Outsourcing and Firm Productivity

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Abstract

I attempt to identify a causal link between the outsourcing of parts of the production process and firm productivity for a large panel of Irish manufacturing firms. Outsourcing is taken to mean the procurement of inputs from outside the boundaries of the firm, with international outsourcing being outsourcing from a foreign provider. Theory suggests that as firms outsource more 'non-core' activities to specialized providers, productivity will increase along two channels: in the short-run, the firm will benefit from cheaper or higher-quality inputs, while in the medium term the firm will be able to reallocate resources towards higher value-added activities. The international outsourcing case adds another dimension, in that firms that oursource from abroad can experience further productivity gains from the higher quality and variety of inputs on offer and from exposure to new technologies, practices and knowledge. I test the above hypothesis using a 'System GMM' estimator as developed by Arellano and Bover (1995) and Blundell and Bond (1998) to control for endogeneity in the panel and allow for a lagged dependent variable to be a regressor. I find that international outsourcing leads to productivity gains, but upon closer inspection that the international orietnation of firms matters. Domestic market-serving firms do not experience gains from outsourcing in any form. I also find that foreign firms in Ireland do not benefit from domestic outsourcing, which is a cause for concern and a legitimate policy target.

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1 Introduction

Outsourcing, defined here as the sourcing of inputs to the production process from outside the boundaries of the firm, has become increasingly prevalent in the last decade, both in its extent and its coverage in the media. Technological advancement and increased global economic integration have reduced transport and trade costs. This, along with increased competitive pressures and the IT and telecommunications revolution of the last two decades, have led to an increased specialization of production across national borders, which we refer to as international or offshore outsourcing. An important clarification must be made straight away, however, as the terminology has often been confused in the literature and particularly in the business press[1]. Outsourcing is defined as the sourcing of inputs from outside the firm, regardless of whether these inputs are sourced abroad or domestically. International or offshore outsourcing, on the contrary, is the sourcing of inputs from outside the boundaries of the firm and beyond home country borders. This should not be confused with offshoring, which is the relocation of a part of the production process to another country, which can occur within the boundaries of the firm through Foreign Direct Investment (FDI) or outside those boundaries (offshore outsourcing).

Some clarifications around the attention given to outsourcing in the media and literature are also necessary. This attention seems to focus in general on fears regarding developed country labour markets and on the proliferation of international services outsourcing, particularly to India.

In addressing the first of these points, it must be pointed out that fears regarding job losses, particularly in the US, may in fact be overstated. The focus on these fears exists in the academic literature but is more prevalent in the media. Famous BusinessWeek headlines have included "The new global job shift" (Feb 3 2003), with that issue's front cover asking "Is your job next?". Initially, fears regarding outsourcing focused on so-called "material"' outsourcing, with resulting fears for the loss of blue-collar jobs in developed countries. These fears seem justified in the light of sizeable relocation of manufacturing jobs in the US and EU to China, Mexico, Eastern Europe and other low-cost locations. Falk and Wolfmayer (2008) find that the outsourcing of materials and services to low-wage locations both have a small negative impact on home employment at the industry level, while outsourcing to similar countries has no significant effect. More recently, the massive attention given to the offshoring of services to countries such as India has led this fear to spread to white collar workers. Jensen and Kletzer

[1] For further distinguishing definitions of the fragmentation of the production process, see Olsen (2006), Section 2

(2006) find that white-collar workers in sectors defined as tradeable have higher displacement rates than their counterparts in non-tradeable sectors. They classify activities that are traded domestically in the US, calculated using geographic concentration data, as *potentially* tradable internationally. They also find negative employment growth for low-skilled workers in the tradeable sectors. They further find that the percentage of job losses in the US accounted for by information, business and financial services has gone from 15% to 43% from the 1979-82 to 2001-2003 periods. None of the above, however, amounts to a credible account of the effect of international outsourcing on US jobs. Rather this paper merely speculates as to the magnitude of the new type of jobs that may possibly be lost due to the phenomenon.

