)
Expo_{it-1}	-0.001	0.087	0.069	0.113	-0.107	-0.113	-0.089
	(0.100)	(0.124)	(0.122)	(0.121)	(0.163)	(0.160)	(0.157)
$\text{R\&D}_{it-1}$				-0.041			-0.138
				(0.071)			(0.147)
Train_{it-1}				0.002			-0.012
				(0.059)			(0.132)
$\text{Log(R\&D)}_{it-1}$			-0.002			-0.011	
			(0.021)			(0.032)	
Log(Train)_{it-1}			0.041			0.046	
			(0.026)			(0.043)	
Obs.	7223	5378	5378	5378	1784	1784	1784
Firms	2264	1625	1625	1625	616	616	616
Instr.	65	65	95	95	65	95	95
Hansen Test	0.464	0.611	0.608	0.197	0.798	0.896	0.829
AR2 Test	0.142	0.217	0.296	0.233	0.781	0.860	0.788

‡ Dynamic panel-data estimation, Difference GMM. For Hansen Test and AR2 Test P-Values are shown. Aggr: Aggregated industries. Manuf: Manufactures. Serv: services. Significance level: *0.10>p-value ** 0.05>p-value*** 0.01>p-value. Year dummies included

4.2 Material and Service Import

This small section is devoted to try to understand which among the import of material or services is more relevant for the efficiency growth. Now the variable of interest, as defined in Eq. (3.1), is decomposed in two parts, one for material (MRatio) and one for services (SRatio) import intensity. The analysis is quite naive because it does not consider any kind of substitution or complementarity effect among the two inputs (it is over the paper's objectives) but it gives interesting intuitions. First of all we estimate Eq. (4.2) with an OLS and the results are reported in Table 4.6.

From the estimations it seems that the import of services is more important than the import of raw materials in determining the level of future productivity, in particular in service sector. An increase of 1% in the import of services increases productivity from 0.1% for manufacture to 0.25% for service sector. This may be explained by the importance of services for firms' efficiency (Forlani, 2008); however it is necessary to have in mind that the import of services is more problematic than the import of goods (Lipsey, 2006). The effect may also depend on the presence of MNEs, which are, on average, more productive and are used to importing services from affiliates abroad. Finally if we exclude mutually SRatio or MRatio, both are positive and significant; this can suggest multicollinearity, even if correlation is not detected. The idea of multicollinearity is partially supported by the introduction of an interaction term to control for a substitution effect among the inputs: the significance disappears[26]. When we control for the endogeneity and the dynamics we obtain slightly different results (Table 4.7). The significance as usual remains for manufacturing sector but SRatio is no more relevant while material import intensity stays weakly significant. Then it seems that part of relation may be explained by the import of materials, even if as we suggest before, we are abstracting from substitution or complementarity.

Table 4.6: OLS Regression: Material and Service Ratio‡

	(1) Aggr.	(2) Aggr.	(3) Manuf.	(4) Manuf.	(5) Manuf.	(6) Serv.	(7) Serv.	(8) Serv.
Log(LP)_{it-1}	0.742***	0.741***	0.743***	0.742***	0.730***	0.720***	0.720***	0.714***
	(0.015)	(0.015)	(0.016)	(0.016)	(0.017)	(0.037)	(0.037)	(0.038)
$\text{Log(MRatio)}_{it-1}$	0.016**	0.015**	0.022***	0.021***	0.019**	-0.027	-0.027	-0.031
	(0.007)	(0.007)	(0.008)	(0.008)	(0.008)	(0.024)	(0.024)	(0.024)
$\text{Log(SRatio)}_{it-1}$	0.124***	0.123***	0.096***	0.096***	0.088***	0.234***	0.235***	0.233***
	(0.022)	(0.022)	(0.023)	(0.023)	(0.023)	(0.054)	(0.055)	(0.054)
Expo_{it-1}	-0.005	-0.005	-0.012	-0.013	-0.034	0.055	0.057	0.036
	(0.020)	(0.020)	(0.020)	(0.021)	(0.020)	(0.062)	(0.065)	(0.063)
$\text{R\&D}_{it-1}$		-0.013		-0.012			0.004	
		(0.016)		(0.017)			(0.048)	
Train_{it-1}		0.019		0.029			-0.021	
		(0.021)		(0.022)			(0.063)	
$\text{Log(R\&D)}_{it-1}$					-0.003			0.011
					(0.004)			(0.009)
Log(Train)_{it-1}					0.030***			0.018
					(0.006)			(0.015)
Cons.	0.949***	0.940***	0.981***	0.965***	1.010***	1.202***	1.218***	1.127***
	(0.084)	(0.085)	(0.204)	(0.204)	(0.206)	(0.186)	(0.192)	(0.182)
Obs.	6984	6984	5797	5797	5797	1115	1115	1115
R^2	0.624	0.624	0.635	0.635	0.637	0.586	0.586	0.588
Time Dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sector Dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

‡ Standard errors in brackets are robust and clustered across individuals. Significance level: *0.10>p-value ** 0.05>p-value*** 0.01>p-value. Aggr: Aggregated industries. Manuf: Manufactures. Serv: services.

[26] Results upon request.

