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International Outsourcing and Productivity: Evidence from Plant Level Data

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International outsourcing and productivity: Evidence from plant level data

by

Holger Görg and Aoife Hanley

Abstract

This paper examines the effect of international outsourcing of intermediate inputs on labour productivity at the level of the plant that engages in outsourcing. To do so we use plant level data for the electronics industry in the Republic of Ireland. Using a fresh perspective on international outsourcing and productivity, we focus on the nature of outsourced inputs (services or tangibles) and the production stage (upstream or downstream) at which the plant engaged in outsourcing operates. We find significant productivity gains to internationally outsourced services. Most importantly, internationally outsourced services generate the highest productivity gains for downstream activities, where firms are closer to the end-customer.

JEL classification: F16, F14, L23, L63

Keywords: international outsourcing, fragmentation, productivity, electronics, production stages

Outline

Non-Technical Summary

It appears to be widely accepted that outsourcing (or fragmentation of production) is becoming more and more important in the world economy and in world trade. There is evidence that companies that outsourced intermediates (material inputs or services), achieved higher profits and revenues than those that did not. Additionally, outsourcing was viewed as a way of achieving cost reductions and accessing technical expertise not available in-house.

This paper focuses on the international dimension of outsourcing (fragmentation of production) and its effects on productivity at the level of the plant that engages in outsourcing. We use plant level data to investigate the impact of international outsourcing (imports of intermediate inputs) on plant level productivity. Also, our data set enables us to separate out the outsourcing of services from materials inputs. We are therefore able to investigate whether there are different productivity effects associated with the outsourcing of different types of inputs. Additionally, we distinguish between plants operating in upstream and downstream sectors. To the best of our knowledge, this is the first study on international outsourcing that uses plant level data to study the effect of outsourcing and productivity, and that makes this distinction between upstream and downstream processes. Uniquely, therefore, we can examine whether there is a differential impact of outsourcing services or physical inputs, the closer to the end-customer we get.

We investigate these issues empirically using plant level data for the electronics industry in the Republic of Ireland. Our analysis provides some evidence that international outsourcing of services inputs increases productivity (levels and growth), although this effect appears to be limited to plants operating in the more downstream sub-sectors of electronics, i.e., those sectors that are closer to the customer. We do not find any evidence that international outsourcing of tangible inputs, such as materials and components, has any effect on plant level productivity.

The positive result for downstream activities is consistent with the idea that these plants outsource activities that are relatively low-skill intensive, therefore allowing them to reallocate

their production towards more skill intensive and productive activities. In that case, plants may "cherry pick" the high value added activities and outsource the less productive activities, hence increasing productivity. On the other hand, the neutral or potentially negative relationship between international outsourcing of services and labour productivity in upstream sectors may suggest that plants in these sectors are likely to outsource skill intensive activities, focusing production on less skill intensive stages of production. Assuming that upstream activities are less skill intensive than downstream activities our results suggest that plants outsource activities at least partly in order to focus on their "core activities".

1 Introduction

It appears to be widely accepted that outsourcing (or fragmentation of production) is becoming more and more important in the world economy. For example, a recent article on car manufacturers in *The Economist* points out that: "The whole industry is disintegrating (or becoming less vertical) as vehicle assemblers try to outsource more and more of what they once did for themselves" (*The Economist*, 23 February 2002, p. 99). There is plenty of anecdotal evidence that this is not limited to the car industry but is also observed in other manufacturing sectors.

A recent *PriceWaterhouseCoopers* survey involving CEOs from 440 product and service companies that the media had earmarked as the fastest growing U.S. businesses over the previous five years, found that respondents that outsourced intermediates (material inputs or services), achieved higher profits and revenues than those that did not. Additionally, outsourcing was viewed as a way of achieving cost reductions and accessing technical expertise not available in-house.[1] In more rigorous analyses, Görzig and Stephan (2002) and Görg and Hanley (2003) use establishment level data for Germany and Ireland respectively and find that outsourcing can positively affect establishment performance, in terms of its returns on sales and profitability.

Outsourcing is also a growing phenomenon in world trade (Feenstra, 1998). Hummels et al. (2001) provide evidence from data collected for 10 OECD and four emerging market countries, that trade in outsourced components in the vertical chain accounts for 21 percent of these countries' exports. Moreover, international outsourcing grew approximately 30 percent between 1970 and 1990. Much research has been devoted to attempting to measure the impact of this disintegration of production on domestic labour markets (see Feenstra and Hanson, 2001 for a review). However, most studies to

[1] Barometer Surveys of Trendsetter Companies, *http://www.barometersurveys.com/production/barsurv.nsf/*, 03/13/2000

date that investigate the impact of international outsourcing do so using aggregate industry or country level data – a notable exception being the recent work on Japanese micro level data by Head and Ries (2002) which examines the impact of outsourcing on relative labour demand.

