Outsourcing, foreign ownership and productivity: Evidence from UK establishment level data

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Abstract

This paper presents an empirical analysis of "outsourcing" using establishment level data for UK manufacturing industries. We analyse an establishment's decision to outsource and the subsequent effects of outsourcing on the establishment's productivity. Our empirical results suggest that high wages are positively related to outsourcing, suggesting that the cost saving motive is important. We also find that foreign-owned firms have higher levels of outsourcing than domestic establishments. In the productivity analysis we find that an establishment's outsourcing intensity is positively related to its labour productivity and total factor productivity growth.

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1 Introduction

"Outsourcing" can be loosely defined as the contracting out of activities that were previously performed within a firm, to subcontractors outside the firm.[1] It appears to become more and more widespread and attracts increasing attention in the popular business press as well as in the academic literature. For example, the *Financial Times* asserts that "Subcontracting as many non-core activities as possible is a central element of the new economy" (*Financial Times*, 31 July 2001, p. 10) while Grossman and Helpman (2002a) state in the opening paragraph of their paper that "We live in an age of outsourcing".

Various aspects of this phenomenon have been discussed in the literature. A large literature spanning from the seminal paper by Coase (1937) to the recent article by Grossman and Helpman (2002b) examines theoretically a firm's decision of whether to produce in-house or to outsource. Recently, in the wake of the increasing interest in globalisation the trade related aspect of outsourcing has also attracted increasing attention in the literature. Trade theoretic models such as Deardorff (2001), Jones and Kierzkowski (2001) and Kohler (2001) examine the effects of trade in "fragmented products" on countries' patterns of specialisation and resulting implications for factor prices.

On the empirical side recent papers by Feenstra and Hanson (1996, 1999) and Hijzen et al. (2002) have analysed the effect of international outsourcing (or fragmentation) on relative wages and labour demand using industry level data for the

US and UK respectively. In line with traditional HOS trade theory these papers find that international outsourcing (moving low skill intensive production to low skill abundant countries) leads to increased demand and increases in the wage premium for high skilled workers in the US and UK. Egger and Egger (2001) investigate the effect of outsourcing on the productivity of low skilled labour in the EU using industry level data. They find that increases in outsourcing have a negative effect on low skilled labour productivity in the short run, but a positive effect in the long run.

In this paper we are not concerned with the international trade dimension to outsourcing. Rather, we investigate empirically an establishment's decision to outsource and the subsequent effect of outsourcing on productivity of that establishment. We do not distinguish between international and domestic outsourcing since we are interested in the establishments' characteristics that determine outsourcing. We therefore may consider it immaterial as to whether the activities are outsourced to firms abroad or in the domestic economy. Also, as we are interested in the subsequent effect on productivity for the outsourcing establishment it should not matter whether outsourcing takes place internationally or domestically. All we may assume is that the firm will minimise transaction costs when outsourcing activities to a subcontractor that can be located in the domestic economy or abroad.

This paper uses establishment level data for UK manufacturing industries for the empirical analysis. It contributes to the literature in a number of ways. Firstly, this is, to the best of our knowledge, the first study to analyse the establishment level determinants of outsourcing using data for the UK.[2] Secondly, the analysis of the effect

[1] This phenomenon, which we refer to as outsourcing may also be termed "make or buy decision" (Grossman and Helpman, 2002b), "vertical disintegration" (Holmes, 1999), "fragmentation" (Arndt and Kierzkowski, 2001), "vertical specialisation" (Hummels et al., 2001) to mention but a few synonyms.

[2] Our approach is closely related to the paper by Abraham and Taylor (1996) who analyse the determinants of outsourcing using plant level data for the US. However, they do not distinguish between domestic and foreign owned establishments. A related paper by Swenson (2000) examines the decision

of outsourcing on productivity of the establishment is an innovation of the paper.[3] Thirdly, we investigate whether there are differences in the determinants of outsourcing, and productivity effects of outsourcing between domestic establishments and foreign-owned establishments which can be assumed to be part of a larger multinational company.

We focus our analysis on establishments in three broad UK manufacturing sectors, namely, chemicals, mechanical and instrument engineering, and electronics.[4] Foreign-owned firms are important players in all three industries, accounting for about 12, 15 and 19 percent of total employment in the sectors respectively (see Griffith and Simpson, 2002, Table 4). We examine these three sectors separately as one may expect at least some heterogeneity in the use of outsourcing and, perhaps more importantly, differences in the impact of outsourcing on productivity across these sectors.

The data used in this paper are available from the Annual Respondents Database (ARD) which is described in more detail in the next section. Section 3 then examines the determinants of outsourcing at the level of the establishment while Section 4 presents the results of our analysis of productivity effects of outsourcing. Section 5 summarises our main findings and concludes.

2 Data description and summary statistics

For the empirical estimations, this paper draws on the Annual Respondents Database (ARD) provided by the Office for National Statistics. The ARD consists of

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to import intermediates for firms located in US foreign trade zones paying particular attention to the effect of changes in international prices imported inputs.

[3] There are a number of papers that look at the effects of outsourcing on manufacturing (ten Raa and Wolff, 2001) or service sector (Fixler and Siegel, 1999) productivity using industry level data. Also, Mazzola and Bruni (2000), using firm level data, find that firms that are subcontractors, or produce large shares of output for order, have higher probabilities of "success" (in terms of profitability) than other firms.