Table 4.7: Difference-GMM: Material and Service Ratio‡

	(1) Aggr.	(2) Manuf.	(3) Manuf.	(4) Manuf.	(5) Serv.	(6) Serv.	(7) Serv.
Log(LP)_{it-1}	0.184***	0.223***	0.210***	0.215***	0.012	-0.007	0.012
	(0.039)	(0.043)	(0.042)	(0.042)	(0.081)	(0.075)	(0.076)
$\text{Log(MRatio)}_{it-1}$	0.113**	0.111*	0.100*	0.110*	0.300	0.211	0.192
	(0.057)	(0.059)	(0.057)	(0.057)	(0.201)	(0.173)	(0.164)
$\text{Log(SRatio)}_{it-1}$	-0.029	0.095	0.088	0.075	-0.518	-0.413	-0.393
	(0.085)	(0.082)	(0.082)	(0.081)	(0.368)	(0.278)	(0.254)
Expo_{it-1}	-0.059	-0.014	-0.064	0.006	-0.086	-0.074	0.005
	(0.133)	(0.150)	(0.147)	(0.148)	(0.215)	(0.212)	(0.221)
$\text{R\&D}_{it-1}$				0.020			-0.005
				(0.091)			(0.238)
Train_{it-1}				-0.057			-0.106
				(0.071)			(0.177)
$\text{Log(R\&D)}_{it-1}$			0.011			0.029	
			(0.025)			(0.050)	
Log(Train)_{it-1}			0.017			0.137**	
			(0.029)			(0.061)	
Obs.	4627	3922	3922	3922	661	661	661
Firms	1641	1358	1358	1358	265	265	265
Instr.	52	52	80	80	52	80	80
Hansen Test	0.505	0.716	0.806	0.413	0.527	0.870	0.780
AR2 Test	0.246	0.246	0.295	0.278	0.974	0.760	0.930

‡ Dynamic panel-data estimation, Difference GMM. For Hansen Test and AR2 Test P-Values are shown. Aggr: Aggregated industries. Manuf: Manufactures. Serv: services. Significance level: *0.10>p-value ** 0.05>p-value*** 0.01>p-value. Year dummies included

5 Robustness Checks

This section is devoted to robustness checks analysis. In a first part we estimate equation (4.3) again, but with a different specification. In the second part we test whether the efficiency's response from variations in import intensity is heterogeneous across firms, according to their distance from the efficient frontier.

5.1 Import Intensity Ratio

In order to assess the importance of imported goods on efficiency we use as variable of interest an index of import intensity as defined in Eq. (3.1). We can define an alternative ratio as follow

$$ImpRatio_{it} = \frac{M(F)_{it} + S(F)_{it}}{M(T)_{it} + S(T)_{it}}, \tag{5.1}$$

where $M(T)_{it}$ and $S(T)_{it}$ are, respectively, the total consumption of material and services for firm i at time t. In this case the ratio will be defined between 0 and 1, where zero is a situation of no importing and one is the case of only imported inputs. With this ratio we try to capture the scale effect due to firms' size, using the total amount of input employed in production $(M(T) + S(T))$; differently the index (3.1) does not allow us to control for scale effect, because it just considers the substitution among foreign and domestic input. Then we plug *ImpRatio* (5.1) in Eq. (4.3), but it is not enough[27]; the new index can be highly correlated with the dependent variable. If the total input consumption increases, output and cost increase too; according to the definition of labor productivity (Appendix A) we may not be able to disentangle the effect due to import intensity from the variation in firms' dimension. Then we introduce as additional variable the log of total input consumption ($Log(Input)$) The results are reported in Table 5.1, just for manufacturing sector.

Table 5.1: Difference-GMM: Labor Productivity - Scale Effect‡

	(1) Aggr.	(2) Irish	(3) Irish	(4) Irish	(5) Foreign	(6) Foreign	(7) Foreign
$Log(LProd)_{it-1}$	0.243***	0.185***	0.184***	0.183***	0.206***	0.174**	0.166**
	(0.040)	(0.040)	(0.040)	(0.040)	(0.080)	(0.077)	(0.076)
$Log(ImpRatio)_{it-1}$	0.449**	0.381*	0.376*	0.411**	0.377	0.415	0.468
	(0.194)	(0.207)	(0.205)	(0.205)	(0.354)	(0.345)	(0.344)
$Log(Input)_{it-1}$	0.158***	0.076*	0.084**	0.089**	0.163**	0.122**	0.107*
	(0.053)	(0.043)	(0.038)	(0.040)	(0.075)	(0.058)	(0.060)
$Expo_{it-1}$	-0.005	0.093	0.095	0.091	-0.576	-0.407	-0.506
	(0.128)	(0.124)	(0.122)	(0.123)	(0.442)	(0.449)	(0.443)
$R\&D_{it-1}$				-0.062			-0.024
				(0.077)			(0.146)
$Train_{it-1}$				-0.039			-0.055
				(0.058)			(0.193)
$Log(R\&D)_{it-1}$			-0.005			-0.005	
			(0.024)			(0.033)	
$Log(Train)_{it-1}$			-0.005			0.059	
			(0.022)			(0.046)	
Obs	5404	3864	3864	3864	1540	1540	1540
Firm	1627	1188	1188	1188	439	439	439
Instr	65	65	95	95	65	95	95
Hansen Test	0.403	0.400	0.647	0.162	0.534	0.435	0.488
AR2 Test	0.297	0.253	0.265	0.249	0.909	0.717	0.667

‡ Dynamic panel-data estimation, Difference GMM. For Hansen Test and AR2 Test P-Values are shown. Aggr: Irish and Foreign manufacturing firms. Significance level: *0.10>p-value ** 0.05>p-value*** 0.01>p-value. Year dummies included

The estimations' results confirm the importance of import intensity for the efficiency of manufacturing firms. The positive sign remains, even if less significant, also when we control for the firms' size ($Log(Input)$); moreover the estimations tell us that input's consumption is statistically (positively) correlated even in the case of foreign firms, and it confirms the goodness of our specification.