The purpose of this paper is to focus on the international dimension of outsourcing (fragmentation of production) and its effects on productivity at the level of the plant that engages in outsourcing. In doing so this paper contributes to the literature in a number of ways. To begin with, our paper is, to the best of our knowledge, the first that uses plant level data to investigate the impact of international outsourcing (imports of intermediate inputs) on plant level productivity. Secondly, our data set enables us to separate out the outsourcing of services from materials inputs. We are therefore able to investigate whether there are different productivity effects associated with the outsourcing of different types of inputs. Additionally, we distinguish between plants operating in upstream and downstream sectors. To the best of our knowledge, this is the first study on international outsourcing that makes this distinction between upstream and downstream processes. Uniquely, therefore, we can examine whether there is a differential impact of outsourcing services or physical inputs, the closer to the end-customer we get. In other words, we are able to determine whether productivity returns to outsourced services or materials differ depending on whether the subsector is upstream or downstream.

We investigate these issues empirically using plant level data for the electronics industry in the Republic of Ireland. Ireland may be considered as an interesting case study given that Hummels et al. (2001) argue that a small open economy is most likely to rely heavily on fragmentation of its production processes. Also, the focus on the electronics industry is deemed appropriate given that electronics in the Irish economy is a rapidly expanding sector which has witnessed significant amounts of fragmentation of production over the last decades (Ruane and Görg, 2001).

We examine international outsourcing, rather than total outsourcing given that one may expect more scope for skill and factor cost differentials in an international context. Therefore, international outsourcing may be expected to be better able to exploit these international differentials than domestic outsourcing. Also, international outsourcing is likely to be more strategic than outsourcing locally. For example, cleaning, sanitation, construction and canteen services can be easily outsourced locally. However, more specialised inputs such as R&D, management or consulting services with 'joint input characteristics' may be more likely to be outsourced internationally because this is an activity that lends itself to fragmentation across boundaries (Carr et al., 2001).

Motivated by the benefits attributed to outsourcing by practitioners and the lack of direct evidence on the productivity gains accruing to firms that outsource internationally, we aim to establish whether outsourcing induces productivity gains. We concentrate on international outsourcing in electronics industries in Ireland. We find that establishments that outsource services inputs internationally, earn significant productivity gains. We do not find any statistically significant evidence that this is also the case for international outsourcing of tangible inputs. Moreover, internationally outsourced services generate the highest productivity gains for downstream activities, where firms are closer to the end-customer.

The structure of our paper is as follows. In the next section we discuss the theoretical rationale for expecting an effect of international outsourcing on productivity, and review the related empirical literature. Section 3 sets out the empirical methodology for analysing the link between outsourcing and productivity at the plant level. Then follows a description of the data along with some descriptive statistics in Section 4. We then present the results of our estimations in Section 5 before concluding in a final section.

2 International outsourcing and labour productivity

The theoretical rationale for expecting an effect from international outsourcing on plant level productivity is fairly straightforward. Assume that goods are produced in a multistage production process, which for each good involve different stages from basic upstream production to the eventual completion of the final good in the downstream stages.[2] With two types of labour, skilled and unskilled, where the former has a higher marginal product than the latter, outsourcing of production stages abroad can lead to changes in overall labour productivity within the plant.

As an example, assume that the less skill intensive upstream stages of production are produced with only unskilled labour, while more skill intensive downstream stages use only skilled labour. If the plant outsources some or all of the upstream production (due to, for example, lower factor prices for unskilled labour abroad) there will be a reallocation of production in the plant towards more skill intensive downstream production. This, ceteris paribus, will lead to a rise in overall labour productivity in the plant. The opposite effect can be expected if for some reason the plant outsources more skill intensive downstream stages of the production process.

The empirical evidence on the link between international outsourcing and productivity is, however, scarce. It appears that to date most of the empirical work has focussed on the labour market – wage effects of outsourcing. For example, Feenstra and Hanson (1999) and Hijzen (2003) use aggregate data to estimate the impact of international outsourcing on wages in the US and UK respectively using the so-called "mandated wage regression" approach. Similar work has been undertaken for other countries, see for example the paper by Egger et al. (2001) for Austria and the review paper by Feenstra and Hanson (2001).

[2] See, for example, Kohler (2003) and Feenstra and Hanson (1996) for theoretical models assuming such multistage production with a continuum of production stages.