On the other side of the argument, Kierkegaard (2003) reports that the vast majority of jobs lost in the period 2000-2002 were in sectors with an average wage below the US national average. He implies that the counterfactual to these jobs being offshored is their replacement by automated means in the medium term. The policy implication of his finding is that the jobs being lost to offshoring would probably not be saved by any policy drive to prevent offshoring. Further, Amiti and Wei (2004) find that services outsourcing leads to a positive significant effect on employment at the industry level. Mann (2003) also points to the *Occupation Outlook Handbook*, stating that 3 of the top 10 sectors in terms of employment growth for 2000-2010 were in computer-related occupations, and to the Bureau of Labour Statistics, stating that 10 of the top 20 job categories in terms of growth prospects were IT-related. The only sectors that were predicted to fall were sectors that could as easily have been automated as offshored, giving the same policy conclusion as Kierkegaard (2003) mentioned above.

Referring to the Japanese labour market, Ahn et al (2008), using COMTRADE commodity data, find that outsourcing to Asia (in particular to China) had a negative effect on Japanese low-skilled labour demand, but a positive effect on high-skilled labour demand. They also find skill upgrading in Japanes manufacturing as a result of outsourcing. This paper has findings most in line with the theoretical explanation of the effects of outsourcing on the labour market, that it will lead to a reallocation away from unskilled labour in the developed country by allowing firms to focus resources on activities in which they have a comparative advantage. The authors also find that outsourcing from Japan to other developed countries, such as the EU, has a negative impact on high-skilled labour demand and a positive impact on low-skilled labour demand. This also seems intuitive if we think that a Japanese firm would only outsource to the EU in order to have a high-skilled complex task done to a better quality there, rather than to save costs.

Data on job losses related to offshoring is hard to come by. One oft-cited report is Forrester (2002), which predicted that 3.3 million US jobs would be lost to offhsoring by 2015. This was revised to 3.4 million by McCarthy (2004). To put this figure into context, many commentators, including Kierkegaard (2003) and Rohde (2004) refer to a quarterly job destruction rate (often referred to as "job churn")in the US of between 7-8 million jobs. Furthermore, Slaughter (2004) reports that 5.4 million jobs in the US for 2002 were attributable to outsourcing to US companies by overseas firms. This figure is larger than any estimates of jobs lost to offshoring, implying that the US is in fact a net beneficiary from the offshoring phenomenon. The services trade balance of payments figures also show the US to be a net beneficiary from services offshoring. Amiti and Wei (2004) report a US Business Services trade surplus of $18bn and a Computer and Information Services surplus of $3bn 2002. Jensen and Kletzer (2006) also allude to a US trade surplus in services of $74 bn for 2002.

Moving onto the magnitude of the attention given to the services side of the outsourcing phenomenon, I feel compelled to outline the true extent of international services outsourcing. The reality is that international outsourcing in the service industry is far smaller than that in the manufacturing sector. Yeats (1998) reports that for 1995 trade in parts and components in the Machinery and Transportation (SITC 7) sector alone totalled roughly $550bn. This sector accounted for about half of global manufacturing trade in that year. Kimura et al (2007) show global exports of machinery parts and components to have reached $1.3trillion by 2003, which was 45% of all machinery exports and 20% of all global commodity exports. To put these figures in perspective, Amiti and Wei (2004) show that the top ten importers of Business and ICT services (the sectors most affected by international services outsourcing) in 2002 accounted for a mere $200bn[2], while Rohde (2004) estimates global business service outsourcing to be $160bn for 2005. Amiti and Wei (2004) also calculate average industry-level international outsourcing intensity ratios, weighted by output, for the UK and US. They find figures of 5.5 and 0.8 percent respectively for services outsourcing against 27 and 12 percent respectively for material outsourcing. They do however show that the services figures are trending upwards while the materials figures decreased in the late nineties and are roughly stagnant since.

[2]Unfortunately the authors do not give a figure for total global service imports. From eyeballing the data, however, it does not appear that the countries outside the top ten account for much more than another $100bn, leaving global Business and ICT Service imports lying between $200bn-$300bn

The far greater importance of "parts and components" or "materials" outsourcing is also borne out in the data in this paper. Figure 1 [3]shows that materials outsourcing far outweighs that of services for the firms in the Census of Industrial Production dataset. In Table 2 it is clear that the intensity of materials outsourcing is far greater than that for services outsourcing for Irish manufacturing firms from 1991-2005. Further details of the data will be given in Section 3.