[27]Similarly to *Ratio* (3.1) the new index is used with logarithmic transformation.

5.2 Distance from the frontier

Now we continue our analysis, going deeper in the relation between efficiency and import intensity. We can hypothesize that firms benefit differently from importing; more precisely we want to test if the benefit from importing is stronger for less efficient firms (in manufacturing sector). To get at this idea, we introduce firm heterogeneity within manufacturing firms (aggregated and by ownership), in terms of their initial distance from the efficient frontier.

Then we construct an "initial distance" variable for each firm i as the ratio of firm's efficiency (LP) over the labor productivity frontier in the initial year of our sample (year 2000). The frontier is defined by the firm with the highest productivity in the same NACE 3-digit sector j:

$$Dist_{ij2000} = \left(\frac{(LP)_{ij2000}}{max(LP)_{j2000}} \right). \tag{5.2}$$

where LP is value added per worker and $max(LP)_{j2000}$ is the maximum level of efficiency in sector j in year 2000. The variable $Dist$ is defined between 0 and 1, and it assumes negative values with logarithmic transformation; then zero will indicate the most efficient firm, and high negative values refer to "laggard" firms in comparison with frontier firm.

The $Dist$ in log is then interacted with the import intensity ratio (3.1) in order to capture the effect of importing activity, conditional on the initial value of efficiency. A similar approach is followed by Konings and Vandenbussche (2008) to estimate the effect of antidumping protection on firms' efficiency. Then equation (4.3) is estimated as usual with difference GMM estimator. In Table 5.2 are provided the results for manufacturing sector. Two important solutions are taken to improve the robustness. The sample is reduced, eliminating year 2000 from the regression: in this way we do not consider information from year 2000 (instruments or regressors) that may be correlated with distance term. Second we use a balanced panel in order to follow firms in the evolution of their productivity from 2001 to 2006.

Table 5.2: Distance effect: Manufacturing Sector‡

	(1) Irish	(2) Irish	(3) Irish	(4) For.	(5) For.	(6) For.	(7) ID	(8) FD
$Log(LProd)_{it-1}$	0.223***	0.202***	0.212***	0.303***	0.279***	0.270***	0.223***	0.313***
	(0.063)	(0.062)	(0.062)	(0.097)	(0.093)	(0.096)	(0.062)	(0.098)
$Log(Ratio)_{it-1}$	-0.281	-0.169	-0.262	0.508**	0.586***	0.509**	-0.163	0.322*
	(0.259)	(0.253)	(0.233)	(0.236)	(0.221)	(0.222)	(0.106)	(0.165)
$Dist00{*}Ratio_{it-1}$	-0.149	-0.101	-0.149	0.210*	0.232**	0.209*		
	(0.133)	(0.129)	(0.121)	(0.123)	(0.112)	(0.118)		
$Dummy{*}Ratio_{it-1}$							0.315*	-0.615**
							(0.187)	(0.298)
$Expo_{it-1}$	0.014	-0.037	0.007	-0.391	-0.348	-0.568	0.014	-0.464
	(0.151)	(0.146)	(0.153)	(0.312)	(0.320)	(0.368)	(0.149)	(0.331)
$R\&D_{it-1}$			0.073			-0.012		
			(0.090)			(0.162)		
$Train_{it-1}$			-0.093			0.209		
			(0.064)			(0.185)		
$Log(R\&D)_{it-1}$		0.007			-0.025			
		(0.024)			(0.038)			
$Log(Train)_{it-1}$		-0.037			0.013			
		(0.027)			(0.071)			
Obs.	1712	1712	1712	796	796	796	1712	796
Firms	428	428	428	199	199	199	428	199
Instr	44	64	64	44	64	64	44	44
Hansen Test	0.258	0.413	0.386	0.197	0.172	0.237	0.128	0.159
AR2 TEst	0.4903	0.594	0.539	0.834	0.904	0.902	0.416	0.879

‡ Dynamic panel-data estimation, Difference GMM. For Hansen Test and AR2 Test P-Values are shown. For: foreign firms. ID: irish firms dummy threshold. FD: foreign firms dummy threshold. $Dummy * Ratio$: interaction between threshold dummy and Ratio. Significance level: *0.10>p-value ** 0.05>p-value*** 0.01>p-value. Year dummies included

Focusing from column 1 to column 3 we do not detect any statical effect from distance: however the sign of coefficients is the expected one. Taking in mind that distance is in log (0 defines frontier firm) we can infer that as a firm is "laggard", larger (and positive) will be the effect coming from an increase in import intensity. In addition we yet know that Irish firms are generally less productive than foreign firms. To which concern foreign firms we find a statistically significant relation but with an opposite intuition: in this case the positive effect from importing raises as a firm is more efficient. On average, as distance decreases ($Dist$ is closer to 0), the positive coefficient of $Dist00{*}Ratio$ magnifies the estimated benefit from a positive variation in import intensity.

Then it is interesting to calculate for Irish and Foreign firms a threshold for distance, i.e. a level of $Dist$ (5.2) above which the effect of import intensity starts be negative (Irish firms) or positive (foreign firms). If we consider results in column 2 and column 5, the thresholds are respectively -1.673 and -2.526; for example if a foreign firm has an initial distance above -2.526, the impact of an increase in input intensity is more positive. To confirm this findings we create two dummies (one for Irish one for foreign) equal to 1 when a firm has the initial distance above the threshold, otherwise zero; then we create $Dummy * Ratio$ variable that is the interaction term. In the last two columns are shown the results. As expected, in the case of Irish firms (column 7) the coefficient is now statistically positive only for laggard firms, while in case of foreigners positive variations in the import intensity improve the efficiency of individuals closer to the frontier.

