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Authors(s)	McCann, Fergal
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International Outsourcing's Role in International Technology Diffusion - The Irish Case

Fergal McCann, University College Dublin

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International outsourcing's role in international technology diffusion - the Irish case

Fergal McCann*§¶
University College Dublin,
Université Paris 1, Panthéon-Sorbonne

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Abstract

This paper analyses how international outsourcing affects plant productivity, with the major contribution lying in the identification of heterogeneous effects for firms with differing internationalisation status. The results point to a striking pattern: the status of being an outsourcer matters strongly for indigenous non-exporters, while for exporters and foreign affiliates, tfp increases are lower, insignificant and sometimes negative. On the other hand, a higher intensity of outsourcing matters for both exporters and foreign affiliates, but not for indigenous non-exporters. Similarly, in dynamic analysis, indigenous non-exporters are found to increase tfp for two periods after entering into international outsourcing, while indigenous exporters experience one more weakly significant period of growth. The key message of the paper is thus: outsourcing's role as a channel of technology diffusion is most pronounced when it serves as a first exposure to international markets.

JEL Classifications: F13, F14, F23, L23
Keywords: Outsourcing, Productivity, Firm Structure

*Corresponding address: Maison des Sciences Economiques, 106 - 112 Boulevard de L'Hopital 75647 Paris cedex 13, France

†fergaljmccann@gmail.com, fergal.mccann@univ-paris1.fr

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1 Introduction

One would expect that the inter-firm importing of intermediates, or international outsourcing, would lead to increases in firms' productivity for a number of reasons. An increased variety of inputs should give a higher likelihood of finding the input that perfectly fits the firm's production process (as in the "market thickness" effect of theoretical papers such as Grossman and Helpman (2003)). Given the higher number of inputs available once a firm enters the import market, the quality of input should also rise, particularly for firms located where domestic producers are not up to international standards. Similarly, one may assert that there is a certain technological advantage embedded in international intermediate inputs, due to firm interaction with foreign dealers who may possess a higher level of expertise. Another way of putting it, as in Keller (2004) is that "employing a foreign intermediate good in final-output production involves the implicit usage of the technology in embodied form. There is a spillover in this process of international technology diffusion to the extent that the intermediate good costs less than its opportunity costs - which include the R&D costs of product development." With these channels of productivity improvement in mind, I posit that becoming an importer of intermediate inputs be a period of change in the operations of a firm. It is these channels of improvement that are tested in the main empirical analysis of this paper.

The empirical analysis takes on two forms, with the aim of illustrating how differing these two approaches are in the mechanisms they are set up to capture, and in the results at which they arrive. If, as recommended by Olsen (2006), we treat outsourcing as a continuous variable, using the firm's outsourcing intensity as an independent variable that enters into a Cobb-Douglas production function, we arrive at the conclusion that more international outsourcing only leads to productivity gains for foreign owned firms and for indigenous exporters in Ireland. The Olsen method, variants of which have also been used by Gorzig and Stephan (2002), Görg et al. (2004), and Görg and Hanley (2005) does not lend itself well to identifying the channels of productivity improvement outlined at the outset. To pick up these theoretically-grounded effects of international outsourcing on productivity, I posit that it is preferable to treat international outsourcing as a binary variable. Rather than test the effect of the magnitude of outsourcing on productivity, the import status of the firm is added to the firm production function. This production function is tested in OLS, Fixed Effects, Difference GMM, System GMM and a modified version of the Olley and Pakes (1996) (OP hereon)[1] structural production function estimator. This

[1]This estimator mimics the work of de Loecker (2007) which allowed the firm's export status to affect its investment decisions and probability of survival. For further explanation of the estimation procedure, see Appendix 3.1.

discrete variable approach is grounded in the idea that becoming an outsourcer may lead to a fundamental change in the way a firm operates. The analysis gives the intuitive result that indigenous non-exporters benefit the most from being an international outsourcer. For indigenous exporters and foreign affiliates, the effect of outsourcing on productivity is either lower, insignificant or negative. The intuition for the results stems from the idea of a "productivity ordering" of international activities. Indigenous exporters and multinational affiliates are likely to have exhausted a lot of the potential for productivity improvement due to the selection effects and the learning effects from entering into these activities. They are unlikely to experience any fundamental shift in the way they operate due to their being an importer of intermediates. Indigenous non-exporting firms, on the other hand, are further down the "productivity chain" so to speak, and are, therefore, more likely to benefit from being an international outsourcer relative to similar firms who only source inputs at home.

Papers similar in approach include Amiti and Konings (2007) and Kasahara and Rodrigue (2008) who both find that importing of intermediates leads to increased productivity, for Indonesia and Chile, respectively. The latter applies both a discrete and continuous measure of outsourcing and finds both to have positive significant effects on productivity. The approach taken in Section 1 is very similar to that in Kasahara and Rodrigue (2008), but can be seen as an extension, given that they do not break firms down by their internationalisation status. The analysis here, by breaking firms down along the delineation of Helpman, Melitz and Yeaple (2004), gives more insight into the detail of the productivity improvement brought about due to outsourcing.

Having shown the importance of the distinction between outsourcing as a continuous variable and outsourcing as a discrete variable, I turn to the literature on exporting originating with Bernard and Jensen's (1999) (BJ hereon) paper on the selection into versus learning from exporting to attempt to estimate a dynamic effect of becoming an international outsourcer. The pool of non-outsourcers at a given time t-1 is taken. Initially a selection regression is run, showing that the more productive firms do indeed select into the international outsourcing market. Given this endogenous entry of more productive firms into the intermediate import market, matching methods are used in regressions explaining the dynamic effect, or "learning" from outsourcing. A dummy for outsourcing status at time t is used as a regressor explaining tfp growth to estimate the performance-enhancing effect of entry to the import market on tfp. Vogel and Wagner (2008) use this BJ approach when analysing importing. Andersson et al. (2007) and Castellani et al. (2008) both point to the fixed costs associated with importing, implying that there should be selection of more productive firms

into import markets as in Melitz (2003) for exporters. Papers studying the learning effects of importing have been mentioned above, such as Kasahara and Rodrigue (2008) and Amiti and Konings (2007). When adopting this BJ approach to the Irish data, I find evidence of selection of more productive firms into international outsourcing, along with evidence that the dynamic effects of becoming an international outsourcer are positive and significant for domestic non-exporters, with a smaller, shorter-lived, less statistically significant effect for indigenous exporters. This reinforces the idea that it is being internationalised that matters.