[4] More precisely, using SIC 1980 classifications, chemicals is SIC 25, mechanical and instrument engineering (hereafter referred to as mechanical engineering) includes SIC32 and SIC 37, electronics

individual establishments' records that underlies the Annual Census of Production and the data used cover the period 1980 to 1992. As Griffith (1999) and Barnes and Martin (2002) provide very useful introductions to the data set, we only include a brief discussion of some of the features of the data that are relevant to the present work. For each year the ARD consists of two files. What is known as the 'selected file', contains detailed information on a sample of establishments that are sent inquiry forms. The second file comprises the 'non-selected' (non-sampled) establishments and only basic information such as employment, location, industry grouping and foreign ownership status is recorded. Some 14,000-19,000 establishments are selected each year, based on a stratified sampling scheme. The scheme tends to vary from year to year, but during the period under consideration, establishments with more 100 employees were always sampled.

In the ARD, an establishment is defined as the smallest unit that is deemed capable of providing information on the Census questionnaire. Thus a 'parent' establishment reports for more than one plant (or 'local unit' in the parlance of ARD). For selected multi-plant establishments, we only have aggregate values for the constituent plants. Indicative information on the 'children' is available in the 'non-selected' file. In the sample period considered in this paper (1980-92), about 95 percent of the establishment that are present in these industries are single-plant firms. In the actual sample we used for the econometric estimation this figure is around 80 percent. Hence, most of the data used is actually plant level data.

The focus of this paper is on outsourcing activities of an establishment. While there has been some empirical research in that area there does not appear to be a

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includes SIC 33 (manufacture of office machinery and data processing equipment) and SIC 34 (electrical and electronic engineering).

standard definition of what constitutes outsourcing.[5] We define as outsourcing the "cost of industrial services received" by an establishment. This includes activities such as processing of inputs which are then sent back to the establishment for final assembly or sales, maintenance of production machinery, engineering or drafting services etc. Note that "non-industrial services" such as accounting, consulting, cleaning or transportation services are not part of that definition.

Outsourcing is a substitute for in-house production and will therefore lead to a reduction in the total wage bill. In some sense the cost of outsourcing is therefore equal to the opportunity wage that may have occurred to in-house employees if the services had not been contracted out. We therefore decided to calculate an indicator of an establishment's propensity to outsource as an outsourcing intensity equal to the cost of industrial services received relative to the total wage bill of the establishment. Some summary statistics for this measure for the three broad manufacturing industries are presented in Table 1. Note that the average outsourcing intensity in the electronics sector is considerably lower than in chemicals and mechanical engineering, although the standard deviation is also considerably higher. We also find that the mean outsourcing intensity for foreign owned establishments appears to be higher than that for domestic owned establishments in the same sector.

[Table 1 here]

Figures 1a to c also plot the development of the outsourcing intensity by sector over time. Figure 1c in particular indicates that the propensity to outsource in the electronics sector has increased sharply since 1989/1990, leaving it at about the same rate as in the other two sectors at the end of the period under consideration in this paper. Hence, the lower means in Table 1 can be attributed to the very low levels in the early

[5] For example, Abraham and Taylor (1996) define as outsourcing various activities, namely, contracting out of machine maintenance services, engineering and drafting services, accounting services, computer

1980s. This recovery appears to have been mainly due to domestic establishments where we see a considerable growth in outsourcing since 1989. However, we also find that the outsourcing intensity in foreign owned establishments has increased over the total period 1980 to 1992, although there has been a slight decrease since 1989.

[Figures 1a to 1c here]

3 Determinants of outsourcing

This section investigates what determines firms' use of outsourcing. Abraham and Taylor (1996) postulate that there are three general considerations that may affect firms' decisions in that regard, namely, wage costs savings, output cyclicality and economies of scale.

Firms may try to cut costs by contracting out activities to firms that operate at lower costs, i.e., offer lower wages to their employees. This may be sensible if a unionised firm pays wages higher than what it would otherwise choose to pay. Even if a firm is not unionised this argument may still apply if the firm pays high wages due to paying "efficiency wages" (e.g., Weiss, 1991) to its employees. In this case, while it may be sensible to pay efficiency wages to the firm's "core" workforce there may be other more peripheral activities for which the payment of above market rate efficiency wages may not be justified. These activities could, therefore, be easily contracted out to low wage producers.[6]

If the firm's output is subject to heavy seasonal or cyclical fluctuations it may also revert to outsourcing in order to smooth the work load for the core workforce. Some firms may choose to even the workload by assigning peak period tasks to outside contractors. Other firms may, however, decide to have work performed in-house during

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services and janitorial services. Our definition includes the first two categories but not the latter three.

slow periods that would have otherwise been assigned to outside contractors. Hence, fluctuations in output may affect the use of outsourcing either positively or negatively, depending on the preferences of the firm in question.

The third reason put forward by Abraham and Taylor (1996) for the use of outsourcing is that there may be economies of scale for specialised services. Hence, it may not be optimal for small or medium sized enterprises to provide a full range of support services, but they may be better off sourcing these from specialised providers outside, which are able to reap scale economies.

While we take into account these three reasons put forward by Abraham and Taylor (1996) we extend their argument by postulating that we would also expect the nationality of ownership of a firm to matter for its use of outside contractors. Foreign establishments, which are by definition part of a multinational company can be expected to use higher levels of technology than purely domestic firms, due to their having access to firm specific assets (e.g., Markusen, 1995). The use of high technology may lead to the contracting out of activities, in particular low tech activities. Also, if the foreign establishment is part of a vertical multinational there will be specialisation of activities and, by definition, outsourcing of activities to vertically linked plants within the same multinational. Such specialisation of activities may be less for purely domestic firms.[7] Furthermore, given that they are embedded into an international production network through their relationship with parent and other affiliates abroad they may be expected to have different strategies for dividing in-house and outsourced production, and may have better access to external providers of services than do purely domestic firms.