Now we focus on the statistically significant case of foreign firms. In a previous table (Tab. 4.4) the coefficient for foreign manufactures was not significant. Now we can suppose that the effect was canceled out, because we were taking an average effect across heterogeneous firms, in an unbalanced panel. Given that the median value for distance is -1.7213 in the sample of foreign firms used in Table 5.2, we can suppose that large part of foreign plants gain. A similar reasoning can be done for Irish manufactures: in (Tab. 4.4) the positive effect due to import intensity was driven by "laggard firms".

Finally this suggests that the distribution of productivity in an industry is skewed on the right (closer to zero) for foreign owned firms and skewed on the left for the Irish ones (independently on their export status): in other word Irish firms are on average less efficient than foreign firms (Table B.3). This can be seen from Fig. 5.1 where we plot the kernel density for foreign firms as a function of their log of initial distance on the horizontal axis. If we weight initial distance by employment level the distribution is more skewed on the right (i.e. closer to frontier).

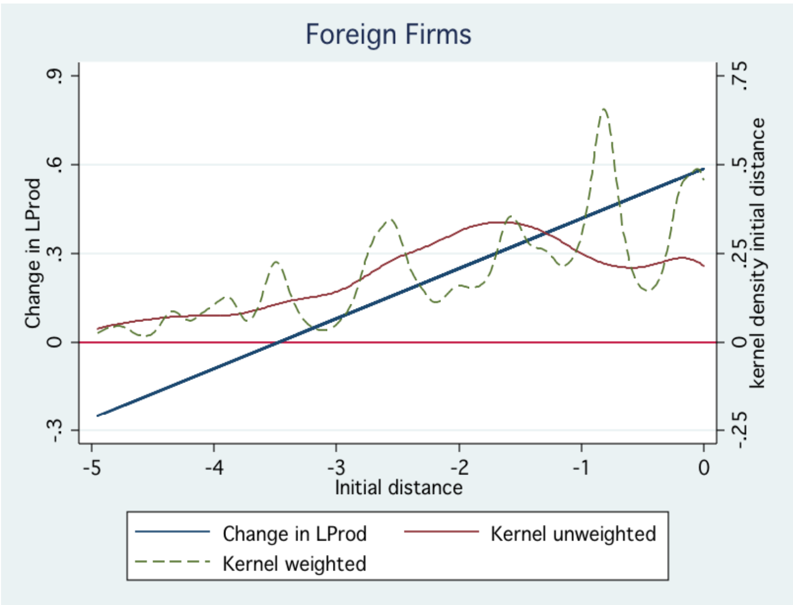


Figure 5.1: The surface under kernel density indicates the mass of foreign firms with a particular initial level of labor productivity. In the left vertical axis are reported the changes in labor productivity are base on the estimated coefficients in column 5 from Tab. 5.2.

6 Learning by importing or self-selection?

6.1 Graphical Analysis

As discussed in the introduction, the import activity can boost by itself a firm's efficiency. In this section we try to test the existence of a learning by importing effect, at least in a naive way. Similarly to learning by exporting (De Loecker, 2007), the hypothesis of learning by importing claims that the simple introduction of imported goods matters; in other words we are asking what happens after that a firm decides to import. From previous sections, we know that importers are, on average, more productive than non-importers, but we do not know whether this decision boosts productivity. In order to verify whether importing causes growth in productivity, we use graphical analysis rather than econometric techniques. The motivation is that just a few firms change their importing behavior in the data-set; only 32 firms out of 4887 decide to begin importing activity, across all sectors/year; a large part of them (25) are concentrated in the year 2002 (12) and 2003(13). Table 6.1 is the import choice's transitional matrix for a group of sectors: the first two columns report the number of firms beginning to import in 2002 and 2003 and in the last column, the continuous non-importers are reported for each sector.

Table 6.1: Importers: transitional matrix

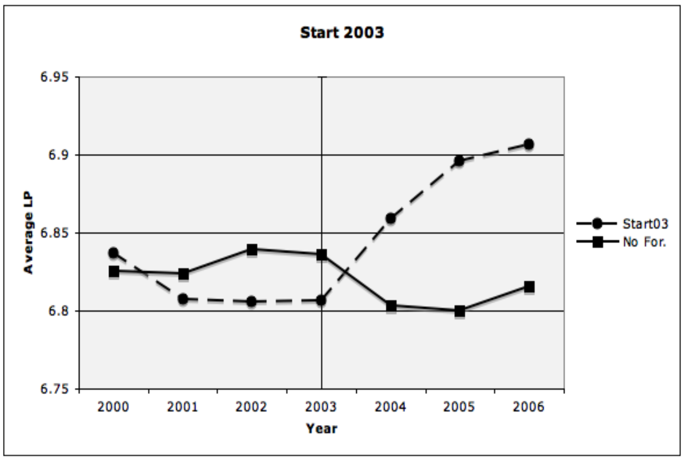
Nace Code	Start 2002	Start 2003	Non-Importers
15 (Food)	1	2	12
27 (Basic Metal)	1	2	4
72 (Computers)	4	4	5
74 (Other Business Activity)	3	2	6

The idea is to compare the evolution of firm productivity among firms that never import relative to firms that decide to import at a certain year and continue until the end of the sample: the approach is similar to that used by Clerides et al.(1999) to test self-selection and learning-by-exporting. If productivity is boosted following the decision to import, it can suggest that foreign inputs help firms to raise their productivity, i.e., learning by importing.