The literature testing causality from international outsourcing to tfp, some of which is mentioned above, is relatively sparse compared to that for exporting. Outsourcing has received far more attention within a well-populated theoretical literature treating the mode in which firms source their inputs. This literature breaks the firm's sourcing decision down along two dimensions, namely the firm boundary (in-house purchases versus outsourcing) and origin of input (domestic versus foreign). This literature has generally concluded that firms sourcing inputs abroad should be more productive than those that source domestically. The literature has been less conclusive with the predicted productivity ranking of firms along the dimension of the firm boundary. Antràs and Helpman (2004), adopting the property rights theory of the firm, predict that firms sourcing in-house should be more productive than those outsourcing. Grossman and Helpman (2003), adopting an incentives systems approach, find the opposite; firms that outsource should be more productive than firms purchasing in-house. Defever and Toubal (2007), motivated by a survey of French firms which found most believed the fixed costs of outsourcing to be higher than those under in-house purchasing, also show outsourcing to be associated with higher productivity than in-house production. They also back up their theoretical model with empirical evidence using firm-level data.

The topic of international outsourcing has grown exponentially in relevance in the last two decades. As Grossman and Helpman (2005) state, "we live in an age of outsourcing". The reasons for the onset of this "age of outsourcing" lie in what Baldwin (2006) refers to as globalisation's "second unbundling". He defines the first unbundling as being marked by industrialisation, trade, growth, urbanisation and increasing internal inequality in the North. The firm was considered a "black box", and firm-to-firm competition was the lowest level of aggregation to be analysed. In Baldwin's "second unbundling", which began in the 1980s, that "black box" was opened up, as firms started to locate different parts of the production process in different locations. The lowest level of disaggregation was no longer the firm but the task. Myriad factors can explain this shift in the process of production. These factors are well documented in the literature. For the purpose of all

analysis that follows I define outsourcing as the procurement of inputs to the production process from outside the boundary of the firm. Offshoring is defined as the procurement of inputs from outside the borders of the firm's home nation, regardless of whether that occurs within the boundaries of the firm (FDI, affiliate purchases) or outside the boundary of the firm (international outsourcing).

To the best of my knowledge, this is the first study to look at both outsourcing status and intensity and test their effect on the productivity of heterogeneous firm types. It is also the first paper to my knowledge to have tested the selection and learning equations proposed by Bernard and Jensen (1999) for outsourcing, using a structurally estimated tfp measure and propensity score matching. The intuitive nature of the differing results, depending on the measure of outsourcing used, comprises an addition to the literature's understanding of the importance of both the importing of intermediates and international trade in general to firm performance.

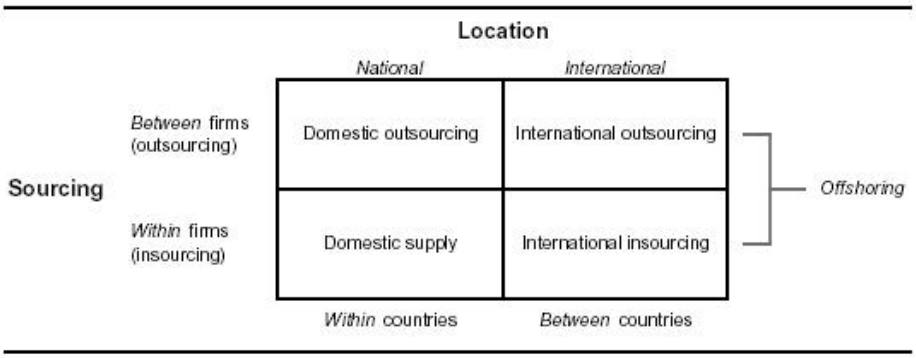
The paper proceeds as follows. The reasons to expect a causal relationship from outsourcing (both in general and offshore) to firm-level productivity are outlined in Section 2. Section 3 explains the data source, the *Census of Industrial Production*, and offers descriptive statistics. Section 4 reports regression results, while Section 5 concludes.

2 Theoretical motivation

Firms make sourcing decisions along two dimensions; the firm boundary and location. The decision matrix in Figure 1 below is borrowed from Olsen (2006). The bottom right-hand corner of the matrix, where firms source from affiliates abroad, is more commonly referred to as Foreign Direct Investment (FDI), usually of export-platform or vertical nature. The data for this paper do not allow analysis along all four of these sourcing modes. By asking firms the percentage of their material inputs that are imported, it allows concise analysis along the top line of this matrix, when firms that purchase from affiliates, are excluded i.e. domestic versus international *out*sourcing. By asking the percentage of purchases coming from affiliates, it allows analysis along the left-hand vertical column for non-importers i.e. domestic outsourcing versus domestic in-house. The data does not break imports down into international outsourcing and intra-firm trade, which means that analysis along the bottom row or the right-hand side column is not possible.

There are a number of theoretical models that offer suggestions as to the expected productivity ordering of different sourcing modes in the data. Two of the broad strands of theoretical literature are the propriety rights, as in

Figure 1: Firms' sourcing modes



Antràs (2003) and Antràs and Helpman (2004) and incentive systems approaches, as in Grossman and Helpman (2002, 2003). The firm incorporates the behaviour of the input supplier into its profit-maximisation decision, in the former due to imperfect contract enforcement, and in the latter due to imperfect opportunities to monitor the supplier. Both of these approaches allow for high fixed costs of entry to either sourcing mode. The productivity rankings in these models depend greatly on the parameters of the model, and imply nothing about the causality from sourcing choice to productivity. On the contrary, they explain more the sorting of firms into sourcing modes based on their productivity, i.e. selection in the parlance of the exporting literature originating with Bernard and Jensen (1999). In Antràs and Helpman (2004), in-house production is associated with higher productivity, while in Grossman and Helpman (2002, 2003), outsourcing is associated with higher productivity. The consistent feature of the literature is that more productive firms, regardless of sourcing mode along the firm boundary, source inputs abroad.