Egger and Egger (2001) present one of the few papers that focuses on the link between international outsourcing and labour productivity, specifically, productivity of low skilled labour. They use aggregate data for EU member countries and a measure of outsourcing similar to Feenstra and Hanson's (1999) narrow measure of cross-border fragmentation. They find that the productivity of low skilled workers is adversely affected by cross-border fragmentation in the EU, albeit only in the short-run. In the long run, low-skill worker productivity rises. They argue that this result is consistent with labour market rigidities in the short run but in the long run factor mobility will lead to the predicted result of rising labour productivity.

Given the increasing number of studies concerning themselves with international fragmentation of production it is perhaps surprising to note that there is a dearth of papers using micro level data. One notable exception is a recent paper by Head and Ries (2002) which conducts a micro level study of international outsourcing in Japan on firm level labour demand. They hypothesise that skill intensity (proxied by the non-production worker share of the wage bill) will differ with offshore production, only in the case where vertical investment characteristics characterise their data. In other words, they expect changes in wage differentials between skilled and unskilled workers to be predicated on the amount of fragmentation that Japanese firms undertake. Their empirical results show changes in skills intensities that are consistent with fragmentation of lower-skill activities abroad. However, when considering the small number of micro level studies of international outsourcing, none seem to have investigated the link between outsourcing and plant productivity.[3]

[3] While Girma and Görg (2002) provide a micro level study of the impact of total outsourcing on productivity, one limitation of their analysis is that they are unable to distinguish outsourcing across borders from domestic outsourcing.

3 Empirical methodology

The purpose of this paper is to investigate the effect of international outsourcing on plant level labour productivity. In order to do so we propose to estimate production functions which allow for a possible impact of international outsourcing. Specifically, we assume a general Cobb-Douglas production function

$$Y_{it} = A^{\phi}(K^{\alpha}L^{\beta}X^{\gamma}) \qquad (1)$$

where Y is output, K is capital, L is labour, X is intermediate inputs and A is a technology parameter. Taking logs and subtracting ln$L$ from both sides yields an expression for labour productivity

$$(y-l)_{it} = \phi a + \alpha(k-l)_{it} + \gamma(x-l)_{it} + \lambda l_{it} \qquad (2)$$

where lower case letters denote natural logs (i.e., y = ln$Y$) and $\lambda = \alpha + \beta + \gamma - 1$ allows for non-constant returns to scale in the production function.

It is not straightforward to incorporate the effects of international outsourcing (or outsourcing in general) in such a production function framework. Outsourcing in its very general form simply means a change in the use of intermediate inputs X. Of course, a higher use of X is expected to increase output via the production function, hence, an interpretation of the coefficient γ as telling us anything about the effects of outsourcing on productivity does not appear sensible.

In this paper, we investigate whether the use of international outsourcing has any further positive effect, over and above the expected positive effect via increasing X by allowing the intensity of international outsourcing to shift the technology parameter A of the underlying production function. In other words, we assume that the reallocation of production within the plant that is due international outsourcing leads to a shift of the plant's production function. Doing so yields the following estimable form of the production function

$$(y-l)_{it} = \pi + \delta outs_{it} + \alpha(k-l)_{it-1} + \gamma(x-l)_{it-1} + \lambda l_{it-1} + \varepsilon_{it} \qquad (3)$$

where *outs* is the intensity of international outsourcing, measured as the ratio of imported inputs over total inputs. We discuss this variable and its measurement in more detail in the following section.

The production factors are included for time *t*-1 in order to reduce concerns about endogeneity of inputs. The constant π and error term ε pick up other factors of technology not captured in the production function, as well as any other unobserved factors. We control for heteroskedasticity of the error term, as well as an unspecified correlation between error terms within establishments, but not across establishments. This allows for the possibility that there may be unobserved plant specific effects which we do not explicitly account for in the empirical model. In the empirical estimation of equation (3) we also include full sets of time and relatively disaggregated sectoral dummies to capture the impact of macroeconomic changes and sector-specific time-invariant effects, respectively.

Estimations of equation (3) allow us to answer the question as to what the effect of outsourcing on the *level* of labour productivity is. A related and also potentially interesting question is, of course, whether international outsourcing has any effect on labour productivity *growth*. In other words, we are not only interested in whether international outsourcing affects the intercept, but also the slope of the production function. In order to examine this question we re-write the production function in terms of labour productivity growth, which relates changes in labour productivity to changes in the production factors. In such a specification it is then important to also control for the lagged level of labour productivity in order to take into account possible temporal correlation (convergence) of productivity. In this labour productivity growth framework we then allow the outsourcing intensity to shift the technology parameter, leading to the following specification of the empirical equation

$$\Delta(y-l)_{it} = \pi + \kappa(y-l)_{it-1} + \delta outs_{it} + \alpha\Delta(k-l)_{it-1} + \gamma\Delta(x-l)_{it-1} + \lambda\Delta l_{it-1} + \varepsilon_{it} \quad (4)$$

In other words, we are allowing for an effect of international outsourcing on productivity growth in the plant, rather than on the level of productivity as in equation (3).[4]

A major econometric issue with equations (3) and (4) is that there may be a potential endogeneity problem, i.e., there may be covariates that are correlated with labour productivity and international outsourcing that are driving the possible statistically significant coefficient δ. For example, it may be the case that highly productive establishments are more skill intensive and therefore more likely to use international outsourcing in order to shift the production of low skill intensive components abroad. In order to take account of this possibility we instrument for outsourcing intensity in equations (3) and (4). We discuss the instruments used in some detail below.