While the coverage of labour-market effects is very important and politically-charged, and has warranted wide attention, much less attention has been given to the reasons underlying firms' outsourcing decisions. Girma and Gorg (2004) model the decision to outsource. Their estimations indicate that higher-wage firms are more likely to outsource, as are larger firms, foreign-owned firms, and more skill-intensive firms. However when they include the lagged levcel of outsourcing as a regressor in a first-differenced equation, they find that only foreign ownership remains statistically significant.

Another important important question that should be answered in the outsourcing debate is whether or not firms indeed benefit from the outsourcing of certain activities. Rohde (2004) references two reports which point to the dangers inherent in engaging in international outsourcing: a 2003 Gartner report which estimated $6bn was wasted annually on failed outsourcing contracts, and a Clearview consulting report which calculated a "flop rate" of 40-50% for outsourcing contracts. The question of outsourcing's link to firm performance is the focus of this paper, with firms' labour productivity as the dependent variable.

A sparsely populated existing literature has generally found evidence for the positive effect of outsourcing on firm productivity. Olsen (2006) gives a good overview of this literature, including studies at industry level. After synopsising the avenues through which outsourcing can increase firm productivity, I will briefly mention some of the firm-level studies carried out to date.

At the most basic level, outsourcing can be thought of as the replacement of a firm's employees and processes with an outside provider. When a process or input is outsourced, the firm reduces it's marginal costs. This cost reduction will usuually come throuogh lower wages, which could prevail outside the firm due to a multitude of reasons, including workers' unionisation, efficiency wage payment, or, if the outsurcing is international, different factor endowments in countries such as China, India and those in Eastern Europe. Dut to Smithian specialisation, the processes or inputs which have

[3]Figure 1 does not yet exist

been outsourced may also be available at a higher quality as well as at a lower cost than would have been possible within the firm's boundaries, leading to a productivity enhancment. Further, a firm can reallocate any excess labour that it has replaced with an outside provider to areas in which it has a comparative advantage, leading to long-run increases in productivity. Outsourcing can also help in smoothing out seasonal fluctuations in economic activity. All of the above-mentioned reasons explain why outsourcing can increase productivity in general. There are numerous reasons why international outsourcing can lead to further productivity gains beyond those mentioned above. The increase in the variety of inputs acquired from international outsourcing can shift the firm's technolgy frontier, through workers becoming more efficient as a result of the new inputs, or through access to more sophisticated technologies. The procurement of service inputs from abroad can also lead to "learning by doing" effects for employees exposed to the new methods. In the empirical section of this paper, I will test whether there is a productivity improvement associated with international outsourcing only, outsourcing in general, or neither.

Early work on outsourcing by Gorzig and Stephan (2002) and Girma and Gorg (2004) did not differentiate bewteen domestic and international outsourcing. The former paper, using German data, generally finds positive and significant effects of outsourcing on returns per employee, but negative effects of service outsourcing on firm profitability, which it uses as an alternative measure of performance in some specifications. The latter paper, using UK data, defines outsourcing as the "cost of industrial services received". Their outsourcing intensity variable is then the ratio of outsourcing to the total wage bill. It finds positive and significant effects of outsourcing on productivity, and finds that this effect is more pronounced for foreign-owned firms. The results only hold in the chemical and engineering sectors however.
Gorg and Hanley (2005), using Irish electronics sector firm-level data from Forfas, find statistically significant positive effects of international outsourcing on productivity. International outsourcing in this case is measured as the ratio of imported inputs to total inputs. When the data is broken down, it appears that only material outsourcing leads to productivity improvements, with no effect from services outsourcing. On further inspection, the authors find that the effect only holds for plants with low export intensities. Employing a similar estimation framework to data on firms in all Irish manufacturing industries, Gorg et al (2004) conjecture that the international orientation of firms is vital in determining the benefit they can reap from outsourcing. They find evidence that foreign-owned firms' productivity increases with both materials and services outsourcing. For Irish-owned firms they find a positive significant effect for materials, but a negative effect for services.

Similar results are borne out when the data is broken down by export status. Exporters have a positive sign for both types of outsourcing, while purely domestic firms have significant negative effects on their productivity due to outsourcing.
There are a number of papers that look at the link between outsourcing and productivity at the industry level. One recent example is Amiti and Wei (2006), which focuses solely on the international outsourcing of services. They combine input-output tables with trade data to get estimates for the level of international outsourcing for 450 manufacturing industries. In regressions explaining labour productivity, they find a positive and significant coefficient on international service outsourcing, twice the magnitude of that on international material outsourcing.

