

International Services Outsourcing, Wages and Innovation

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Abstract

Theories of international outsourcing predict rises in firms' innovation rates mediated through lower wages per worker. Consistent with the predictions of Glass and Saggi (2001), we find a tradeoff between wages and innovation. However, we do not find that the proportion of internationally outsourced service inputs reduces but rather increases a firm's wage per worker, a result most likely driven by increased specialisation and upskilling. The direct effect of international services outsourcing on innovation (as opposed to the indirect effect as mediated through wages) is positive. We conclude that the positive effect of international services outsourcing on innovation is not mediated through wages but more likely to result from cost savings or even increased scope for specialisation.

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1 Introduction

International outsourcing as a topic for study still excites curiosity from academic and practitioners judging from the recent volume being written and sound bytes produced by both parties. However, the jury is still out as to whether it is a valid strategy and generates net positive, sustained economic outcomes. This paper is most concerned with the latter part of the previous statement: can international services outsourcing be sustained through the mechanism of wages and innovation? If international services outsourcing can be shown to enhance innovation, there is a case to be made for its continuity as a strategy. Our reasoning is based on theories positing ever shifting technical frontiers. Under conditions of a continuously shifting technical frontier the technical gap between industrialised and industrialising countries remains and the outsourcing of foreign inputs is more likely to persist into the future.

The basic mechanism of international outsourcing can be explained by describing how firms in more industrialised countries exploit wage differentials, outsource production typically of a lower skilled activity abroad, and observe wages for lower skilled workers in their home country to fall for their services falls (Kurz, 2006; Egger and Egger, 2006). This wage fall is accompanied by a rise in profits as the firm's input and worker costs fall (Egger and Egger, 2004). This rise in the firm's profits coincides with a shift towards the firm's higher skilled labour who generate more innovative output or outputs at the more innovative part of the production chain. Accordingly we should observe innovation rising as a consequence of international outsourcing.

The above chain of events seems to reflect what economic observers have noted in recent years. The World Bank Development Report (World Bank 1975-1995) notes that most industrialised countries have experienced higher levels of international outsourcing which has been coupled with a decreased relative wage. However, innovation in industrialised countries remains buoyant in many industries. Such patterns cause theoretical economists such as Glass and Saggi (2001) to conclude that "forces that increase international outsourcing, accelerate the progression of the technology frontier" (p.82).

As the technology frontier advances it further facilitates international outsourcing because it leads to lower adaptation costs in the lower wage, industrialising country (Glass and Saggi, 2001). Precisely this, is what makes the link between international outsourcing and innovation so interesting, because embedded in innovation is the key to the continuity of international outsourcing as a strategy. International outsourcing can be continued into the future despite periodic wage convergence between industrialising and industrialised countries due to this possibility of an ever moving technology frontier, an aspect Glass and Saggi (2001) have been careful to emphasise. Thus understanding the impact of international outsourcing on innovation is key to understanding whether we can expect international outsourcing to fizzle out once wage convergence is reached or whether it is a strategy to be sustained.

With this in mind, we set out to look at the effect of international services outsourcing on innovation. We choose international services because of their negligible sunk costs, thus creating a more level playing field for firms to participate (Bartel et al., 2005). Moreover there has been recent interest in the growth in international services outsourcing despite the fact that it still constitutes a relatively small part of overall outsourcing (Amiti and Wei, 2004; Görg et al., 2005).

Several economists have recently urged for more work to be carried out at a micro-level in order to overcome standard issues of aggregation bias (Cassidy et al., 2005; Kurz, 2006; Egger and Egger, 2006) and this need underpins our use of a unique panel of Irish firms from the Annual Business Survey, collected by Forfás, the policy and advisory board with responsibility for enterprise, trade, science, and technology in the Republic of Ireland. As Cassidy et al. (2005) point out, there is substantial heterogeneity across firms even within narrowly defined industries, a fact that policy makers are concerned about when using the results of economic studies to inform policy. The potentially more serious, albeit technical issue, of aggregation bias means that aggregate data are not equipped to explaining this heterogeneity, an issue that can severely bias the econometric results.