4 Description of the data

In order to investigate the relationship between international outsourcing and productivity we use plant level data for the electronics industry in Ireland. The data are taken from the *Irish Economy Expenditure Survey*, undertaken annually by Forfás, the government agency with responsibility for enterprise development, science and technology. This is an annual survey of larger plants in Irish manufacturing with at least 20 employees, although a plant, once it is included, is generally still surveyed even if its employment level falls below the 20 employee cut-off point. The survey provides plant level information on, inter alia, output, employment, capital employed, as well as details on plants' expenditure

[4] An additional advantage of equation (4) compared to equation (3) is that it also purges any plant-specific effects that affect the production function in levels and that may not be taken fully into account with the specification of the error term in equation (3).

on labour, materials, and services inputs. The response rate to this survey is generally estimated to be between 60 and 80 per cent of the targeted plant population.

The main variables of interest are international outsourcing intensity and productivity at the establishment level. The former is measured as the ratio of imported inputs to total inputs, thus giving us a measure of the importance of imported intermediates in the production process. Our first measure of international outsourcing is, thus, defined as the ratio of total imported inputs over total inputs. Another advantage of our data set is that we can distinguish intermediate inputs into raw materials and components (referred to as materials) and services inputs. We can therefore calculate two more disaggregated measures of international outsourcing, namely, the ratio of imported materials over total inputs, and the ratio of imported services inputs over total inputs. With regard to the latter measure, services inputs are defined as other direct and indirect cost, excluding materials, wages, rent, interest payments and depreciation. This includes contracted out services, such as consultancy, maintenance, security, cleaning, catering etc.

While the survey has been undertaken by Forfás between 1982 and 1998, data are available to us for plants in the electronics sector over the period 1990 to 1995. These data are classified into 12 sub-sectors of electronics, which cover both manufacturing and service activities, making the dataset quite unique. These sub-sectors are: Computers, Consumer Electronics, Electronic Components, Instrumentation, Networking & Data Communication, Printed Circuit Board Assembly (PCBA), Peripherals & Media, Semiconductors, Software Development, Software Production, Telecommunications, and IT Services. The inclusion of both manufacturing and services sub-sectors makes the dataset particularly interesting for our analysis.

A further advantage of this sectoral classification is that we can further distinguish upstream from downstream electronics sectors, based on a classification used by Görg and

Ruane (2001).[5] Accordingly, upstream sectors are Components, Instrumentation, PCBA, Peripherals & Media, and Semiconductors, i.e., plants in these sectors produce goods that are largely used as intermediate inputs in further production. Computers, Consumer Electronics, Networking, Services, Software Development, Software Production and Telecommunications are considered to be downstream, i.e., mainly final good producing sectors. This classification allows us to determine whether international outsourcing has different effects on labour productivity of plants in sectors producing at different stages of the production process.

To illustrate the data, Table 1 shows the breakdown of plants in our sample by sector and additionally by whether the sector was categorised as upstream or downstream. Table 2 provides some summary statistics for the main variables in our data. Internationally outsourced inputs (column 3) is made up of internationally outsourced materials (column 4) and internationally outsourced services (column 5). We note that plants in upstream sectors are smaller in terms of value added than their downstream counterparts and are also comparatively labour intensive. The average number of employees in upstream sectors is 162 vis-à-vis 135 for downstream sectors.

[Tables 1 and 2 here]

This recognition in the summary statistics of a more productive pattern to downstream activities is also evidenced in Figure 1 showing the distributions of labour productivity (*lnkl1*) by production stages. Although the density graph shows evidence of significant overlap between the distributions of upstream and downstream activities respectively, the accompanying Kolmogorov-Smirnov test indicates that upstream activities are significantly associated with lower productivity levels than downstream activities with a test statistic of –0.11. This may reflect the fact that upstream activities are less skill

[5] This classification is based on information obtained from industry experts on production interrelationships in the Irish electronics industry. Note that the definitions are based on the peculiarities of the Irish

intensive than downstream stages of production.[6] For example, it may be the case that downstream activities, being closer to the end user involve elements of tailoring which are non-routine and therefore likely to be high skill. A case in point is IT Services and Networking/Data Communications.