The varying predictions of the theoretical literature mean that a more inductive approach, incorporating analysis of the data, has merit in this field of research. Tomiura (2007) and Federico (2008) find that, for Japanese and Italian firms, respectively, integrating firms are more productive than outsourcing firms, and firms sourcing abroad are more productive than firms sourcing at home, both of which support the predictions of Antràs and Helpman (2004). Defever and Toubal (2007) find support for outsourcing firms as more productive than FDI firms.

As explained above, of the four potential sourcing modes mapped in Figure 1, comparisons can only be made between two pairs. The data limita-

tions underlying this are outlined in Section 3. The ranking of international outsourcers as more productive than domestic outsourcers is of key interest to this paper, and motivates the empirical analysis in Section 4. Theoretical reasons for which we might expect a causal effect from outsourcing to tfp are now outlined.

The productivity-enhancing effect of outsourcing (in general, not specifically international) can be explained theoretically through models such as principal-agent frameworks and transaction cost theory. The former suggests that outsourcing will increase productivity as it limits opportunism and self-serving behaviour on behalf of employees. In this context, output can be better controlled and inefficiencies minimized through a contract than within the boundaries of the firm, so outsourcing is chosen. The latter theory suggests that outsourcing is subject to certain costs such as search costs, contract incompleteness and relationship-specific investment. If these costs are outweighed by the savings from specialization which outsourcing offers, then a firm will decide to outsource. Grossman and Helpman (2003) and others point out that this characteristic of outsourcing is more easily exploitable the "thicker" the outsourcing market. The logic is that the more input suppliers there are in a given country, the higher the likelihood of finding a supplier that matches the needs of the final good producing firm. This idea brings us back to the most basic of explanations for the incentive to outsource: simple Smithian specialisation. When a firm outsources a low-value activity such as its call centre or the manufacture of a basic input, it can then reallocate resources into other activities at which it is better, often referred to in the management literature as its "core competencies". Outsourcing can also help firms in smoothing out seasonal fluctuations in economic activity, which means that excess spending on unnecessary labour is avoided.

International outsourcing may lead to further productivity gains above and beyond those for outsourcing from within the home country. These reasons are outlined at the beginning of Section 1. Amiti and Wei (2006) cite the increase in the variety of inputs acquired from international outsourcing as one channel of increased productivity. The increased variety means that, in the "market thickness" framework mentioned above, the probability of finding an input provider with the "perfect fit" increases. With an increased variety of inputs will often come an increased quality of input. Thus, the firm's technology frontier also shifts with workers becoming more efficient through exposure to more sophisticated technologies embedded in these inputs. The procurement of inputs from abroad can also lead to "learning by doing" effects for employees exposed to new methods. This is akin to the argument proposed by Keller (2004), in summarising the role of importing in international technology diffusion. All of these effects suggest that inter-

national outsourcing may have a supplementary effect beyond the general productivity-enhancing effects of sourcing an input from outside the firm mentioned in the previous paragraph.

In the approach proposed by Olsen (2006), outsourcing intensity, measured as outsourcing divided by the total wage bill of the firm, is allowed to affect the "technology shifter", a in a firm's production function. This gives an estimable equation

$$y_{it} - l_{it} = \alpha_0 + \alpha_1 FOS_{it} + \beta_1(k_{it} - lit) + \beta_2 l_{it} + \epsilon_{it} \quad (1)$$

where the dependent variable is labour productivity, k is capital input, FOS is foreign outsourcing of materials.

It can be argued that there are numerous problems with the above strategy. These include the fact that labour productivity as a dependent variable may be capturing factors other than the unobservable ability captured by tfp, particularly non-technological scale effects. I also argue that a binary variable indicating whether or not a firm is an international outsourcer is a more appropriate measure for picking up the technology-enhancing effects summarized in Keller (2004) than a continuous outsourcing intensity measure. Both these measures are included in a production function as follows, as in Kasahara and Rodrigue (2008):

$$y_{it} = \alpha_0 + \beta_l l_{it} + \beta_k k_{it} + \beta_m m_{it} + \beta_i i_{it} + \epsilon_{it} \quad (2)$$

where $\beta_i i_{it}$ can take the form of outsourcing intensity or the firm's outsourcing status, a (0,1) variable. The crucial component of either model is the treatment of the error term, which is assumed to be composed of a "productivity component", ω_{it} and an i.i.d. error, η_{it}. A number of different treatments of the error are tested in Section 1, from OLS, Fixed Effects, Difference GMM, System GMM to a modified version of the Olley-Pakes (1996) estimator, which takes account of outsourcing status in the same way de Loecker (2007) does for exporting with Slovenian firms.

The theory suggests that when a firm orientates itself towards international inputs, the technological advantage of these inputs should lead to a change in the firm's performance. In this vein, the "discrete variable" model appeals more as a true estimate of the "technology shifting" or tfp-enhancing effects of engaging in international outsourcing, as it captures the difference between those that do import intermediates at arm's length versus those that do not, while a continuous measure identifies the effect of more outsourcing on productivity, which may be tied up with issues of scale. The contrast in processes identified by differing empirical methodologies, as borne out in the results of Section 1, is stark. The discrete variable shows

that indigenous non-exporting firms are most likely to benefit from the technological enhancement offered by a shift into international outsourcing, while the continuous measure tells us that more intense outsourcing is of benefit to foreign affiliates and indigenous exporting firms only. The insignificance of import status for these already internationalised firms sits well with the idea that becoming an importer of intermediates shifts the operations of a firm. For these latter firms, outsourcing status is not a determinant of productivity as they have already undergone the shift in operations that international trade can instigate. For indigenous firms serving the domestic market, on the other hand, outsourcing represents a first step into international trade. The empirical results bear out the fact that for such firms this initial outward orientation should lead to a productivity increase.