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6 This argument of course implies that firms cannot pursue different wage strategies, paying high (efficiency) wages to core workers and lower wages to other workers. This may be due to unionisation, or to internal equity considerations.

[7] Although it may be similar for domestic establishments which are part of a UK multinational. Unfortunately, we are not able to observe UK multinationals in our dataset.

Hence, we would expect that foreign firms have higher propensities of outsourcing than domestic firms.[8]

In order to test for the importance of these determinants we estimate empirically variants of the following equation

$$outs_{it} = \beta_0 + \beta_1 w_{it}^{s} + \beta_2 w_{it}^{us} + \beta_3 un_{jt} + \beta_4 size_{it} + \beta_5 own_{it} + \ldots$$
$$\ldots + d_j + v_t + r_s + dv_{jt} + \varepsilon_{it} \qquad (1)$$

where *outs* is measured as the log of the cost of industrial services received by establishment *i* at time *t*. The regressors w^s and w^{us} are the log of wage rates for skilled and unskilled workers respectively while *un* captures the degree of unionisation in the four digit industry *j*. These variables are included to capture the "cost saving" motive for outsourcing. Given our discussion above we would expect high wage firms to do more outsourcing than other firms. Also, firms in highly unionised sectors may prefer outsourcing as union work rules may act to increase costs, even if wages are no different in unionised and non-unionised firms. The *size* variable is the log of establishment size measured in terms of employment and is included to control for the economies of scale effect. Based on this reasoning we would expect smaller firms to be more intensive users of outsourcing. However, given that our dependent variable is measured in absolute terms the size variable controls for the fact that large firms may do more outsourcing (in absolute terms) than smaller firms. *own* is an ownership dummy equal to one if the establishment is domestically owned and zero otherwise. As pointed out above, we would expect this variable to have a negative coefficient if foreign firms are more intensive users of outsourcing. Furthermore, sectoral time dummies are also included to control for the effect of cyclical or seasonal variations in output in the four

[8] The fact that multinationals have been found to import more of their intermediate inputs than domestic firms (Turok, 1993; Görg and Ruane, 2000) may give some preliminary support for this assumption.

digit industries. Finally, we include four digit sector, time and region dummies in equation (1).

Equation (1) is estimated for each of the three broad sectors (chemicals, mechanical engineering, and electronics) separately using ordinary least squares (OLS) estimation. We allow 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 establishment specific effects which are correlated with the regressors but which we do not explicitly account for in the empirical model. The estimation results for the three sectors are presented in Tables 2 to 4.

[Tables 2 to 4 here]

In line with our prior expectations we find that high wage establishments are more prone to using outsourcing. Our distinction between skilled and unskilled wages shows that the larger effects seems to stem from the former, rather than the latter part of labour costs. Unionisation also has the expected positive effect, although it is only statistically significant for the chemicals sector.[9] Large firms also outsource more than small firms. This may reflect a pure scale effect – large firms produce higher levels of output and therefore have more activities, in absolute terms, to outsource than smaller firms. The inclusion of sectoral time dummies to control for the differences in cyclicality of output across different sectors does not affect any of these results, as is apparent from columns (3) and (4) of the respective tables.

We now turn to the importance of nationality of ownership for the use of outsourcing. As pointed out above we would expect foreign firms to be more intensive users of outsourcing due to differences in their production and possibly input sourcing

[9] This is perhaps surprising given that the average unionisation rate is lowest in this sector with 0.11, compared with 0.20 in mechanical engineering and 0.13 in electronics.

behaviour. As can be seen from columns (1) and (3) in all three tables this result is borne out by the data for all three manufacturing sectors. Controlling for size, labour costs and cyclicality of production, foreign owned establishments use more outsourcing than domestic establishments.

A reasonable question to ask then is whether the determinants of outsourcing are systematically different for foreign compared to domestic establishments as well. In other words, do the slope coefficients on the regressors differ between foreign and domestic establishments? To investigate this issue we interact all regressors included in the regression (i.e., wage, union and size variables) with the ownership dummy and re-run the augmented specification of equation (1). The results are reported in columns (2) and (4) of Tables 2 to 4.

We test for the joint significance of the three interaction terms using an F-test. The test statistics suggest that for the chemicals and electronics sector we cannot reject the hypothesis that the interaction terms are jointly equal to zero. Hence, we do not find systematic differences in the determinants of outsourcing between foreign and domestic establishments in these sectors. This is different in the mechanical engineering sector, where the interaction terms are jointly significant. We now find that the ownership dummy is statistically insignificant, suggesting no differences in the use of outsourcing between foreign and domestic establishments. What differs between these two groups of establishments is the effect of the other regressors included in the equation. The size effect is much larger for domestic than for foreign establishments, while the effect of skilled wages on the use of outsourcing is reduced substantially for the former compared to the latter.

4 Productivity effects of outsourcing

In this section we investigate whether outsourcing leads to an improvement in establishments' performance. More specifically we analyse whether outsourcing has a positive effect on productivity, measured in terms of labour or total factor productivity (TFP), of the establishment that decides to outsource the activities.