[Figure 1 here]

So far we have looked at summary statistics detailing the association between the stage in the production process and the corresponding level of productivity. We now introduce a third dimension, namely international outsourcing and distinguish whether the outsourced input is a service or material. Table 3 shows the partial correlation coefficient for the relationship between the production stage and productivity while at the same time controlling for whether the input is a service or a physical component. The most striking observation is the difference in the magnitude of the partial correlation coefficient for the two production stages of internationally outsourced services. We see that productivity in downstream stages is positively correlated with increased levels of internationally outsourced services. While this simple correlation is only illustrative, it suggests that firms engaged in activities that are closer to the end-user (downstream) that outsource services, stand to raise their productivity rates considerably. A possible explanation is that internationally outsourced services represent non-core production that can readily be outsourced to external agents and in doing so allow the firm to raise productivity.

[Table 3 here]

electronics industry and may therefore not necessarily coincide with interrelationships in electronics industries in other countries or world-wide.

[6] Kohler (2003) makes the assumption that "downstream stages are always more capital intensive than more upstream stages" (p. 4) and our finding would be in line with that assumption.

5 Econometric analysis

These summary statistics do not allow us to take adequately into account other covariates that may impact on plant level productivity. In order to do so we now turn to estimating the production functions described in equations (3) and (4). In order to allow for the possible productivity differences between plants in upstream and downstream sectors we, in addition to including sectoral dummies, also include a dummy variable equal to one if the sector is a downstream activity, according to the classification described above.

We commence our empirical analysis by investigating the effect of total international outsourcing, i.e., the ratio of total imported inputs to total inputs, on labour productivity levels and growth. These results are reported in Table 4. As pointed out above, besides the simple OLS estimations we also use IV techniques to allow for the possible endogeneity of the outsourcing variable. Instruments used are based on the ratio of transport costs to inputs, expenditure on fuel over inputs, total expenditure on electricity relative to inputs, and the intensity of total input use (i.e., total inputs relative to output). In the estimations we use current, lagged, and differenced values of these instruments as appropriate.

Intuitively, these variables may be potential valid instruments for a number of reasons. Expenditure on transport costs and fuel may be correlated with international outsourcing as they may be proxies for transport costs in general. Expenditure on electricity may be a proxy for changes in the production processes induced by international outsourcing. Finally, the use of total inputs relative to output may again be an indicator of the importance of international outsourcing in production.

We use the robust form of Hansen's test of overidentifying restrictions to examine the null hypothesis that the correlation between the potential instrumental variables used for the analysis and the error terms in the productivity equation is zero; a necessary

condition for the validity of the instrumental variables regression approach. Depending on the equation in question (levels or differences) instruments which are found to be invalid, are dropped from the specification. We are also careful to assess the strength of the relationship between the instruments and the potentially endogenous regressors. Staiger and Stock (1997) recommend that the F-statistics from the first-stage regression be routinely reported in applied work. The F-statistic tests the hypothesis that the instruments should be excluded from the first-stage regressions, i.e. the relevance of the instruments. The basic idea is that when the F-statistic is small (or the corresponding p-value is large), the instrumental variable estimates and the associated confidence interval are unreliable.

Turning to the results in Table 4 note, firstly, that the coefficients on the production factors are well behaved and as expected, and that there is evidence for increasing returns indicated by the positive coefficient on total employment. Also, the lagged level of labour productivity is negative and statistically significant in the growth equation, which indicates that there is some level of convergence; plants with higher labour productivity in time t-1 grow slower in time t. From the regressions there is no statistically significant evidence that downstream plants have higher productivity levels or growth than upstream plants, ceteris paribus, although the coefficients on the dummy are positive in three out of four cases (but only statistically significant in the case of the IV growth equation).[7] In terms of instruments used, the Hansen test indicates that they are valid, while the F-statistics from the first stage regressions also show that they are relevant.

The variable we are most interested in is, of course, the international outsourcing intensity. In three out of four cases we find positive coefficients on that variable, suggesting a positive relationship between international outsourcing and plant level productivity. However, the coefficient is only statistically significant in the IV growth equation in column (4). In this case a Hausman test indicates that we cannot reject the null

hypothesis that the difference in coefficients in OLS and IV is not systematic, hence, the OLS estimation is the preferred specification. While we also find a positive coefficient in the OLS regression, it is not statistically significant, as in the two levels equations as well. Hence, there is only weak evidence of a causal link between total international outsourcing and labour productivity at the level of the establishment.

[Table 4 here]

The total outsourcing measure combines, of course, tangible and intangible inputs into one index. If, however, outsourcing of materials and services have different effects on productivity we may not be able to discern these relationships with the aggregate measure. Hence, in order to investigate this issue further we distinguish intermediate inputs into materials *m* and services inputs *s* and calculate outsourcing intensities for these two inputs separately. Modifying the production functions in order to include these more disaggregated variables produces results that are reported in Table 5.