I model outsourcing as affecting the technology parameter in a Cobb-Douglas Production Function framework. Above and beyond the productivity enhancement that materials and services offer as inputs, I posit that the intensity with which firms outsource, both at home and abroad, can have an additional producitivity-enhancing effect, for reasons mentioned above. One consideration when analysing the effect of international outsourcing is through which channel outsourcing has its effect: through input quality and variety, worker and manager know-how, and learning-by-doing effects, or through extreme cost savings. The modern interpretation of international outsourcing as a cost-saving practice engaged in with firms in India and China does not seem to fit the Irish data. A look at Table 1 will show that the vast majority of Irish firms' inputs have come from other developed nations in the EU, along with the US and UK. This allows me to claim with confidence that when I test for the productivity-enhancing effects of international outsourcing, I am indeed testing for effects such as exposure to technology and know-how, and variety and quality of inputs.
I test these hypotheses using a System GMM Dynamic Panel Data specification, developed by Arellano and Bover (1995) and Blundell and Bond (1998). This specification allows for a lagged dependent variable and for endogeneity in inputs and the outsourcing decision. These issues are discussed further in Section 4.

The rest of the paper is organised as follows: Section 2 introduces a theoretical framework in which outsourcing and international outsurcing can affect firm-level producivity. Section 3 explains the data source, the CSO Census of Industrial Production. Section 4 reports regression results, while Section 5 concludes.

2 Theoretical Framework

I explain the potential prodcutivity benefits of outsourcing, as in most of the literature on the topic, within the Cobb-Douglas Production Function framework. In the first instance, I posit that only international outsourcing can have an effect on the technolgy shifter. In the second instance, the intesntity of both domestic and international outsourcing are allowed to have an effect.

2.1 International outsourcing as a determining factor

The C-D Function with capital, labour, materials and services included as inputs looks as follows:
$Y_{it} = A_{it}[F(K_{it}, L_{it}, M_{it})]$

Where A is the technology shifter, K_{it} is firm capital stock, L_{it} is labour, measured as number of employees per firm and M_{it} is material inputs. If we take logs and subtract $l_i = ln(L_i)$ from both sides, thus transforming both sides to levels per employee, we get the following expression for the log of labour productivity:
$y_{it} - l_{it} = a_{it} + \beta_1(k_{it} - l_{it}) + \beta_2(m_{it} - l_{it}) + \beta_3(s_{it} - l_{it})$
Where miniscules indicate logs.

It is common to incorporate international outsourcing's effect on productivity into this framework through the technology factor in the production function, as outlined by Olsen (2006). To achieve this, I define from above, $a_{it} = \alpha_0 + OS_{it}^m + \delta Z_{it}$
Where OS is a measure of international outsourcing intensity and Z is a vector of firm characteristics that could include export status, ownership status, location, age, etc.

This means we are allowing international outsourcing, along with some other firm characteristics, to shift the intercept of the production function. Adding in a dynamic element, this gives the following base regression:

$y_{it} - l_{it} = \alpha_0 + \alpha_1 OS_{it} + \alpha_2 Z_{it} + \beta_1(k_{it} - l_{it}) + \beta_2(m_{it} - l_{it}) + \beta_3(y_{i,t-1} - l_{i,t-1}) + \omega_i + \epsilon_{it}$ (1)

Where OS refers to International Outsurcing and Z refers to a vector of other firm characteristics, which could include country of ownership, export status, skill intensity of workforce and age, ω refers to firm fixed effects and ϵ refers to the error term.