In a recent paper ten Raa and Wolff (2001) argue and provide evidence that TFP growth in manufacturing industries is positively related to an increased use of outsourcing, defined as inputs purchased from services industries. Their empirical evidence is based on industry level data using US input-output tables to calculate the importance of outsourcing. The effects of outsourcing for services industries have also been investigated recently. Fixler and Siegel (1999) argue that outsourcing has played a major role for the growth of the services sector. Their empirical evidence, based on industry level data for the US, suggests that outsourcing has led to short run reductions in service sector productivity, but that there have been positive effects in the long run. Extending this literature our paper is, to the best of our knowledge, the first study to investigate with establishment level data the effects of outsourcing on productivity in the establishment undertaking the outsourcing.

As we saw in the previous section one of the reasons for outsourcing is to economise on labour costs. An increase in outsourcing may therefore lead directly to a reduction of employment, while keeping output constant. Outsourcing may, therefore, have an immediate effect on labour productivity. Our investigation of this issue is based on the following equation of labour productivity growth at the level of the establishment

$$\Delta y / l_{it} = \alpha_0 + \alpha_1 \Delta k / l_{it} + \alpha_2 \Delta m / l_{it} \qquad (2)$$

where y is output, l is labour, k is capital and m is material outputs. We assume that the intensity of outsourcing shifts the technology parameter of the underlying production function. Hence, we augment this equation by including a measure of outsourcing intensity,

$$\Delta y / l_{it} = \alpha_0 + \alpha_1 \Delta k / l_{it} + \alpha_2 \Delta m / l_{it} + \alpha_3 out_{it} + \alpha_4 own_{it} + \alpha_5 y / l_{it-1} + \varepsilon_{it} \quad (3)$$

The outsourcing intensity is calculated as the value of industrial services received divided by total wage costs, as in Section 2. The ownership dummy (= 1 if establishment is foreign owned) is included as there is a large literature that argues that foreign multinationals have higher productivity (levels or growth) than domestic firms (e.g. Griffith and Simpson, 2002; Doms and Jensen, 1998). In order to see whether there are different productivity effects of outsourcing for foreign and domestic firms we allow α_3 to vary for the two nationality groups by including an interaction term calculated as *out* * *own*. Finally we also include lagged productivity to allow for adjustment of labour productivity and an age variable in the regression to capture different labour productivity growth for establishments of different ages.

One econometric concern with the above equation is that there may be a potential endogeneity problem if, for example, highly productive establishments are more skill intensive and thus more likely to use outsourcing. In order to take account of this possibility we instrument for outsourcing intensity using the growth rates of skilled and unskilled wages, and establishment size as instruments. The Sargan test of overidentifying restrictions indicates that in all cases these appear to be valid instruments.

Table 5 presents firstly the results of estimating the labour productivity growth equation without instrumenting for outsourcing. As in the previous section we estimate the model separately for the three manufacturing sectors. Columns (1), (4) and (7)

present results including only the foreign dummy and lagged labour productivity. As may be expected we find a labour productivity premium for foreign owned establishments in all sectors, which is in line with the literature. We then add outsourcing intensity and the ownership – outsourcing interaction term into the model. For all sectors we find that outsourcing is positively related with labour productivity growth, while there does not appear to be a differential effect of outsourcing for foreign and domestic owned establishments.

[Table 5 here]

We then allow for the possible endogeneity of outsourcing by using instrumental variable regression, the results of which are reported in Table 6 for all three sectors. Note that the Sargan test in all cases indicates that the instruments are valid. Compared to the results of the simple OLS estimations we note that the coefficients, in terms of magnitude and statistical significance are very similar in all cases. Hence, we find that foreign establishments have higher labour productivity growth, and that outsourcing intensity is positively related to labour productivity growth also.

[Table 6 here]

Outsourcing may not only affect the productivity of labour but also that of other factors of production if it leads to an adjustment of the production process. In order to capture these productivity effects as well we subsequent to the analysis of labour productivity also examine whether outsourcing affects total factor productivity (TFP) growth. Hence we estimate the following TFP growth equation[10]

$$\Delta tfp_{it} = \phi_0 + \phi_1 \Delta tfp_{it-1} + \phi_2 out_{it} + \phi_3 own_{it} + \varepsilon_{it} \qquad (4)$$

As in the labour productivity growth estimation we allow for the possible endogeneity of outsourcing using IV regression. The results of these estimations are

[10] See Appendix for a description of how TFP is calculated.

reported in Tables 7 (OLS) and 8 (IV). Note again that the Sargan test does not allow us to reject the hypothesis of instrument validity, hence we can take the instruments as being appropriate.

Results are similar for both OLS and IV regressions. We find again that outsourcing intensity is positively related with productivity growth. There is no differential effect of outsourcing intensity on productivity for domestic and foreign firms. In contrast with the labour productivity results we find for the TFP regressions that the ownership dummy is statistically insignificant, indicating that foreign establishments do not have higher TFP growth than domestic establishments.

[Tables 7 to 8 here]

5 Conclusions

This paper presents an empirical analysis of "outsourcing" using establishment level data for UK manufacturing industries. We analyse an establishment's decision to outsource and the subsequent effects of outsourcing on the establishment's productivity. Our empirical results suggest that high wages are positively related to outsourcing, suggesting that the cost saving motive is important. We also find that foreign-owned firms have higher levels of outsourcing than domestic establishments. In the productivity analysis we find that an establishment's outsourcing intensity is positively related to its labour productivity and total factor productivity growth.