3 Data, descriptive statistics

The dataset used is the *Census of Industrial Production* (CIP), which is collected each year by the Central Statistics Office (CSO) of Ireland. It is compulsory, giving plant and enterprise-level information on all manufacturing firms with 3 or more persons engaged in Ireland from 1991-2005. The majority of the analysis in this paper will focus on the years 2001-2005, as these are the only years for which information on purchases from affiliates is asked of the firms. This allows the identification of firms firms that are outsourcing as opposed to firms that are simply importing. Industry breakdown at the 2, 3 and 4 digit level is given in accordance with NACE Rev 1 from 1991-2001 and NACE Rev 1.1 from 2002-2005. The panel is unbalanced, with sample size for each year fluctuating between 4,500 and 5,000 plants. All monetary variables have been deflated using the CSO's *Consumer Price Index Annual % Changes* table, with 1991 used as the base year.

In Table 1, the international orientation of firms in the data is outlined. We see that, in line with expectations, given the fact that Ireland is well known as a hub for export-platform FDI, 90% of foreign-owned firms[2] export. For Irish-owned firms, roughly half export some of their output. A similar amount of foreign-owned firms import some of their material imports, compared with just 30% of Irish-owned firms.

[2]Firms are reported as "foreign-owned" if the "ultimate beneficial owner" of the firm is located outside Ireland.

Table 1: International orientation of firms in Ireland

	Irish-owned	Foreign-owned
Non-Exporter	50%	6%
Exporter	50%	94%
Non-importer	31%	9%
Importer	69%	91%

The key variables of interest to this study are those that ask whether a firm's input purchases are imported or not, and whether the firm's purchases are from an affiliate or not. As the census does not ask whether the affiliates are located abroad or not, this study is limited from fully analysing sourcing modes along the lines of Antràs and Helpman (2004). Rather, comparisons can only be made along two dimensions:

- IN_D vs OS_D, for non-importers
- OS_F vs OS_D, for firms with no affiliate purchases

where IN refers to purchases from affiliates only, OS refers to arm's length purchases, or outsourcing, subscript D refers to purchases in Ireland, and subscript F refers to imports. Given reports from the state industrial policy agency Forfás[3] that between 2002-2006 there were 212 outward direct investments from Ireland, only 55 of which were in manufacturing, it can be reasonably assumed that the majority of imports by Irish-owned firms were not intra-firm but rather through outsourcing. Nevertheless, in the empirical section the sample will be restricted to firms that had zero affiliate purchases to ensure that only the effects of outsourcing are picked up. Table 2 breaks the outsourcing dummy, affiliate dummy and continuous outsourcing measure down by the categories analysed in Helpman, Melitz and Yeaple (2004) (HMY hereon):

- Domestic: Indigenous Irish firms that only serve the domestic market
- Export: Indigenous Irish firms that serve international markets
- Foreign: Multinational affiliates

The data show importing is more common among foreign-owned firms and indigenous exporters (around 85-90% of both categories import some of their inputs) than among indigenous non-exporters (of which roughly half import). This is to be expected given the complementarities between the two methods of engagement in international trade. The picture is different when

[3] "Outward Direct Investment and the Irish Economy", 2007.

examining the percentage of firms that purchase some input from affiliates (information on whether the affiliate is in Ireland or abroad is not available). Amongst indigenous Irish firms, regardless of their export status, less than a fifth purchase inputs from an affiliate. On the other hand, almost half of foreign firms purchase from an affiliate. This is again to be expected, as it is hard to imagine a majority of indigenous Irish manufacturing firms being members of large corporate groups, as evidenced by the Forfás policy report mentioned above. *OSint*[4], foreign outsourcing intensity, which is calculated as the euro amount of inputs sourced divided by the firm's total wage bill, is highest for foreign firms, followed by exporters, followed by domestic firms, as should be expected. I calculate the intensity relative to the wage bill as it gives a better sense for the degree of (an inverse measure of) vertical integration of the firm, than a simple measure of the percentage of total purchases imported.

Table 2: Percentage of firms engaging in international outsourcing and purchases from affiliates, international outsourcing intensity, by HMY

	Importer?		Affiliate?		*OSint*
	No	Yes	No	Yes	
Indigenous Domestic	48	52	89	11	0.7815
Indigenous Exporter	14	86	82	18	1.5962
Foreign Affiliates	9	91	57	43	3.1489

The predictions of the HMY paper and many others suggest that foreign firms should out-perform exporters, who should outperform domestic firms along any number of firm characteristics. The reason for this lies in the theory emanating from Melitz (2003) regarding the fixed entry costs to international activity. The Irish data confirm that foreign firms have higher sales, are larger, use more capital[5], more materials and more services than exporters, who in turn use more of each than domestic firms. Now that a picture of the trends in the data has been painted, Section 4 will test for the causal effect of outsourcing on productivity.

[4]This includes "Raw Materials, Materials for repairs, Materials purchased for the production of capital goods by your enterprise for your own use, Packaging, Office supplies".

[5]The CIP does not report capital stock figures. To get around this problem, changes in capital stock were regressed on differences in energy usage for each year at the NACE2 level, with the resulting parameter applied to levels of energy usage to get a proxy for capital stock.

4 Empirics

4.1 Outsourcing shifts the production function

The causal effect of international outsourcing on tfp is now estimated. To ensure that it is indeed outsourcing, rather than simply importing (which could include intra-firm trade), the sample was restricted to firms that do not purchase any inputs from affiliates[6]. The equation estimated is Equation 2 from Section 3, where outsourcing is allowed to affect productivity by entering the production function, similar to that in Kasahara and Rodgrigue (2008). Initially, I treat the international outsourcing of inputs as a continuous variable. *OSint*, foreign outsourcing intensity, is measured as total imports of inputs divided by the firm's wage bill. Table 3 reports regression results for all firms, under several different specifications. Each specification treats the error term, $\epsilon = \omega + \eta$ differently. FE refers to Fixed Effects, DGMM to the Arellano and Bond (1991) estimator, SGMM24 and SGMM35 to that of Blundell and Bond (1998) with second to fourth lags, and third to fifth lags, used as instruments, respectively. Modified OP estimates the production function structurally, as in de Loecker (2007) for exports by letting international outsurcing affect the firm's productivity, investment decisions and probability of survival. Table 3 provides some support for the tfp-enhancing effect of international outsourcing intensity - the OLS, FE and modified OP estimators find a significant increase of between 0.8 and 1.8 percent due to a one unit increase in outsourcing intensity, measured as the ratio of imported inputs to total wages. As is common in the literature, OP results in lower coefficients on the variable inputs l and m than OLS. This is due to the choice of input being correlated with the unobserved ω, which is not dealt with by OLS. In all tables in this section, time and NACE2 industry dummies are included as default.