We now find a positive effect of international outsourcing of services on productivity levels and growth. However, the coefficient is only statistically significant in the OLS growth regression, while the Hausman test indicates that the IV specification be preferred. Therefore, again, there is only weak evidence for any impact of international outsourcing of services inputs on the level or growth of labour productivity from our regressions. Furthermore, the coefficients on outsourcing of materials are always statistically insignificant, suggesting that there is no causal link between this variable and labour productivity growth or levels. It is notable also that in the IV growth regression we now find statistically significant evidence that plants in downstream sectors of electronics have higher productivity growth than upstream plants.

[Table 5 here]

[7] In that case, however, the Hausman test indicates that the OLS estimation be preferred.

As discussed above, these disappointing results on the effect of international outsourcing on labour productivity may be due to the fact that we pool data for electronics sub-sectors at upstream and downstream stages of the production process. If international outsourcing affects plants across these two sectoral groups differently, however, the pooled estimates may not be appropriate to reflect the impact of international outsourcing. Hence, in the estimations reported in Table 6 we make use of the classification that distinguishes the electronics sub-sectors into upstream and downstream sectors. We allow the coefficients on the outsourcing intensities to vary across these two sectoral groups by interacting the outsourcing variables with dummies for upstream and downstream sectors respectively.

Re-estimating the equations shows some important changes to the previous conclusions. We now find, from Table 6, that international outsourcing of services inputs raises productivity, both levels and growth, for downstream plants, as indicated by the positive and statistically significant coefficients (in 3 out of 4 cases) on the services outsourcing variable. The point estimate in column (1), for example, suggests that an increase in the outsourcing intensity by one percentage point will raise labour productivity in the average plant by 0.99 percent. Similarly, from column (3) we can deduce that a one percentage point increase in international outsourcing of services leads to an increase by 0.55 percent in the average plant's rate of labour productivity growth. However, as the coefficients on services outsourcing for upstream sub-sectors indicate, there is no such positive effect for upstream firms. If anything, there is some evidence from columns (1), (2) and (3) – albeit only statistically significant in one case - that international outsourcing of services reduces labour productivity for upstream plants.

In none of the regressions, either for downstream or upstream plants, do we find any statistically significant evidence of an effect of international outsourcing of material inputs on plant level labour productivity. Furthermore, it is notable that now we do not

discern any statistically significant differences in labour productivity growth or levels between plants in upstream or downstream sub-sectors of the electronics industry.

[Table 6 here]

6 Conclusions

This paper presents, to the best of our knowledge for the first time, evidence on the effect of international outsourcing of intermediate inputs on labour productivity at the plant level. The analysis is based on data for plants in the Irish electronics sector, a rapidly expanding industry with a high potential for international fragmentation of production. Our analysis provides some evidence that international outsourcing of services inputs increases productivity (levels and growth), although this effect appears to be limited to plants operating in the more downstream sub-sectors of electronics, i.e., those sectors that are closer to the customer. We do not find any evidence that international outsourcing of tangible inputs, such as materials and components, has any effect on plant level productivity.

The positive result for downstream activities is consistent with the idea that these plants outsource activities that are relatively low-skill intensive, therefore allowing them to reallocate their production towards more skill intensive and productive activities. In that case, plants may "cherry pick" the high value added activities and outsource the less productive activities, hence increasing productivity. On the other hand, the neutral or potentially negative relationship between international outsourcing of services and labour productivity in upstream sectors may suggest that plants in these sectors are likely to outsource skill intensive activities, focussing production on less skill intensive stages of production. Assuming that upstream activities are less skill intensive than downstream

activities our results suggest that plants outsource activities at least partly in order to focus on their "core activities".