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Appendix: TFP estimation

Using log values, we write the production function as $y_{it} \equiv f(l^s_{it}, l^u_{it}, k_{it}, m_{it}, TFP_{it})$, where y is output and there are four factors of production: skilled labour (l^s), unskilled labour (l^u), materials or cost of goods sold (m) and capital stock (k). For estimation purposes we employ a first-order Taylor approximation and write the production function as:

$$y_{it} = \beta_0 + \beta_s l^s_{it} + \beta_u l^u_{it} + \beta_k k_{it} + \beta_m m_{it} + TFP_{it} \quad \text{(A1)}$$

TFP is assumed to follow the following AR(1) process:

$$TFP_{it} = \rho TFP_{it-1} + \delta D_t + f_i + v_{it} \quad \text{(A2)}$$

where D is a common year-specific shock, f is a time-invariant firm specific effect and v a random error term. Note that we do not simply model productivity as a fixed effect, as that would imply that TFP differences are fixed, and there is no role for technology diffusion (convergence).

Recently the fundamental assumption of pooling individual times series data has been questioned. Pesaran and Smith (1995) demonstrate that standard GMM estimators of dynamic panel models lead to invalid inference if the response parameters are characterised by heterogeneity. They argue that one is better off averaging parameters from individual time series regressions. This is not feasible here since the individual firm's time series data is not of adequate length. However, we take some comfort from a recent comparative study by Baltagi and Griffin (1997) which concludes that efficiency gains from pooling are likely to more than offset the biases due to individual heterogeneity. Baltagi and Griffin (1997) especially point out the desirable properties of the GLS-AR(1) estimator, and we use this estimator to obtain estimates of the factor elasticities, and derive TFP as a residual term. We estimate equation (4) for each of the four-digit SIC80 industries available in our sample.

Table 1: Mean outsourcing intensity by sector
(standard deviation in parentheses)

Sector	All	foreign	domestic
Chemicals	0.138	0.161	0.128
	(0.279)	(0.256)	(0.343)
Mechanical engineering	0.140	0.161	1.136
	(0.360)	(0.288)	(0.226)
Electronics	0.091	0.097	0.090
	(0.554)	(0.458)	(0.599)