In Table 4, the same regressions as above are run, for the Helpman, Melitz and Yeaple subsamples. For ease of exposition, the coefficient on *OSint* alone is reported. Table 4 shows that the intensity with which foreign affiliates outsource their intermediates abroad positively affects tfp by between 1 and 2 percent. This effect is extremely robust and significant under all treatments of the unobservable. Indigenous exporting firms also experience productivity gains of between 0.3 and 1.4 percent, significant only under OLS, Fixed Effects, Difference GMM and modified OP estimations. A positive effect of outsourcing intensity on productivity for domestic non-exporting firms, meanwhile, is only significant under OLS and the modified OP estimator, and has smaller coefficients in both cases. The message to

[6] As a robustness check, all regressions were run on the full sample of firms, but include a dummy for affiliate purchasing to sweep up the effect of intra-firm imports. This does not change the results qualitatively.

be taken from Table 4 is that when we test the effect of the magnitude of outsourcing, it appears that more internationalised firms experience larger and more robust tfp benefits from more intense outsourcing.

Table 3: International outsourcing intensity enters production function

	(1) OLS	(2) FE	(3) DGMM	(4) SGMM35	(5) SGMM24	(6) Mod. OP
l	0.4580***	0.4820***	0.3804***	0.2986***	0.2956***	0.4171***
	(0.0054)	(0.0096)	(0.0119)	(0.0785)	(0.0793)	(0.0056)
k	0.1505***	0.0685***	0.0712***	0.0959**	0.0901*	0.1070***
	(0.0042)	(0.0047)	(0.0053)	(0.0447)	(0.0546)	(0.0028)
m	0.4500***	0.2177***	0.2661***	0.1739***	0.1214*	0.4406***
	(0.0042)	(0.0052)	(0.0061)	(0.0487)	(0.0724)	(0.0042)
$OSint$	0.0185***	0.0081***	0.0002	0.0029	0.0079	0.0169***
	(0.0012)	(0.0014)	(0.0003)	(0.0043)	(0.0058)	(0.0169)
y_{t-1}			0.3371***	0.5744***	0.6075***	
			(0.0325)	(0.0789)	(0.1287)	
Cons	5.1607***	9.1948***	4.0997***	-0.5557	3.2387	6.5511***
	(0.0867)	(0.1957)	(0.5682)	(2.9540)	(2.8776)	(0.2569)
Obs	20220	20220	16312	18266	18266	18261
R-sq	0.91	0.38	.	.	.	.3265

Standard errors in parentheses
Time and industry dummies included
*** $p \leq 0.01$, ** $p \leq 0.05$, * $p \leq 0.1$

Table 4: Effect of international outsourcing intensity for HMY breakdown

	(1) OLS	(2) FE	(3) DGMM	(4) SGMM35	(5) SGMM24	(6) Mod. OP
Dom	0.0117***	-0.0001	0.0001	-0.0005	0.0143	0.0098***
	(0.0019)	(0.0023)	(0.0003)	(0.0036)	(0.0109)	(0.0019)
	10513	10513	8258	9422	9422	9419
Exp	0.0140***	0.0122***	0.0032**	0.0064	0.0043	0.0158***
	(0.0019)	(0.0023)	(0.0015)	(0.0084)	(0.0055)	(0.0019)
	7851	7851	6561	7186	7186	7184
For	0.0224***	0.0224***	0.0147***	0.0162**	0.0115**	0.0271***
	(0.0032)	(0.0048)	(0.0037)	(0.0064)	(0.0051)	(0.0033)
	1856	1856	1493	1658	1658	1658

Standard errors in parentheses
No. of observations reported below standard errors
k, m, l, time and industry dummies included in all regressions
*** $p \leq 0.01$, ** $p \leq 0.05$, * $p \leq 0.1$

A significantly different question to ask is whether *being* an international outsourcer, as opposed to the *intensity* of outsourcing, affects tfp. This method, I posit, is better suited to picking up the "technology shifting" effect of importing, as outlined in Keller's (2004) summary of channels of international technology diffusion. If the importing of intermediates does indeed change the way a firm operates, one would expect a binary variable indicating import status to better pick up this effect than an indicator of the outsourcing intensity of a firm. Furthermore, when firms are broken down by Helpman, Melitz and Yeaple's (2004) delineation, different results to those found for the continuous variable should be expected. The technology-enhancing effect of being an outsourcer should be most applicable to indigenous domestic firms. For indigenous exporters and foreign affiliates, this effect is less likely to hold as these firms have already experienced productivity gains from international orientation. For firms with no prior engagement with the international economy, on the other hand, I hypothesize that import status should indeed be a significant determinant of productivity.

Table 5 reports results for OLS, Fixed Effects, Difference and System GMM and a modified OP estimator, with import status included in the production function as in Equation 2. For all firms, there is only a weakly positive effect of import status on productivity, with the import coefficient only positive for Fixed Effects and Difference GMM, and in fact negative under the modified OP estimator.

Table 6 then applies the same regressions for the HMY subgroups. As in Table 4, only the coefficient on the import dummy is reported for ease of presentation. Here the results match up with the intuition given above: being an international outsourcer increase tfp by 2.5 percent for domestic non-exporters, significant under OLS, FE and DGMM. The coefficients are either negative or insignificant under all specifications for indigenous exporters and foreign affiliates. One striking feature of Table 6 is the highly negative coefficient under the modified OP estimator for exporters and foreign affiliates, which is absent for domestic non-exporters. This indicates that outsourcing is indeed unimportant for these internationalised firms. Firms of this nature that source inputs in Ireland, which brands itself as being a quality provider of products all along the value chain, might in fact be better off than those that source abroad.