2.2 Outsourcing as a determining factor

Here I start off in exactly the same way as above,
$Y_{it} = A_{it}[F(K_{it}, L_{it}, M_{it})]$
Now, however, we have $a_{it} = \alpha_0 + \alpha_1 FOS_{it} + \alpha_2 DOS_{it} + \alpha_3 SOS_{it} + \alpha_4 X_{it}$, where DOS is domestic outsourcing of materials, FOS is foreign outsourcing of materials and SOS is outsourcing of services, which can not be broken down into domestic of foreign in the data for this paper. The technology shifter is now assumed to be influenced by outsourcing of inputs from outside the firm in general, not only international outsourcing of inputs. Once a dynamic specification is allowed, we end up with the following:
$y_{it} - l_{it} = \alpha_0 + \beta_1 y_{it-1} + \beta_2(k_{it} - l_{it}) + \alpha_0 + \alpha_1 FOS_{it} + \alpha_2 DOS_{it} + \alpha_3 SOS_{it} + \alpha_4 X_{it} + \delta Z_i + \mu_i + \epsilon_{it}$ (2)

I have now derived two estimable equations (1) and (2), which will be the subject of regression analysis in Section 4.

3 Data

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 a compulsory survey, giving plant and enterprise-level information on all manufacturing firms with 3 or more persons engaged in Ireland from 1991-2005. The availability of plant-level data allows the exploitation of productivity heterogeneity within industries, something which is not possible with aggregate-level studies. 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 outlined in Table 2. Out of 9,837 firm IDs that appear in the sample, 1564 appear in every year. All monetary variables have been deflated using the CSO's *Consumer Price Index Annual % changes* table, with 1991 used as the base year.

My dependent variable is the log of labour productivity, where labour productivity is calculated as gross output divided by total number of employees. We see from Table 2 that this is smallest for Irish domestic market-serving firms, larger for Irish exporters and larger still for foreign-owned firms, in line with the predictions of the Melitz strand of theoretical literature. We also see from the data that Irish firms are smaller than exporters, who are much smaller than foreign-owned firms. This same ranking holds true for capital stock, for which I have had to use a proxy due to data restrictions. The proxy is the amount of fuel used, in line

with Ruane and Ugur (2002), which uses this dataset to analyse the productivity spillover effects of foreign presence in Ireland on Irish firms.

Table 2: Summary Firm Characteristics			
	Dom	Ex	For
Dom Mat OS	3.181	3.1	1.436
For Mat OS	0.7815	1.5962	3.1489
Serv OS	0.177	0.143	0.1668
logprod	10.94	11.0698	11.6855
firm size	23	43	161
l	2.508	2.857	4.216
k	6.872	6.918	7.267

I calculate the outsourcing intensity for each type of input as the ratio of the purchases of that input from outside the firm to the firm's total wage bill. My Materials Outsourcing variable is total materials purchased[4]. The foreign/domestic outsourcing distinction is simply given by the total figure multiplied by the percentage reported as imported and as sourced within the Republic of Ireland respectively. This approach seems sensible if we think that outsourcing is a way of replacing labour costs within a firm. I also adopt an alternative approach in some regression specifications, as suggested by Gorg and Hanley (2005), using the ratio of the purchases of a given input to the total purchases of the firm. We see again from Table 2 that Irish firms source more from Ireland than exporters, who in turn source more than foreign-owned firms. The opposite applies for Foreign Materials Outsourcing, which is to be expected if we believe the Melitz selection argument that only more productive firms can overcome the fixed costs involved in entering foreign markets, whether they be export or input-importing markets. My Services Outsourcing variable is defined as "work done on commission or contract, amounts paid for repairs and maintenance, etc"'. As mentioned above, this variable is unfortunately not separable into domestic and foreign components. For this reason we have no *a priori* expectations regarding which type of firm will outsource more services. As it turns out, it is Irish domestic firms that have the highest services outsourcing intensity. This indicates that, if the trend in Materials is followed, most services outsourcing is domestic rather than international outsourcing.
The CIP data allow for a much more direct measure of outsourcing than that used in older studies such as Feenstra and Hanson (1999). This older measure involves

[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"'

calculating the share of imported intermediate inputs over total costs at the industry level. The availability of sourcing decisions at the firm level means that we are sure we are dealing with a much more accurate measure of outsourcing than that used in these older studies.
In Table 3 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 export. For Irish-owned firms, we see that roughly half export some of their output.