Figure 1a

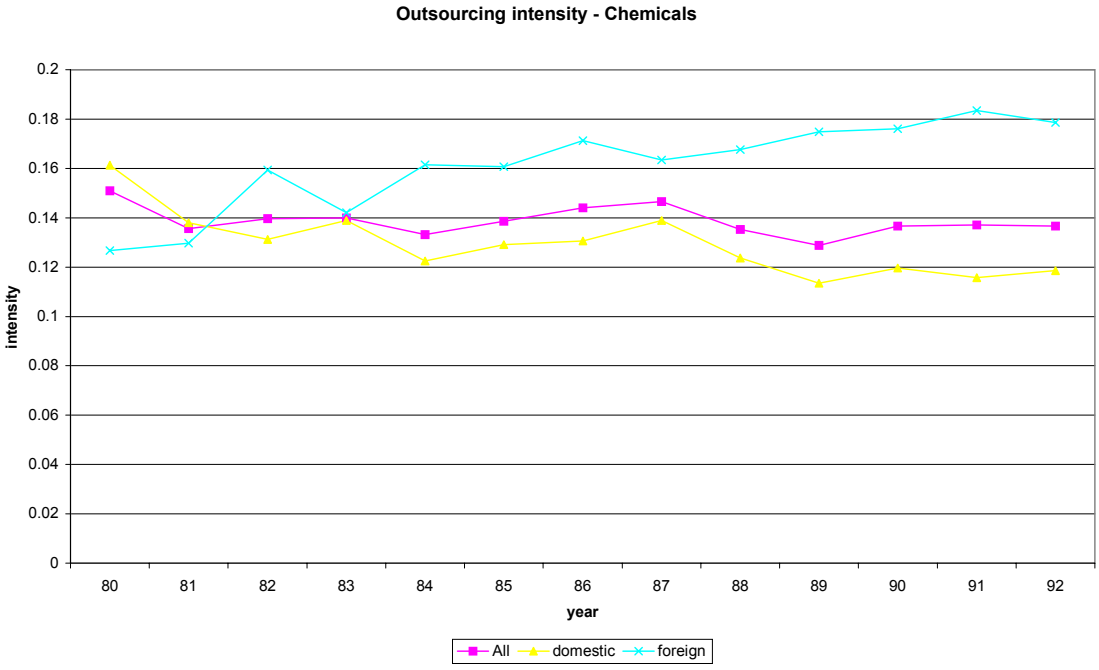

Figure 1b

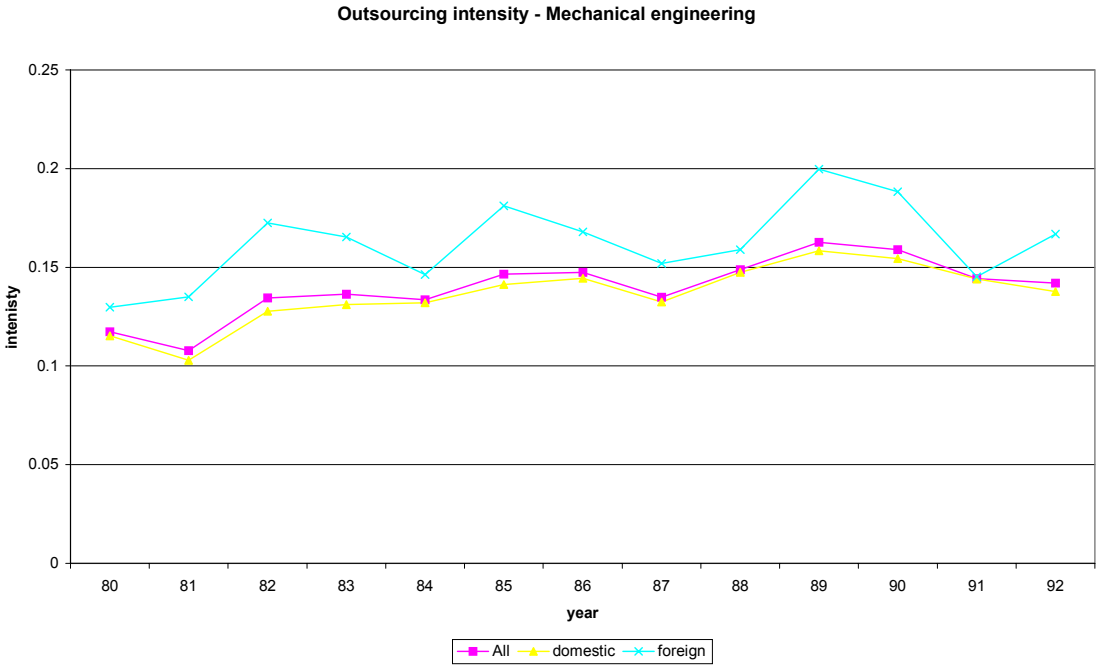

Figure 1c

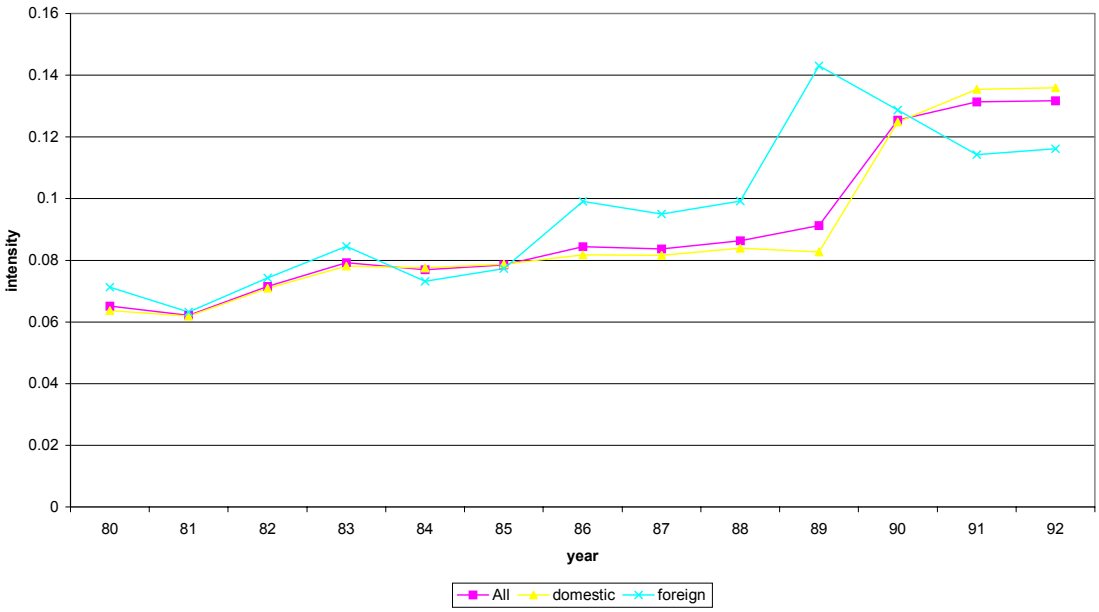

Table 2: Determinants of outsourcing in the chemicals sector
Dependent variable: log of industrial services received

	(1)	(2)	(3)	(4)
ln (skilled wage)	0.538	0.969	0.541	0.939
	(0.133)**	(0.383)*	(0.132)**	(0.382)*
ln (unskilled wage)	0.141	0.256	0.144	0.269
	(0.120)	(0.125)*	(0.123)	(0.126)*
union	2.014	1.983		
	(0.734)**	(0.733)**		
ln (size)	1.558	1.395	1.556	1.393
	(0.054)**	(0.098)**	(0.054)**	(0.098)**
domestic dummy	-0.693	3.993	-0.699	3.740
	(0.130)**	(3.495)	(0.131)**	(3.480)
domestic * ln(size)		0.215		0.215
		(0.108)*		(0.107)*
domestic* ln (skilled wage)		-0.496		-0.456
		(0.401)		(0.400)
domestic * ln (unskilled wage)		-0.162		-0.175
		(0.189)		(0.194)
Constant	-1.650	-5.602	-0.416	-4.081
	(0.945)+	(3.438)	(1.524)	(3.562)
Observations	8476	8476	8476	8476
F-test		1.86		1.84
R-squared	0.30	0.30	0.32	0.32

Heteroskedasticity-autocorrelation consistent standard errors in parentheses
+ significant at 10%; * significant at 5%; ** significant at 1%
Regressions include 4-digit sector, time and region dummies.
Regressions (3) and (4) also include sectoral time dummies
Union variable in (3) and (4) is dropped due to multicollinearity with the sectoral time dummies
F-test is for joint significance of three interaction terms

Table 3: Determinants of outsourcing in the mechanical engineering sector
Dependent variable: log of industrial services received