The results of this subsection confirm the idea put forward in this paper that a discrete variable indicating a firm's import status is better suited to picking up the "international technology diffusion" effects of international outsourcing. Further, they confirm that there seems to be an ordering of the importance of modes of internationalisation for tfp. Outsourcing appears to

only be an important activity for tfp improvement if firms have not already begun exporting or setting up plants abroad.

Table 5: outsourcing status enters the production function

	(1) OLS	(2) FE	(3) DGMM	(4) SGMM35	(5) SGMM24	(6) Mod. OP
l	0.4415***	0.4783***	0.3808***	0.2599***	0.2418***	0.4000***
	(0.0054)	(0.0096)	(0.0118)	(0.0645)	(0.0736)	(0.0055)
k	0.1471***	0.0675***	0.0702***	0.0556	0.0296	0.1083***
	(0.0042)	(0.0047)	(0.0053)	(0.0367)	(0.0492)	(0.0031)
m	0.4704***	0.2205***	0.2640***	0.1798***	0.1819***	0.4643***
	(0.0040)	(0.0052)	(0.0061)	(0.0459)	(0.0559)	(0.0040)
import	-0.0058	0.0321***	0.0218***	0.0084	0.0128	-0.0557***
	(0.0076)	(0.0078)	(0.0082)	(0.0383)	(0.0498)	(0.0079)
y_{t-1}			0.3265***	0.5604***	0.5970***	
			(0.0336)	(0.0739)	(0.1014)	
Cons	5.0106***	9.1687***	4.2720***	-0.0781	3.5546	5.7582***
	(0.0867)	(0.1957)	(0.5831)	(2.3487)	(2.5293)	(0.3568)
Obs	20220	20220	16312	18266	18266	18261
R-sq	0.91	0.37	.	.	.	.2943

Standard errors in parentheses
Time and industry dummies included
*** $p \leq 0.01$, ** $p \leq 0.05$, * $p \leq 0.1$

Table 6: Outsourcing status by HMY

	(1) OLS	(2) FE	(3) DGMM	(4) SGMM35	(5) SGMM24	(6) Mod. OP
Dom	0.0227**	0.0248**	0.0256**	0.0675	0.0521	-0.0131
	(0.0096)	(0.0113)	(0.0104)	(0.0484)	(0.0431)	(0.0101)
	10513	10513	8258	9422	9422	9419
Exp	-0.0413***	-0.0037	0.0140	0.0255	0.0506	-0.1128***
	(0.0126)	(0.0130)	(0.0122)	(0.0739)	(0.0886)	(0.0134)
	7851	7851	6561	7186	7186	7184
For	-0.0776*	-0.0041	-0.0332	0.1604	0.1595	-0.1789***
	(0.0457)	(0.0346)	(0.0338)	(0.1772)	(0.1274)	(0.0496)
	1856	1856	1493	1658	1658	1658

Standard errors in parentheses
No. of observations reported below standard errors
k, m, l, time and industry dummies included in all regressions
*** $p \leq 0.01$, ** $p \leq 0.05$, * $p \leq 0.1$

4.2 Dynamic effects

In the previous subsection I have shown how continuous and discrete measures of international outsourcing affect productivity. The final aim of this paper is to investigate the dynamic effect of becoming an outsourcer on tfp. This is done by taking from the literature stemming from Bernard and Jensen (1999), which tests the selection of more productive firms into exporting and the productivity improvement or "learning" which occurs after becoming an exporter. This approach is adopted and applied to the switch into international outsourcing for firms that previously only sourced inputs at home. Vogel and Wagner (2008) use labour productivity as a dependent variable to test this. They find evidence of selection of more productive firms into importing, but minimal evidence of learning. Two distinguishing features of this paper are that I use a structurally estimated tfp measure and that the effects of international outsourcing on productivity are isolated, by excluding firms that may have been involved in intra-firm trade from the analysis.

4.2.1 Selection

As in Melitz (2003) for exporting, it may be assumed that entry to the import market is subject to fixed costs such as reputation earning, credit constraints to be overcome, search for the correct buyer, etc. This logic leads to the possibility that only the more productive firms enter to become outsourcers, which would lead to endogeneity in the "learning from outsourcing" analysis to follow. With this in mind, a random effects probit regression of all firms that are non-outsourcers at $t-1$ is run, to examine whether productivity at $t-1$ and $t-2$ significantly influences the probability of becoming an outsourcer at t. The following model is run:

$$Pr(OS_{it} = 1 | OS_{i,t-1} = 0) = F(\Phi_{i,t-1} + \delta_s + \delta_t + e_{it}) \tag{3}$$

where Φ includes productivity, ownership, age and skill intensity, and δ_s and δ_t are industry and time dummies. In column (1) and (2) of Table 7, Equation 3 above is tested for selection to outsourcing. Column 1 tests the equation for all firms that were non-importers at $t-1$, and is thus subject to contamination due to the incomplete data problem mentioned earlier. To test for cleaner effects, Column 2 restricts the sample to firms that were non-importers at $t-1$, and never purchasers from affiliates, thus ruling out firms engaging in intra-firm trade. This, therefore, tests selection into international outsourcing cleanly. Column 2 finds indeed that firms that begin to outsource internationally at t are more productive, but only two years before entry, than those that stay sourcing domestically.

Table 7: Selection into importing and outsourcing, RE Probit

	(1) importing	(2) outsourcing
tfp_{t-1}	0.7425*	0.4583
	(0.4327)	(0.4547)
tfp_{t-2}	0.9450**	1.1457***
	(0.4061)	(0.4252)
ctry	-0.3226*	-0.2876
	(0.1911)	(0.2021)
age	0.0362***	0.0423***
	(0.0106)	(0.0115)
Constant	-10.0024***	-9.2088***
	(1.8332)	(1.8629)
Observations	3903	3492
Standard errors in parentheses		
Time and industry dummies included		
*** $p \leq 0.01$, ** $p \leq 0.05$, * $p \leq 0.1$		