Table 3: International Orientation		
	Irl	For
Domestic	49.9%	10.1%
Exporter	50.1%	89.9%

3.1 Outsourcing in Ireland

Ireland, as one of the world's most globalised countries, seems an interesting country in which to study the effects of outsourcing on firms' performance. On the services side, Amiti and Wei (2004) report Ireland to be the world's largest exporter of Computer and Information Services for 2002, indicating that Ireland is a net beneficiary from service outsourcing. The Irish Central Statistics Office (CSO) Balance of International Payments data indicates that this is not necessarily the case. For 2006, 2007 and the first quarter of 2008, Ireland is running a trade deficit in services. It's main surplus sectors are Computer Services (21bn) and Financial Services (3bn), which admittedly indicate that Irish firms do benefit from international outsourcing of services. The deficit is being driven mainly by Royalties payments (16.4bn), but Miscellaneous Business Services, an offshoring-related sector in which one would have expected Ireland to run a surplus, also contributes heavily to the deficit (13bn). These figures indicate that Irish firms are engaging in international outsourcing itself to a large extent, rather than only benefiting from foreign firms' outsourcing decisions. The extent to which the purchases of these services from overseas takes place within the manufacturing sector, which is the focus of this study, can not be ascertained from the data unfortunately.

Table 4 gives an indication of the relative intensity with which materials and services are outsourced by firms in the CIP data. Outsourcing intensity is calculated as the amount outsourced divided by the firm's total wage bill, as suggested in Gorg and Hanley (2005). Similarly to the cases alluded to in the introduction, we see that materials outsourcing is far more prevalent that services outsourcing.

We also see that roughly twice as much material outsourcing takes place within Ireland than from firms overseas, indicating that Irish manufacturing firms certainly have not abandoned the Irish market in the search for eithere higher quality or lower-cost inputs.

Table 4: Evolution of outsourcing intensities				
Source	1992	1996	2000	2004
Materials	4.59	4.73	6.288	2.76
Foreign Mat	1.68	1.56	1.53	.996
Domestic Mat	2.91	3.17	4.75	1.76
Service	.1177	.1427	.2986	.1289

Wakasugi et al (2008) show that for Japanese firms, the extent of offshore outsourcing increases with firm size. 10% of firms employing 99 or less emplyees engaged in offshore outsourcing, with that figure rising to 20%, 50% and 65% for firms under 300 employees, less than 1,000 and over 1,000 respectively. I find a similar pattern for Irish firms. For firms employing under 20 people, the international outsourcing intensity ratio is 1.23. For firms between 20 and 50 employees it is 1.38, while for firms employing more than 50 it is 2.16. This links with the the idea that only more productive firms can overcome the fixed costs of engaging with international markets, whether it be for exporting of final products or importing of inputs. This is the case due to the large correlations generally observed between firm size, productivity and international orientation.

4 Empirics

4.1 Estimation Procedure

My empirical analysis comprises the testing of equations (1) and (2). In dealing with production functions, there are a number of issues which mean that a standard Panel Data approach will not lead to credible results. Firstly, it is reasonable to believe that a production function can be characterised as a dynamic relationship. This means that there will be serial correlation in the dependent variable, so that lagged labour productivity is an important explanatory variable. Given that y_{it} is a function of the ω_i, it will immediately follow that the $y_{i,t-1}$ are correlated with the ω_i. Secondly, the endogeneity of factor inputs must be dealt with. By this I mean that it may be that more productive firms can choose to purchase more capital or materials or services, or hire more labour, rather than it simply being the case that causality only runs from inputs to productivity. Further to these problems common to all production functions, in this study there is also the possibility that international outsourcing decisions may be endogenous, i.e. more productive firms may be more likely to outsource. The reasoning behind this endogeneity can be thought of in the Melitz (2003) framework. It may be the case that more productivte firms are the only ones capable of entering into international markets for inputs, due to the higher fixed costs involved in entering these markets. If this were the case, any causal effect from international outsourcing to productivity would be endogenous. This thought line may also even apply to domestic outsourcing, if we think that there are search costs involved in finding an outsourcing partner, as in the theoretical work of Grossman and Helpman (2004) and others.

Given the possible endogeneity of the lagged dependent variable and other explanatory variables, I use the "Difference"' and "System"' GMM estimators developed by Arellano and Bond (1991), and Arellano and Bover (1995) and Blundell and Bond (1998) respectively to estimate equations () and (). To quote Roodman (2006):

> (These estimators were both designed for) situations with "large N, small T"' panels ...; independent variables that are not strictly exogenous, meaning correlated with past and possibly current realizations of the error; fixed effects; heteroskedasticity and autocorrelation within individuals

The "Difference GMM"' estimator allows the user to treat all independent variables and all lagged dependent variables as potentially endogenous. It estimates an equation in first differences to purge the fixed effects, using lagged levels of the endogenous variables and levels of the exogenous variables as instruments.