	(1)	(2)	(3)	(4)
ln (skilled wage)	0.364	0.841	0.369	0.879
	(0.101)**	(0.200)**	(0.103)**	(0.204)**
ln (unskilled wage)	0.084	0.073	0.086	0.074
	(0.041)*	(0.051)	(0.041)*	(0.050)
union	0.393	0.362	0.179	0.026
	(0.402)	(0.402)	(1.164)	(1.162)
ln (size)	1.596	1.229	1.597	1.213
	(0.040)**	(0.120)**	(0.041)**	(0.121)**
domestic dummy	-0.600	1.489	-0.592	1.698
	(0.112)**	(2.003)	(0.112)**	(2.041)
domestic * ln(size)		0.423		0.444
		(0.124)**		(0.125)**
domestic* ln (skilled wage)		-0.508		-0.544
		(0.215)*		(0.219)*
domestic * ln (unskilled wage)		0.022		0.024
		(0.054)		(0.053)
Observations	30793	30793	30793	30793
F-test		5.32**		5.78**
R-squared	0.20	0.20	0.21	0.21

Heteroskedasticity-autocorrelation consistent standard errors in parentheses
+ significant at 10%; * significant at 5%; ** significant at 1%
Regressions include 4-digit sector, time and region dummies.
Regressions (3) and (4) also include sectoral time dummies
F-test is for joint significance of three interaction terms

Table 4: Determinants of outsourcing in the electronics sector
Dependent variable: log of industrial services received

	(1)	(2)	(3)	(4)
ln (skilled wage)	0.364	0.441	0.359	0.453
	(0.073)**	(0.173)*	(0.074)**	(0.170)**
ln (unskilled wage)	0.079	0.100	0.083	0.092
	(0.050)	(0.115)	(0.050)+	(0.111)
union	0.876	0.875		
	(0.765)	(0.765)		
ln (size)	1.822	1.758	1.820	1.749
	(0.040)**	(0.098)**	(0.041)**	(0.099)**
domestic dummy	-0.297	0.285	-0.307	0.294
	(0.133)*	(1.410)	(0.133)*	(1.402)
domestic * ln(size)		0.075		0.083
		(0.105)		(0.105)
domestic* ln (skilled wage)		-0.089		-0.108
		(0.187)		(0.184)
domestic * ln (unskilled wage)		-0.025		-0.012
		(0.119)		(0.117)
Constant	-6.396	-6.224	-7.026	-6.879
	(1.030)**	(1.495)**	(2.708)**	(2.903)*
Observations	15818	15818	15818	15818
F-test		0.24		0.29
R-squared	0.27	0.27	0.28	0.28

Heteroskedasticity-autocorrelation consistent standard errors in parentheses
+ significant at 10%; * significant at 5%; ** significant at 1%
Regressions include 4-digit sector, time and region dummies.
Regressions (3) and (4) also include sectoral time dummies
Union variable in (3) and (4) is dropped due to multicollinearity with the sectoral time dummies
F-test is for joint significance of three interaction terms

Table 5: Labour productivity adjustment and outsourcing
(labpro_dh.do)
Dependent variable: Labour productivity growth

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	chemicals I	chemicals II	chemicals III	electronics I	electronics II	electronics III	engineering I	engineering II	engineering III
labprod lagged	-0.109	-0.027	-0.027	-0.199	-0.108	-0.108	-0.333	-0.273	-0.273
	(0.024)**	(0.005)**	(0.005)**	(0.060)**	(0.053)*	(0.053)*	(0.065)**	(0.072)**	(0.072)**
foreign dummy	0.053	0.016	0.016	0.101	0.053	0.053	0.134	0.113	0.113
	(0.013)**	(0.004)**	(0.004)**	(0.026)**	(0.022)*	(0.022)*	(0.026)**	(0.028)**	(0.028)**
outsourcing intensity		0.002	0.001		0.002	0.002		0.004	0.004
		(0.001)*	(0.001)		(0.001)*	(0.001)+		(0.001)**	(0.001)**
foreign * outsourcing			0.003			0.001			0.001
			(0.002)			(0.002)			(0.002)
capital intensity growth		0.008	0.008		0.011	0.011		0.009	0.009
		(0.005)	(0.005)		(0.003)**	(0.003)**		(0.006)	(0.006)
materials intensity growth		0.761	0.761		0.650	0.650		0.479	0.479
		(0.029)**	(0.029)**		(0.044)**	(0.044)**		(0.038)**	(0.038)**
age		-0.001	-0.001		-0.004	-0.004		-0.001	-0.001
		(0.001)	(0.001)		(0.001)**	(0.001)**		(0.001)	(0.001)
Constant	1.671	0.405	0.404	1.932	1.087	1.087	3.199	2.630	2.630
	(0.359)**	(0.080)**	(0.080)**	(0.587)**	(0.529)*	(0.529)*	(0.639)**	(0.713)**	(0.713)**
Observations	6917	6917	6917	12552	12552	12552	23555	23555	23555
R-squared	0.08	0.69	0.69	0.13	0.45	0.45	0.15	0.26	0.26

Notes:
Regressions include time and region dummies.
Heteroskedasticity-autocorrelation consistent standard errors in parentheses
+ significant at 10%; * significant at 5%; ** significant at 1%

Table 6: Labour productivity adjustment and outsourcing (instrumental variables) (labpro_dhiv.do)