In Figure 6.1 the average productivity for non-importers (continuos line) versus the productivity of firms that begin to import in 2003 (dotted line) is plotted. It is possible to notice that average efficiency increases following the decision to import compared to other firms[28].

[28]The averages are calculated including both manufactures and services, Irish and foreign firms using

Figure 6.1: Average Log(LP): aggregated

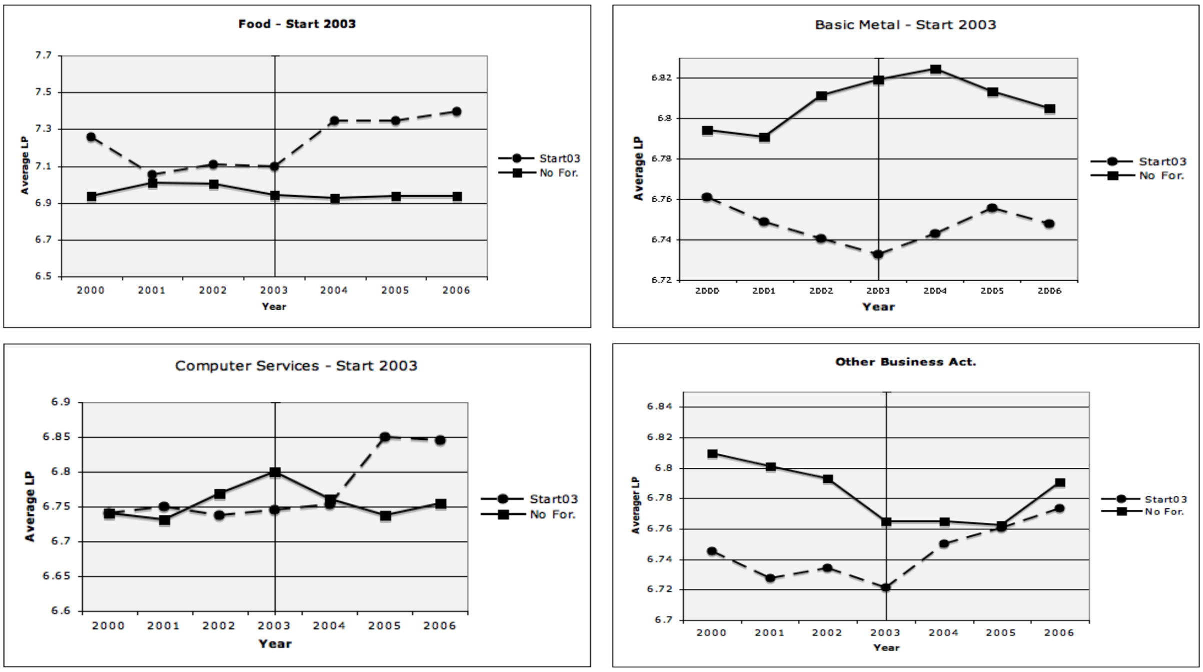


The Figure 6.1 shows that the decision to import has a positive impact on efficiency, or, in other words, that there exists a sort of *"learning-by-importing"* process. Moreover, the level of average productivity before the beginning of imports is lower compared to the non-importer firms, whereas, at the end of the period, the productivity is higher for importers; this may suggest a catch-up process for importers. Second, as the productivity of non-importers overcomes the productivity of importers before the importing decision, it partially excludes a self-selection effect. With self selection effect we entail the most efficient firms self-select into import activity, because the existence of sunk cost in importing (Castellani et al., 2009). For a more rigorous analysis, it is convenient to go into more detail, disentangling sectors. In Figure 6.2, we consider four different sectors in which it is possible to observe the begin of importing activity in the year 2003. There are four sectors considered, two from manufacturing and two from services; these are the only sectors for which it is possible to define a group of starters (dotted line) and a group of non-importers (continuous line). The graphics show a jump following the introduction of imported inputs for all considered sectors in the year 2003. In food (15) and computer (72) sectors the introduction of imported goods is associated with a jump and higher efficiency compared to non importers. In the case of basic metal (27) the gap remains wide among the two groups, even if jump is observed, probably associated to industry trends. Finally also in sector 74 we observe jump and catch up process. What is common among the four figures is the absence of any hints in favor of self-selection process. In conclusion, the figures support more the idea of learning-by-importing than

Log(LP) as an efficiency indicator.

the one of self-selection. However it is necessary to test more properly the idea of self-selection to corroborate the previous results, and to eliminate any suspects of double causality (more efficient firms use more imported inputs).

Figure 6.2: Average Log(LP): by sector



6.2 Self-Selection

Here, we discuss whether there exists a self-selection process for the import market, or at least if productivity determines the consumption level of imported goods; the following exercise is an additional robustness check to support the results obtained in Section 6 and Section 4. More specifically, we are going to test whether the past level of efficiency affects both the importing decision and the level of imports, as defined in (3.1). The first objective is to test the existence of fixed cost of importing, using the import choice as the dependent variable: other papers in the literature find more evidence of self-selection rather than learning by importing effects. The second objective is to verify reverse causality, which can be a problem: we want to be sure that the most productive firms do not import more simply because they are more productive. For our purposes, we will use a dynamic discrete choice model; in the former case, we estimate a probit model, and in the latter, we use a tobit model for the bounded ratio variable.