The lagged level should not be related to the error, unless the errors are serially correlated.

The "System GMM"' estimator was developed as an improvement to the Arellano-Bond estimator due to the risk that untransformed lags could be poor instruments for transformed variables if the dependent variable is close to a random walk. "System GMM"' takes differences of the instruments to make them exogenous to the fixed effects. It uses these differences as instruments for level equations, stacking them on top of the Arellano-Bond differenced equations which are still instrumnted by lagged levels, thus giving twice as many observations. Again validity of instruments depends on the errors not being serially correlated.

Another advantage of "Systems GMM"' is that it can estimate coefficients for time-invariant variables, such as the foreign ownership variable, *ctry* and the exporting variable, export in my dataset. The Arellano-Bond estimator cannot do this due to the fact that all explanatory variables are transformed by first-differencing. Baltagi (3rd Edition, what year??) also states that, relative to the Difference GMM estimator, System GMM improves precision and reduces finite sample bias, particularly for small-T samples.

The standard treatment for an endogenous regressor is to start instrumenting from the second level for the transformed equations. This is because the the first lagged level, x_{it-1} will be endogenous to the v_{it-1} in the $v_{it} - v_{it-1}$.

In some regressions, using the second lagged level as the most recent instrument is not enough to remove second-order autocorrelation in the differences i.e. first-order autocorrelation in the levels. This is because if there is serial correlation of order 1 in the errors, $x_{i,t-2}$ is endogenous to the Δv_{it-1} term in the error term in differences, $v_{it} - v_{i,t-1}$. In this case, I am forced to start instrumenting with the third lagged difference. The lagged difference with which I start will be reported in every regression column in the row "laglimits".

4.2 Regression Results

In my first regressions, I estimate Equation (1) using the "System GMM" estimator. A positive significant coefficient on the international outsourcing variable indicates that it does indeed have an effect on the firm's technology shifter, and hence on firm productivity. The results of the regressions on the full sample of firms are reported in column (1) of Table 5 below. An insignificant coefficient is marked in bold font. We find the expected positive significant coefficients on the lagged dependent variable and on the Cobb-Douglas inputs. Export status does not have a significant effect however. This is surprising, but may be expected given that in many previous studies using Irish data the productivity differential due to exporting has proven difficult to prove. Foreign ownership on the other hand does have a positive significant coefficient, which we should also expect from the Melitz (2004) line of theoretical research. The parameter of interest, international material outsourcing intensity, also comes in with a positive, significant, albeit small coefficient. A one unit increase in the outsourcing intensity variable leads to a quarter of a percent increase in firm labour productivity.

Given the possibility that this effect may not be applicable to all firms, I then break the data down into three subgroups: Irish domestic firms, Irish exporters, and foreign-owned firms. I then run Equation (1) on these three subsamples with the results shown in columns (2), (3) and (4). From this breakdown we can see that the effect of international outsourcing on firm productivity does depend on the international orientation of the firm. All other variables have the same sign and significance as the full sample. Foreign owned firms get three times as large an increase from international outsourcing as exporters, while domestic firms do not experience an increase. If we believe that the exposure to international markets, a knowledge of global production processes, an embeddedness in international production networks and easier access to more advanced technologies are associated with international orientation, then these results seem to make sense.

Dependent variable: log of labour productivity				
	(1)	(2)	(3)	(4)
Subsample	Full	For	Exp	Dom
L1.Logprod	.6295	.588	.4195	.3266
L2.logprod	-.0626	.0783	.04344	.11987
k	.0395	.0394	.0752	.0828
m	.2543	.2021	.3081	.2789
export	**-.00001**	**.0241**	n/a	n/a
ctry	.0628	n/a	n/a	n/a
ForMatOS	.00257	.00736	.00232	**.00205**
D.t?	y	y	y	y
D.i?	y	y	y	y
laglimits	3	3	3	4
A-B stat	**0.00**	.413	.154	**0.00**
Obs	47,092	6,602	15,339	15,760

Table 5: Estimation of Equation (1)

From the above it seems that international outsourcing does have an effect on firm productivity. As mentioned earlier, we can be confident that this effect arises due to increased input variety and/or quality, or a technology or know-how access effect, rather than through cost savings. This is due to the provenance of imported inputs in the data, which in the vast majority come from other developed nations.