4.2.2 Learning

Above I have found that amongst non-importers at time $t-1$, firms that enter into international outsourcing at time t are more productive at $t-1$ and $t-2$ than those that remain non-importers at t. This leads to an endogeneity issue when testing for the productivity-enhancing effects of international outsourcing - firms may be outsourcing internationally *because* they are more productive, rather than vice-versa. To estimate the learning effect of becoming an international outsourcer, I use the propensity score matching followed by Difference in Difference (DD) method proposed by Blundell and Costa Dias (2009). This method mimics randomization by creating a counterfactual for what would have been observed if an observation did not enter into a treatment. Initially, among the pool of non-outsourcers at time (t-1), a propensity score (Rosenbaum and Ruben, 1983) for entry to international outsourcing at time t is estimated as a function of capital, tfp, export status and foreign ownership, controlling for NACE2 industry classification and year dummies:

$$Pr(Enter_t = 1) = F(tfp_{t-1}, k_{t-1}, export_{t-1}, foreign_{t-1}, \delta_i, \delta_t) \quad (4)$$

The inclusion of tfp_{t-1} is vital, as this controls for the fact that more productive firms are more likely to enter into the intermediate import market, as shown in Table 8. As a robustness check, skill intensity and investment were added as additional determinants of the propensity score, with no non-negligible difference to the significance and magnitude of coefficients resulting. A continued non-outsourcer from $t-1$ to t with the closest propensity

score is selected as a match for the outsourcing entrant at time t, using the "nearest neighbour" matching method. The DD procedure first calculates the difference between tfp before and after entry to the intermediate import market for the treatment group, conditional on the right hand side variables of Equation 4. This difference in tfp cannot be fully attributed to outsourcing, due to factors that could be contemporaneous with entry. This first difference is then differenced with respect to the before and after difference of the matched control group, i.e. firms which never begin to outsource but look like those that do begin to outsource. The DD estimator has in this step removed the effect of common shocks, providing a better estimate of the effect of international outsourcing on tfp. What I am estimating finally is the difference in tfp evolution between firms that become outsourcers and firms that *ex-ante* had the same probability of becoming an outsourcer but did not. The key assumption to identify a "learning from outsourcing" effect is that any unobservable left in the propensity score is uncorrelated with the decision to start outsourcing. Common support is also imposed, so that any observations with a propensity score too far away from their nearest neighbour are dropped. These dropped firms never amount to more than five, indicating the matching procedure does not result in many outliers. Furthermore, for each regression a balancing test has been performed before and after the matching. The t-tests for the mean of tfp, k, $export$ and $foreign$ indicate in each regression that the matched and control groups do not have significantly differing means. Table 8 reports results from the matching DD estimator. Each figure reported corresponds to the average treatment effect on the treated (those entering into international outsourcing). The sample size of the treatment and control groups are reported below the coefficients. There are 831 firms that become international outsourcers and remain in existence for at least one year[7]. 391 firms become international outsourcers and continue to do so for 2 periods, while 168 do so for three periods and a mere 63 do so for four periods. The outcome variable of interest is the mean difference in tfp, one, two, three and four years after the switch into international outsourcing. The initial regressions on the top line indicate that firms increase their productivity over a one, two and three year horizon after becoming international outsourcers. This is at odds with Vogel and Wagner (2008) who find no evidence of learning from importing.

The story is not fully told from the top line, however. By the same logic offered in the previous section, we should expect that firms with lower *ex-ante* productivity should be more likely to experience gains from entering the outsourcing market. Internationalised firms (which in this sample are indigenous exporters and foreign affiliates) are found to never benefit in tfp terms from becoming an international outsourcer. For indigenous domestic

[7]The reader is reminded that the data run from 2001-2005.

market-serving firms, however, over one and two year horizons, average tfp increases by almost two percent due to the entry to the import market for intermediates. These results show that there are dynamic effects to becoming an outsourcer for domestic firms, along with the productivity-enhancing effects reported in Section 1. For indigenous exporters, there is an instantaneous increase, only significant at the ten percent level, however. The results of Table 8 fit in with the pattern uncovered throughout the paper; for firms that are completely domestic, international outsourcing may be seen as a productivity-driving first step into international trade. For firms that are already internationalised, however, entering into international outsourcing is not as important a factor in productivity-improving shifts in firm operations.

Table 8: average treatment effect on the treated for entry to international outsourcing, for all firms and HMY decomposition

Outcome = Δtfp_{t+s}	s=1	s=2	s=3	s=4
All firms	0.0168***	0.0180***	0.0108***	-0.00317
	(.0048)	(.0044)	(.0050)	(.0060)
Treatment	831	391	168	63
Control	4801	2557	1184	435
Domestic	0.0193***	0.0199***	0.0005	0.0081
	(.0048)	(.0048)	(.0056)	(.0054)
Treatment	404	182	69	23
Control	3684	1981	920	290
Exporter	0.0251*	0.0134	0.0147	.0028
	(.0120)	(.0084)	(.0104)	(.0091)
Treatment	247	98	31	8
Control	687	271	81	21
Foreign	-0.0653	0.0153	0.0143	0.00549
	(.0455)	(.0377)	(.0209)	(n/a)
Treatment	54	19	3	1
Control	152	59	22	5

Standard errors in parentheses
*** $p \leq 0.01$, ** $p \leq 0.05$, * $p \leq 0.1$

5 Conclusion

The main aim of this paper is to investigate the causal effect of international outsourcing on firm tfp. The literature, adopting very different approaches, has generally found that international outsourcing is good for firms' productivity. A significant contribution of this paper is to show that differing methods of measuring international outsourcing, applied to the same data, can come up with widely differing results. A higher intensity of outsourcing leads to increases in tfp for indigenous exporters and multinational affiliates

(Table 4). This conclusion, that the international orientation of firms matters, has been found in previous studies such as Görg et al. (2004). I argue that this method does not identify the appropriate mechanisms needed if we believe the "international technology diffusion" literature summarised by Keller (2004). As an alternative to outsourcing intensity, a discrete variable indicating whether or not a firm imports their intermediates is included in the production function. This discrete variable finds support for the hypothesis that domestic-market-serving firms are more likely to benefit from international outsourcing, as other firms will have experienced productivity improvements from exporting or international investment. This logic is again applied when examining the *dynamic* effect of *becoming* an international outsourcer on tfp. This approach is similar to that of Bernard and Jensen (1999) for exporting. Support is found for the idea that more productive firms select into outsourcing, following Melitz's (2003) logic for exporting, using a random effects probit model. Given this fact, endogeneity is then considered an issue when any effect from international outsourcing to productivity is estimated. A matching difference in difference estimator, as proposed in Blundell and Costa-Dias (2009) is used to estimate the effect of becoming an international outsourcer on tfp. I again find that indigenous non-exporters benefit the most from becoming international outsourcing firms. As argued above, there are logical reasons to expect a weaker effect for indigenous exporters or foreign affiliates. These results suggest that being an internationalised firm is what matters. A future research question emanating from the findings of this paper could revolve around the question of whether there is indeed a hierarchy of entry to international activities, i.e. an examination of whether the order in which firms enter importing, exporting and foreign investment matters for the productivity improvements from each activity.