Dependent variable: Labour productivity growth

	(1)	(2)	(3)	(4)	(5)	(6)
	chemicals II	chemicals III	electronics II	electronics III	engineering II	engineeringIII
labprod lagged	-0.037	-0.037	-0.017	-0.017	-0.292	-0.292
	(0.006)**	(0.006)**	(0.004)**	(0.004)**	(0.103)**	(0.103)**
foreign dummy	0.020	0.020	0.021	0.021	0.109	0.109
	(0.005)**	(0.005)**	(0.004)**	(0.004)**	(0.038)**	(0.038)**
outsourcing intensity	0.004	0.003	0.002	0.002	0.004	0.004
	(0.001)**	(0.001)*	(0.001)**	(0.001)**	(0.001)**	(0.001)**
foreign * outsourcing		0.004		0.001		0.000
		(0.002)+		(0.002)		(0.002)
capital intensity growth	0.023	0.023	0.036	0.037	0.000	0.000
	(0.009)**	(0.009)**	(0.010)**	(0.010)**	(0.024)	(0.024)
materials intensity growth	0.762	0.762	0.522	0.522	0.489	0.489
	(0.033)**	(0.033)**	(0.017)**	(0.017)**	(0.054)**	(0.054)**
age	-0.002	-0.002	-0.001	-0.001	-0.004	-0.004
	(0.001)+	(0.001)+	(0.000)**	(0.000)**	(0.002)+	(0.002)+
Constant	0.570	0.570	0.207	0.207	2.985	2.985
	(0.092)**	(0.092)**	(0.045)**	(0.045)**	(1.062)**	(1.062)**
Observations	5707	5707	8175	8175	14509	14509
Sargan test (p-value)	0.29	0.29	0.39	0.45	0.28	0.65
R-squared	0.70	0.70	0.46	0.46	0.25	0.25

Notes:
Regressions include time and region dummies.
Heteroskedasticity-autocorrelation consistent standard errors in parentheses
+ significant at 10%; * significant at 5%; ** significant at 1%
Instruments used: growth of skilled and unskilled wages and employment size lagged two periods (and interaction terms) in (3) and (4), lagged one period in (1), (2), (5), (6)

Table 7: TFP adjustment and outsourcing
(tfp_dh.do)
Dependent variable: TFP growth

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	chemicals I	chemicals II	chemicals III	electronics I	electronics II	electronics III	engineering I	engineering II	engineering III
tfp growth lagged	-0.353	-0.352	-0.352	-0.250	-0.248	-0.248	-0.708	-0.708	-0.708
	(0.087)**	(0.087)**	(0.087)**	(0.016)**	(0.016)**	(0.016)**	(0.118)**	(0.118)**	(0.118)**
foreign dummy	0.002	0.002	0.002	0.000	0.000	0.000	0.002	0.002	0.002
	(0.004)	(0.004)	(0.004)	(0.005)	(0.005)	(0.005)	(0.007)	(0.007)	(0.007)
outsourcing intensity		0.004	0.004		0.003	0.003		0.004	0.003
		(0.001)**	(0.002)*		(0.001)**	(0.001)**		(0.001)**	(0.001)**
foreign * outsourcing			0.002			0.001			0.002
			(0.003)			(0.002)			(0.002)
age		-0.001	-0.001		-0.000	-0.000		-0.001	-0.001
		(0.002)	(0.002)		(0.000)	(0.000)		(0.002)	(0.002)
Constant	0.007	0.002	0.003	-0.001	0.014	0.014	-0.030	0.020	0.020
	(0.013)	(0.019)	(0.019)	(0.006)	(0.012)	(0.012)	(0.012)*	(0.029)	(0.029)
Observations	4180	4180	4180	7315	7315	7315	11287	11287	11287
R-squared	0.11	0.12	0.12	0.07	0.07	0.07	0.37	0.37	0.37

Notes:
Regressions include time and region dummies.
Heteroskedasticity-autocorrelation consistent standard errors in parentheses
+ significant at 10%; * significant at 5%; ** significant at 1%

Table 8: TFP adjustment and outsourcing (instrumental variables)
(tfp_dh.do)
Dependent variable: TFP growth

	(1)	(2)	(3)	(4)	(5)	(6)
	chemical II	chemical III	electronics II	electronics III	engineering II	engineeringIII
tfp growth lagged	-0.349	-0.349	-0.255	-0.255	-0.708	-0.708
	(0.092)**	(0.092)**	(0.017)**	(0.017)**	(0.118)**	(0.118)**
foreign dummy	0.003	0.003	-0.002	-0.002	0.002	0.002
	(0.004)	(0.004)	(0.005)	(0.005)	(0.007)	(0.007)
outsourcing intensity	0.003	0.004	0.001	0.001	0.003	0.003
	(0.001)**	(0.001)**	(0.001)+	(0.001)	(0.001)**	(0.001)**
foreign * outsourcing		-0.001		0.001		0.002
		(0.003)		(0.002)		(0.002)
age	-0.001	-0.001	-0.000	-0.000	-0.001	-0.001
	(0.002)	(0.002)	(0.000)	(0.000)	(0.002)	(0.002)
Constant	0.011	0.011	0.005	0.005	0.020	0.020
	(0.010)	(0.010)	(0.009)	(0.009)	(0.029)	(0.029)
Observations	3980	3980	7070	7070	11287	11287
Sargan test (p-value)	0.43	0.70	0.08	0.22	0.42	0.46
R-squared	0.11	0.11	0.07	0.07	0.37	0.37

Notes:
Regressions include time and region dummies.
Heteroskedasticity-autocorrelation consistent standard errors in parentheses
+ significant at 10%; * significant at 5%; ** significant at 1%
Instruments used: growth of skilled and unskilled wages and employment size lagged two periods (and interaction terms) in (1) - (3), lagged one period in (4) - (6)