Moving on to Equation (2), I am now interested in testing whether the intensity of domestic material outsourcing and service outsourcing have an effect on the technology shifter. Columns (5) to (7) report the results of the estimation of Equation (2) using the "System GMM" estimator. The significance of international material outsourcing does not change when we include these two extra variables. Foreign and exporting firms still gain from international outsourcing, while domestic firms do not. In many instances we see that the intensity with which firms source inputs from outside the boundaries of the firm does not matter, unless they are sourced from beyond the borders of the firm's home nation. Exceptions to this are (a): foreign owned firms experience a productivity boost from service outsourcing intensity; (b) exporters experience a gain from domestic outsourcing. This may be expected as these exporters are still Irish firms, who preseumably are well linked into both Irish and overseas markets. Foreign owned firms, on the other hand, would be expected to have more difficulty successfully sourcing inputs from Irish firms, and this is borne out in the results. These finding can have interesting implications for firms and policymakers alike. One policy

insight may be to attempt to better align Irish input suppliers with foreign owned firms, which would help create gains for foreign firms and for indigenous Irish industry. At the moment the fact that productvity gains from this type of arrangement seem hard to come by may be leading to foreign firms continuing to source inputs from abroad, at the expense of Irish firms and jobs.

Dependent variable: log of labour productivity			
	(5)	(6)	(7)
Subsample	For	Exp	Dom
L1.Logprod	.599	.3189	.3783
L2.logprod	.0792	.0833	.0784
k	.0494	.0737	.1086
m	.1999	.34	.3034
export	**.0309**	n/a	n/a
ctry	n/a	n/a	n/a
ForMatOS	.0069	.0029	**.-.0016**
DomMatOS	**.0037**	0.0055	**-.0005**
ServOS	.0295	**-0.024**	**.0197**
D.t?	y	y	y
D.i?	y	y	y
laglimits	3	3	4
A-B stat	.543	.251	**0.00**
Obs	6,602	15,339	15,760

Table 6: Estimation of Equation (2)

5 Conclusions

The outsurcing of inputs to the production process can lead to productivity gains at firm level. These gains can arise through cost savings, higher quality products from specialised providers, reallocation of workers and resources to "core competence" activities, and in the case of international outsourcing, higher quality or variety of inputs, exposure to new tehcnologies and know-how and learning-by-doing effects for workers. After having theoretically explained how outsourcing can affect productivity in a Cobb-Douglas production function framework, I go on to test the hypothesisis using a "System GMM" estimator on data for Irish manufacturing firms. This estimator allows for a lagged dependent variable and

endogenous inputs. Upon estimating, I find a positive significant effect of international outsurcing of material inputs on firm productivity. Upon further inspection I find that this effect exists for foreign and exporting firms but not for Irish domestic firms, indicating that exposure to foreign markets is important in securing gains from international outsourcing for a firm. When I include domestic outsourcing, I find that foreign firms do not experience productivity gains. This finding could lead to an interesting recommendation looking to improve the linkages between foreign-owned firms and their Irish suppliers. If these links are not improved it would be sensible for foreign-owned firms in Ireland to continue to source their inputs from abroad, given that I show that this type of outsourcing does lead to a productivity gain.

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99

6 appendix

Table 1: Evolution of Irish Input Imports by Provenance					
Source	2001	2002	2003	2004	2005
UK	18.24	18.58	13.96	12.6	14.37
EU	11.28	10.27	7.96	9.92	10.94
US	3.12	3.43	3.82	3.78	3.48
RofW	3.35	3.5	3.99	3.69	3.85
Imports/Materials	37%	36%	31%	32%	36%

Table 2: Sample Size by Year	
1992	4473
1993	4459
1994	4541
1995	4586
1996	4605
1997	4740
1998	4713
1999	4799
2000	5051
2001	4948
2002	5189
2003	5169
2004	4885
2005	4508