The estimation of a discrete-choice model raises several econometric issues. The main concern is the initial condition problem. The initial condition problem is the way of dealing with the initial observation of the dependent variable; which, in our case, is import status (Imp_{i0}), particularly if we suspect the existence of unobserved heterogeneity c_i. A second concern arises from a dynamic dependent variable and the fixed effect. The dependent variable is dynamic because the import choice or import ratio may be highly persistent due to the fixed costs that a firm incurs to begin this activity. Therefore, a lagged dependent variable is included in the estimated model with the unobserved heterogeneity c_i.

To deal with this, we follow the approach proposed by Wooldridge (2005), which applies to both a probit and a tobit model. In the specific case of probit (though it is the same for tobit), we assume a specific distribution for the unobserved heterogeneity (c_i), given Imp_{i0}, the initial condition, and $\mathbf{Y}_i$, a vector of individual characteristics (in this case the Log(LProd)). The distribution of c_i is a normal, with mean and the standard deviation given by $(\psi + \xi_0 Imp_{io} + \xi_i \mathbf{Y}_i, \sigma_a)$. This allows the standard conditional maximum likelihood method to be applied, so that the dynamic panel with fixed effect can be estimated using a random effect probit model, including Imp_{i0} and $\mathbf{Y}_i$. Finally the likelihood function[29] is

$$Imp_{it}^m = 1[\psi + \sum_{s=1}^{2} \beta_s Imp_{it-s}^m + \gamma_s \sum_{s=1}^{2} Log(YL)_{it-s} + \tag{6.1}$$

$$+\delta_f \sum_f X(f)_{it-1} + TD_t + \xi_i \mathbf{Y}_i + \xi_0 Y_{i0}^m + a_i + \varepsilon_{it}] > 0$$

where Imp_{it}^m is the import status in year t and Ex_{i0} is the initial condition, the import status at time 0 for firm i. The dependent variable is lagged by two periods $\left(\sum_{s=1}^{2} \beta_s Imp_{it-s}^m\right)$. The equation (6.1) can be estimated with a standard probit random effect model (averaged across the population), and the error term is corrected for second-order autocorrelation; the average partial effect can be estimated in the same way as in Chamberlain's unobserved effect probit model.

The two tables below report the results for the probit and tobit models, respectively. The estimation sample considers manufacturing firms, which are more sensible to the imports of intermediate goods. The sample is balanced and covers observations from 2001 to 2006; the first three columns present the results for all manufacturing firms, with different specifications; in columns 4 and 5 are reported the same results for Irish and foreign firms separately (including fixed effects and initial condition); while in the

[29] From the Normal distribution we can write $c_i = \psi + \xi_0 Imp_{i0} + \xi \mathbf{Y}_i + a_i$ where $a_i \sim Normal(0, \sigma_a^2)$

last column the estimation sample includes manufacturing firms which start to import in year 2002, 2003, and 2004 plus continuous non importers (pooled estimator). Control variables such as export status, the log of R&D and initial distance from frontier($Dist$) as well as time dummies are included in the regression.

Table 6.2 presents the results of decisions regarding importing (just simple coefficients). The coefficient of lagged productivity($Log(LP)_{it-1}$) is just positive in the pooled case[30], and without the lagged dependent variable. We can suppose that past efficiency does not explain a firm's import choice, and differently from previous research (Castellani et al, 2008; Vogel and Wagner, 2009) we do not find self-selection. This does not imply that self-selection does not exist for importing activity, and several explanations are possible. A first one depends on the nature of Ireland as it is a small but open economy. The fixed cost associated to importing may be very small, eliminating any type of self-selection process[31]; the introduction of fixed costs and initial condition confirm the result, and a strong persistency is observed in the data (coefficient of lagged dependent variable is significant). However past import status does not explain everything. It is interesting to note that export is positive and significant; it indicates that exporters are more likely to be importers (as shown in Table 3.5), and it suggests a causal relation from export to import.

Instead, Table 6.3 reports the results for tobit regressions, where the censored dependent variable is the log of import intensity ratio (3.1). Here we are verifying that reverse causality does not affect the finding of Section 4. The columns report the results for the same samples defined in Table 6.2. The coefficients show that the lagged value of productivity is statistically significant just in the case of pooled or (weakly) in the random effect tobit. However we can be quite confident that higher imports are not originated by higher level of productivity, when we include fixed effects and dynamics in the in the estimations. It seems again that the past level of import highly affect the present import intensity ratio.

[30]The results do not change if we use just one lag of productivity.

[31]However we cannot exclude that the results are partially driven by the data-set's characteristics.

Table 6.2: Import choice: Probit Model‡

	(1) Pooled	(2) R.E.	(3) F.E.	(4-Irish) F.E. & I.C.	(5-Foreign) F.E. & I.C.	(6) Pooled
Log(LP)_{it-1}	0.132**	0.081	0.092	0.111	-0.046	-0.419
	(0.063)	(0.135)	(0.107)	(0.130)	(0.533)	(0.357)
Log(LP)_{it-2}	0.055	0.034	-0.031	-0.069	-0.234	0.326
	(0.063)	(0.135)	(0.109)	(0.129)	(0.604)	(0.306)
Dist_{i00}	-0.051	0.000	-0.023	-0.069	-0.005	0.142
	(0.035)	(0.147)	(0.067)	(0.082)	(0.267)	(0.133)
Import_{it-1}			3.169***	3.133***	3.690***	
			(0.207)	(0.232)	(1.182)	
Import_{it-2}			0.086	0.071	-1.383	
			(0.218)	(0.258)	(1.020)	
Import_{i00}				0.151	12.933	
				(0.266)	(440.699)	
$\text{Log(R\&D)}_{it-1}$	0.106	0.267	-0.013	0.035	0.086	-0.576*
	(0.076)	(0.226)	(0.128)	(0.163)	(0.415)	(0.345)
Expo_{it-1}	0.805***	1.422***	0.313*	0.396**	-4.321	-0.108
	(0.090)	(0.303)	(0.160)	(0.182)	(764.313)	(0.355)
Observations	2983	3103	3103	2114	989	121
Firms		621	621	423	198	
ρ		0.856	0.050	0.115	0.245	
σ_u		2.44	0.230	0.361	0.569	