Appendix 3.1 - tfp estimation

A production function is set up in logs as follows:

$$y_{it} = \beta_k k_{it} + \beta_l l_{it} + \beta_m m_{it} + \omega_{it} + \eta_{it} \tag{5}$$

where y_{it} is log of gross output, k_{it} is log of capital, m_{it} is log of material inputs used and l_{it} is log of labour input. ω_{it} and η_{it} are unobservable to the econometrician. The difference between the two unobservables is vital to the rest of the model: ω_{it} represents shocks that are potentially observable to the firm when it makes its production decisions at time t, such as managerial ability, expected down-time of machinery or expected changes in the manufacturing environment. This ω_{it} is often referred to as the "productivity shock". η_{it} represent shocks that are unobservable both to the firm and

econometrician when the firm makes its production decision at time t.

Olley and Pakes (1996), OP from here on, deal with the well-established endogeneity problem between ω and factor inputs by imposing structure on the firm's behaviour and movement through discrete time. Under certain assumptions, which have been the cause of much concern to econometricians, the following investment function can be inverted, leading to an expression for unobservable productivity.

$$i_{it} = f_t(\omega_{it}, k_{it}, d_{it}) \Leftrightarrow \omega_{it} = f^{-1}(i_{it}, k_{it}, d_{it}) \tag{6}$$

where i_{it} is investment and d_{it} is the firm's outsourcing status or intensity. This treatment of the firm's outsourcing status is identical to de Loecker's (2007) treatment of exporting. In the traditional Olley-Pakes estimator, Φ will be a function of investment and capital only.
Stage 1 of this modified OP estimator runs

$$y_{it} = \beta_l l_{it} + \beta_m m_{it} + \Phi_t(i_{it}, k_{it}, d_{it}) + \eta_{it} \tag{7}$$

where $\Phi_t = \beta_k k_{it} + f^{-1}(i_{it}, k_{it}, d_{it})$, meaning that β_k is unidentified in the first stage. Φ_t is a polynomial function of the firm's control variables, investment, capital and outsourcing status/intensity. Labour and materials are considered to be variable inputs and can thus be estimated consistently outside of Φ in Stage 1.

The next stage accounts for exit from the sample. The probability of exit from the sample is calculated as

$$Pr(\chi_{i,t+1} = 1|I_t) = Pr(\chi_{i,t+1} = 1|\omega_{it}, \underline{\omega}_{i,t+1}, (k_{i,t+1})) = \hat{P}_{it}(i_{it}, k_{it}, d_{it}) \tag{8}$$

where $\underline{\omega}_{i,t+1}$ is the productivity value in $(t+1)$ that causes the firm to be indifferent between continuing and exiting. Armed with this estimate of the probability of survival, which is allowed to depend on the outsourcing status or intensity of the firm, the last stage identifies a consistent coefficient on capital. It is calculated using a non-linear least squares estimator on the following equation:

$$y_{i,t+1} - \beta_l l_{i,t+1} - \beta_m m_{i,t+1} = \beta_0 + \beta_k k_{i,t+1} + g((\hat{\Phi} - \beta_k k_{it}), \hat{P}_{i,t+1}) + \eta_{it} \tag{9}$$

This NNLS estimate requires that β_k be consistent across time. Given that outsourcing was included in the first stage, an estimate for outsourcing is recovered in this third stage (this of course does not hold in the traditional OP estimator). Given Φ and $\hat{\beta}_k k$ we can back out tfp as $\omega_{it} = \hat{\Phi} - \hat{\beta}_k k_{it}$.

Appendix 3.2 - Robustness checks

The *Census of Industrial Production* comprises differing survey forms for plants which form an enterprise (single-plant firms) and plants that are part of a multi-plant enterprise. Importantly for this study, for plants that are part of a multi-plant enterprise, the question regarding the percentage of purchases coming from affiliated firms is only asked to the enterprise and not to the plant. The figure reported in the data for affiliate purchases for such plants is in fact a statistical imputation carried out by the Central Statistics Office. Of the plants in the data, a very significant proportion (93% of domestic firms, 93% of exporters, 84% of foreign affiliates) are single-plant firms in Ireland, which means this is not a major issue. In any case, any bias resulting from potentially erroneous imputation should be accounted for. I take all firms for whom the total enterprise value for affiliate purchases was zero. This means that the CSO's imputed value for each plant within the enterprise will be zero, thus leaving no imputation worries. I run all regressions on all these firms, with minimal change from the regressions reported in Sections 1 and 2. With this robustness check, this data worry should be assuaged.

As an alternative to breaking the data down by Helpman, Melitz and Yeaple (2004) into indigenous non-exporters, indigenous exporters and foreign affiliates, as in Tables 3.4 and 3.6, I run a single regression in which the outsourcing variable in question is interacted with a dummy for each HMY category. This allows the effect of being in different HMY categories to be pinned down by ensuring that the intercept and coefficients on l, k and m are identical for all firms. The results of this robustness check for Tables 3.4 and 3.6 show that, across all specifications, whether the coefficients on the production inputs are allowed to differ across HMY categories has almost no impact: the coefficients on the interacted outsourcing term are almost identical to three decimal places to the corresponding subgroup coefficients in Table 4 for outsourcing intensity and are similar, usually identical to a minimum of two decimal places for all except Difference GMM for domestic firms in Table 6 for outsourcing status.

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