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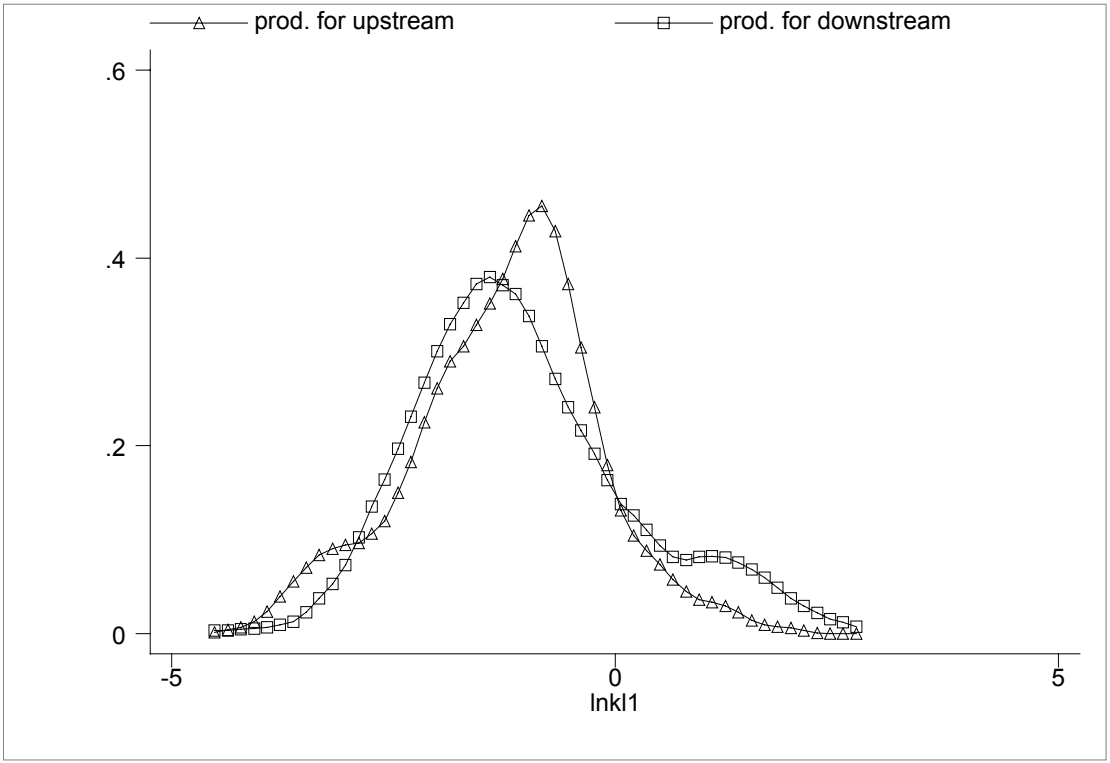
Table 1: Summary Statistics

Sector	Total number of observations
upstream sectors	
Components	112
Instrumentation	66
Printed Circuit board Assembly (PCBA)	53
Peripherals and Media	72
Semiconductors	23
downstream sectors	
Computers	23
Consumer Electronics	67
Networking/Data Communications	18
Services	39
Software Development	96
Software Production	33
Telecommunications	50

Table 2: Summary Statistics

		Inputs (1)	Value added (2)	Internationally O/S inputs (3)	Internationally O/S materials (4)	Internationally O/S services (5)	Employment (6)
downstream	mean	250	151	149	147	30	135
	std. dev.	772	380	474	474	146	167
	median	36	23	13	12	1	67
	No. obs.	326	325	326	263	326	326
upstream	mean	170	68	124	117	8	162
	std. dev.	591	331	442	428	31	249
	median	36	15	21	21	1	78
	No. obs.	326	326	326	321	324	326
Total	mean	210	109	136	131	19	149
	std. dev.	688	359	458	449	106	212
	median	36	19	16	17	1	73
	No. obs.	652	651	652	584	650	652
Note: (1, 2, 3, 4, 5) in £IEP, 000 deflated by 1995 Consumer Price Index							

Figure 1: Distribution of labour productivity by production stage



Two-sample Kolmogorov-Smirnov test for equality of distribution functions

Lower values of labour productivity (lnkl1)	Test statistic D	P-value
Downstream	0.06	0.33
Upstream	-0.11	0.02
Combined K-S	0.11	0.04

Table 3: Bivariate correlations for productivity

Pearson r	
(sig. r)	
ratio of internationally outsourced services to inputs	
upstream sector	0.10
	(0.08)
downstream sector	0.21**
	(0.00)
ratio of internationally outsourced materials to inputs	
upstream sector	0.09
	(0.11)
downstream sector	0.13*
	(0.04)
*. Correlation is significant at the 0.05 level (2-tailed) **. Correlation is significant at the 0.01 level (2-tailed)	

Table 4: Total international outsourcing and labour productivity (innsbruck3.do)

	(1)	(2)	(3)	(4)
	Levels	Levels	Growth	Growth
	OLS	IV	OLS	IV
total outsourcing	0.036	-0.157	0.013	0.567
	(0.129)	(0.669)	(0.063)	(0.296)*
$(k-l)_{t-1}$	0.112	0.095	0.048	0.032
	(0.028)***	(0.031)***	(0.050)	(0.050)
$(x-l)_{t-1}$	0.659	0.709	0.396	0.395
	(0.037)***	(0.043)***	(0.053)***	(0.060)***
$(l)_{t-1}$	0.122	0.137	0.105	0.094
	(0.030)***	(0.040)***	(0.054)*	(0.062)
$(q-l)_{t-1}$			-0.181	-0.205
			(0.042)***	(0.048)***
Downstream dummy	0.244	-0.024	0.112	0.568
	(0.220)	(0.152)	(0.120)	(0.226)***
Constant	-0.045	-0.019	-0.155	-0.575
	(0.209)	(0.485)	(0.066)**	(0.248)**
Hausman (p-value)		0.05		1.00
Hansen (p-value)		0.15		0.89
F first stage (p-value)		0.00		0.00
Observations	458	391	287	254
R-squared	0.82	0.84	0.40	0.33