‡ Probit Model with import dummy as dependent variable. The regressions consider always balanced samples. Significance level: *0.10>p-value ** 0.05>p-value*** 0.01>p-value. Year dummies included. R.E.: random effect model. F.E.: fixed effect model. I.C.: initial condition included.

Table 6.3: Import Intensity : Tobit Model‡

	(1) Pooled	(2) R.E.	(3) F.E.	(4-Irish) F.E. & I.C.	(5-Foreign) F.E. & I.C.	(6) Pooled
Log(LProd)_{it-1}	0.112***	0.025*	-0.010	0.003	-0.039*	0.026
	(0.028)	(0.014)	(0.012)	(0.016)	(0.022)	(0.043)
Log(LProd)_{it-2}	0.081***	0.013	-0.003	-0.005	-0.002	-0.058
	(0.027)	(0.013)	(0.012)	(0.015)	(0.021)	(0.044)
Distance_{i00}	0.010	0.060**	0.004	-0.005	0.014	0.117
	(0.013)	(0.025)	(0.007)	(0.009)	(0.012)	(0.099)
Log(Ratio)_{it-1}			0.814***	0.775***	0.815***	0.081
			(0.022)	(0.030)	(0.031)	(0.091)
Log(Ratio)_{it-2}			0.044**	0.031	0.029	-0.135*
			(0.017)	(0.023)	(0.034)	(0.077)
Log(Ratio)_{i00}				0.052**	-0.005	
				(0.025)	(0.022)	
$\text{Log(R\&D)}_{it-1}$	-0.050*	0.028	-0.008	0.007	-0.009	-0.185**
	(0.028)	(0.025)	(0.014)	(0.018)	(0.024)	(0.087)
Expo_{it-1}	0.185***	0.098**	0.026	0.018	0.025	0.089
	(0.046)	(0.043)	(0.021)	(0.024)	(0.077)	(0.101)
Obs.	3103	3103	3103	2114	989	239
Firms		621	621	423	198	51
ρ		0.785	0.034	0.094	0	0.854
σ_e		0.314	0.325	0.301	0.356	0.197
σ_u		0.599	0.061	0.097	0	0.476

‡ Probit Model with import dummy as dependent variable. The regressions consider always balanced samples. Significance level: *0.10>p-value ** 0.05>p-value*** 0.01>p-value. Year dummies included. R.E.: random effect model. F.E.: fixed effect model. I.C.: initial condition included.

7 Conclusions

In this paper, the productivity pattern for a sample of Irish firms and the relation between firm's efficiency and imported inputs have been illustrated. Several facts capture our attention. First of all, foreign firms are more productive than Irish firms, but they grow with a lower rate. Second, foreign firms use more imported inputs in their production process (both services and materials). Third, exporters employ in their production process more imported inputs than the amount used by domestic firms. Finally, importers are more productive than non-importers (import premia). These facts suggest a question: do the imports of intermediates matter for a firm's productivity? We know from past literature that composition of input mix can change for three reasons: 1)The price of imported inputs is lower given a certain level of quality. 2)The quality of imported inputs is higher for a given price. 3)The foreign goods are more technologically advanced.

In light of this, throughout this paper, we have shown that there exists a positive effect of import activity on firms' efficiency: firms that change their input structure gain in terms of efficiency. The fundamental results are

1. There is a statistical and positive relation between importing activity and firm efficiency.

2. There is evidence that increasing the imports per se increases average efficiency, in particular for Irish firms in manufacturing sector.

3. The effect seems non linear, after the introduction of quadratic term. An optimal input mix may exist.

4. There is weak evidence that the productivity of less efficient Irish firms grows if the ratio of imported goods increases (in manufacturing sector): the intensive margin of import is important to determine productivity growth of left behind firms and we yet know that Irish firms are generally less productive than foreign firms. The opposite relation exists for foreign owned firms.

5. Importing boosts productivity among firms that decide to begin importing: the *learning-by-importing* effect is suspected.

6. There exists no evidence of self-selection in the data-set, and no evidence of reverse causality: import intensity level is not affected by past level of efficiency in our sample.

The internationalization process in the intermediate goods' market has a positive effect on the efficiency of manufacturing Irish firms particularly those that might be more exposed to international competition: the import of intermediate goods facilitates productivity growth, which is necessary to remain in the market.

The issue that has to be tackled is the channel through which imported goods increase productivity. It is reasonable to believe that imported inputs replace R&D activity because they have better characteristics. It is even more reasonable to assume that imported inputs force firms to upgrade their production process or the internal capabilities in order to use them. Future research thus requires the use of more detailed data-sets from which it is possible to proxy the quality or the kind of imported inputs, as well as the origin.

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A Data and Sectors

Table A.1: Dataset description: Firms

Sector	Nace Sector	Firms	Domestic	Foreign
Agricolture	10	41	39	2
Food Beverages & Tobacco	15	620	555	65
Textile Clothes Leather	17	175	141	34
Wood	20	111	105	6
Pulp Paper & Printing	22	194	170	24
Chemical	24	259	114	145
Rubber and Platics	25	183	117	66
Non-Metallic Minerals	26	133	113	20
Basic Metal & Fabricated Metals	27	413	346	67
Machinery n.e.c.	29	272	216	56
Electrical and Optical Equipment	30	564	285	279
Transport Equipment	34	79	46	33
Manufacturing n.e.c.	36	211	196	15
Networks	40	65	46	19
Construction	45	21	20	1
All Other Services	50	262	231	31
Financial Intermediation	65	41	20	21
Computer and Related Activities	72	929	643	286
Research and Development	73	51	45	6
Other Business Activities	74	263	197	66
Total		4887	3645	1242

All data on values are in thousands of euros.

- Material: Total cost of material and components used directly in the production of goods and the provision of services.
- Irish material: Material produced in the Republic of Ireland.
- Services: Total costs of all bought in services, e.g., advertising, transportation, fuel, power repairs, royalties, telephone, postage, stationery, computing services, professional fees, etc.
- Irish Services: Services sourced in the Republic of Ireland.
- $Ln(LP)$: This represents labour productivity and is calculated as the value added per worker. Value added is derived from the data-set as sales minus total payroll. The value added is deflated with a sector-specific deflator (source:EU-KLEMS).

- $Ln(YL)$: Output per worker. It is calculated as the deflated value of A firm's sales over the total number of employed people. Sales are deflated in order to obtain a proxy value for the output produced.
- R&D: Expenditure in research and development activities.
- Train: Total cost of all formal structured training of management and staff (in-house and external)
- IH(R&D) and IH(R&D Work): Expenditure in R&D performed inside the firm and the number of people employed in in-house R&D activities.
- Exp(Ratio): Percentage of sales from foreign markets.
- Exp(UK, EU, WR): Dummy variable that is equal to one if one firm exports to the UK, European Union or other countries in the world and equals zero otherwise.

B Additional tables

Table B.1: Average intensity ratios for domestic and exporting firms: Services

		Domestic	Exporter	Total
Irish	Mean	0.39	0.73	0.63
	Std	1.31	2.81	2.49
Foreign	Mean	1.60	45.75	40.58
	Std	8.99	837.97	787.47
Total	Mean	0.55	14.45	11.17
	Std	3.49	462.96	404.72

Table B.2: Average Output per worker by export and importing status: Services

Export	No-Importer	Importer	Total
	Aggegated		Total
Domestic	2.74	3.26	3.05
Exporter	4.11	4.42	4.34
Total	3.61	4.18	4.02

Table B.3: Average Productivity by sector/ownership.

	Log(YL)			Log(LProd)		
Nace Code	Irish	Foregin	Total	Irish	Foreign	Total
10	4.662	4.362	4.650	3.216	3.740	3.240
15	4.860	5.533	4.945	3.275	4.247	3.398
17	4.166	4.492	4.213	3.141	3.318	3.165
20	4.491	5.303	4.566	3.315	3.556	3.338
22	4.421	4.735	4.462	3.439	3.690	3.472
24	4.646	5.879	5.422	3.345	4.894	4.327
25	4.452	4.659	4.525	3.328	3.513	3.392
26	4.191	5.141	4.354	3.209	3.933	3.341
27	4.252	4.558	4.301	3.308	3.451	3.331
29	4.348	4.839	4.449	3.301	3.767	3.397
30	4.333	5.236	4.805	3.452	4.171	3.848
34	4.420	4.679	4.528	3.239	3.550	3.372
36	4.234	4.699	4.272	3.074	3.868	3.137
40	4.186	4.285	4.228	3.533	3.614	3.569
45	4.553	4.281	4.536	3.530	4.114	3.567
50	4.444	5.022	4.555	3.757	4.561	3.906
65	4.839	4.956	4.914	4.157	4.570	4.423
72	3.741	4.903	4.051	3.294	4.242	3.564
73	3.601	4.077	3.711	3.088	4.048	3.280
74	4.237	4.036	4.188	3.499	3.369	3.468
Total	4.322	5.051	4.516	3.333	4.092	3.537

Source: ABSEI Data-set. Averages calculated across years.

Table B.4: Correlation Table (b)

	R&D(pw)	Train(pw)	IH(R&D)	IH(R&D Work)	Log(YL)	Log(LP)
R&D(pw)	1					
Train(pw)	0.01	1				
IH(R&D)	0.1058*	0.0537*	1			
IH(R&D Work)	0.0413*	0.0175	0.3325*	1		
Log(YL)	-0.0272*	0.0270*	0.0483*	0.0672*	1	
Log(LP)	-0.0579*	0.007	-0.0506*	0.0204	0.8716*	1

Table B.5: Correlation Table (c)

	Exp	Exp(UK)	Exp(EU)	Exp(WR)	Exp(Ratio)	Log(YL)	Log(LP)
Exp	1						
Exp(UK)	0.6488*	1					
Exp(EU)	0.4796*	0.3083*	1				
Exp(WR)	0.4114*	0.2504*	0.5088*	1			
Exp(Ratio)	0.5626*	0.2243*	0.5836*	0.5420*	1		
Log(YL)	0.1633*	0.2677*	0.2885*	0.2318*	0.2147*	1	
Log(LP)	0.1071*	0.2606*	0.2294*	0.1533*	0.0816*	0.8716*	1

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