Notes:
Heteroskedasticity-autocorrelation consistent standard errors in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%
all regressions include time and sectoral dummies
Hausman test examines the null hypothesis that there is no statistically significant difference between the OLS and IV estimates.

Table 5: International outsourcing of materials and services and labour productivity

	(1)	(2)	(3)	(4)
	Levels	Levels	Growth	Growth
	OLS	IV	OLS	IV
services outsourcing	0.610	0.278	0.395	0.304
	(0.376)	(2.810)	(0.185)**	(0.496)
materials outsourcing	0.124	-0.558	-0.019	0.217
	(0.171)	(0.854)	(0.068)	(0.517)
$(k-l)_{t-1}$	0.141	0.133	0.046	-0.008
	(0.034)***	(0.041)***	(0.046)	(0.038)
$(s-l)_{t-1}$	0.392	0.447	0.365	0.345
	(0.065)***	(0.148)***	(0.046)***	(0.057)***
$(m-l)_{t-1}$	0.273	0.250	0.039	0.050
	(0.072)***	(0.205)	(0.030)	(0.031)*
$(l)_{t-1}$	0.165	0.179	0.102	0.021
	(0.038)***	(0.076)**	(0.074)	(0.062)
$(q-l)_{t-1}$			-0.179	-0.144
			(0.042)***	(0.026)***
Downstream dummy	0.451	-0.165	0.099	0.326
	(0.249)*	(0.388)	(0.122)	(0.143)**
Constant	0.170	0.532	-0.137	-0.291
	(0.315)	(0.772)	(0.072)	(0.348)
Hausman (p-value)		0.00		0.03
Hansen (p-value)		0.70		0.69
F first stage (p-value) services		0.02		0.00
F first stage (p-value) materials		0.02		0.05
Observations	417	368	268	193
R-squared	0.80	0.80	0.45	0.48

Notes:
Heteroskedasticity-autocorrelation consistent standard errors in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%
all regressions include time and sectoral dummies
Hausman test examines the null hypothesis that there is no statistically significant difference between the OLS and IV estimates.

Table 6: International outsourcing of services and material inputs in upstream and downstream sectors

	(1)	(2)	(3)	(4)
	Levels	Levels	Growth	Growth
	OLS	IV	OLS	IV
services outsourcing * downstr. dummy	0.993	3.406	0.549	0.301
	(0.341)***	(1.190)***	(0.146)***	(0.912)
materials outsourcing * downstr. dummy	-0.022	0.859	0.064	0.360
	(0.229)	(1.596)	(0.084)	(0.673)
services outsourcing * upstream dummy	-1.525	-5.904	0.192	-0.169
	(0.478)***	(4.550)	(0.339)	(1.759)
materials outsourcing * upstream dummy	0.143	-1.006	-0.114	1.719
	(0.352)	(1.186)	(0.117)	(1.499)
$(k-l)_{t-1}$	0.149	0.158	0.050	-0.004
	(0.035)***	(0.055)***	(0.046)	(0.069)
$(s-l)_{t-1}$	0.390	0.393	0.363	0.324
	(0.062)***	(0.140)***	(0.046)***	(0.078)***
$(m-l)_{t-1}$	0.263	0.248	0.032	0.040
	(0.069)***	(0.186)	(0.030)	(0.064)
$(l)_{t-1}$	0.167	0.197	0.095	0.093
	(0.035)***	(0.064)***	(0.075)	(0.096)
$(q-l)_{t-1}$			-0.178	-0.223
			(0.042)***	(0.064)***
Downstream dummy	-0.090	-1.375	0.181	1.051
	(0.335)	(1.470)	(0.126)	(1.110)
Constant	0.318	0.988	-0.059	-1.347
	(0.366)	(0.838)	(0.101)	(1.084)
Hausman (p-value)		1.00		1.00
Hansen (p-value)		0.16		0.75
F first stage (p-value) services * downstr.		0.00		0.00
F first stage (p-value) materials * downstr.		0.38		0.05
F first stage (p-value) services * upstream		0.17		0.00
F first stage (p-value) materials * upstream		0.05		0.48
Observations	417	367	268	240
R-squared	0.81	0.67	0.45	0.12

Notes: as in Table 5