The application of Irish data to this research question is in some respects analogous to using data from another Anglophone industrialised country such as the US or UK who could potentially outsource services such as IT to another Anglophone industrialising country such as India. One feature of the Irish data is that there has been historically a strong tradition of FDI, a phenomenon which explains the high presence of foreign multinationals. As in Cassidy et al. (2006), we differentiate between foreign owned multinationals and domestic firms or multinationals in our data in order to see whether they show different sensitivities of innovation to international outsourcing.

We find that a simple regression framework is inadequate to explaining the effect of international services outsourcing on innovation, either directly or indirectly via wages per worker. Instead we find that more structured 2-SLS modelling reveals that the effect of international services outsourcing is positive for innovation. This is consistent with theories positing that such fragmentation of production overseas allows for a freeing up of resources towards innovative outputs. However, the effect of international outsourcing on innovation, as moderated through wage per worker is less clear cut. In our causal framework we observe that higher proportions of international outsourcing of services is accompanied by higher wage per worker possibly a result of reconfiguration of the existing workers towards higher skilled activities (consistent with the literature) or even a selection effect where higher wage firms might be more likely to engage in international services outsourcing as a defensive mechanism.¹ Our most unambiguous finding however, is

¹ This result even held when we used lagged outsourcing to help counter this possibility

that irrespective of the measure for innovation used, international services outsourcing is beneficial for innovation.

Our paper is structured as follows. In the next section we outline the background to outsourcing in more detail. This is followed by a description of our methodology and the data used. Then follows the analysis section followed by a short summary of our main findings.

2 Background

Several theoretical papers describe the complex interplay between international outsourcing, wages and possibilities for further innovation (Feenstra and Hanson, 1996; Glass and Saggi, 2001). As is typical in this literature, both models assume a technological and accordingly wages gap between industrialised countries (the North) and industrial countries (the South). Also assumed is a chain of manufacturing processes which can be broken down into discrete components or fragments and which vary from each other in terms of technological complexity. Assuming constant productivity over the processes for manufacture in both the North and South, potential wage savings will prompt the North to outsource those processes from the South which are relatively low in technological complexity and retain those other processes which are more truly original, innovative or relatively near the technological frontier. Some economists argue that firms in the South commence production of their own accord and start to imitate less technologically advanced processes either under licence or with a view to selling independently as intermediates on Northern markets (Jensen and Thursby, 1987; Segerstrom et al., 1990). Glass and Saggi contend that the appearance of manufacturing capacity in the South is caused by the North deliberately adapting technologies for use in the South. The predictions from either the imitative or adaptive interpretation for the effect of international outsourcing on wages are expected to be similar, only differing according to whether labour is assumed to be homogeneous or heterogeneous.

Cost savings are realised as expenditure on wages per worker falls in the short run, some of the additional products accruing to the firm being reinvested in the relatively technologically more complex processes which are still retained in-house in the North. The net result is a predicted fall in wages expenditure. If, as Glass and Saggi assume, workers are homogeneous, we should also observe a fall in wage per worker in the North as the demand for workers drops as the equilibrium price of labour falls. However, the assumption of homogeneous labour is a strong one to make and one that is relaxed in Feenstra and Hanson (1996) and some more recent empirical work by Egger and Egger (2006). However, the latter focuses on value added per worker rather than the price of labour and accordingly is less useful in terms of observing the effect of international outsourcing on wages per worker.

Since it is generally accepted that skilled labour is paid a higher wage than unskilled labour, substituting internationally outsourced inputs for in-house manufacture by non-skilled labour should raise rather than reduce the wage per worker, at least as a short run response to international outsourcing.

Where there is consensus in the literature is the effect of wage savings on profits and ultimately innovation. Another area on which there is agreement is the effect of a firm being able to dedicate a higher proportion of its workforce on higher value added activities which yield higher quality, differentiated products for which a premium price can be charged (Egger and Egger, 2004).² The profits accruing to the firm from wage savings and product price premia can be ploughed back into R&D or efforts to shift the technological frontier even further. As such the predicted effect of international outsourcing on innovation is relatively unequivocal: increased proportions of international outsourcing lead to higher innovation rates.³

3 International outsourcing of services

Our paper deals with the effect of internationally outsourced services on innovation and as such we need to outline what distinguishes services from materials outsourcing and more importantly whether this has any implications for how we interpret the literature which generally does not make this distinction.

With the advent of cheaper transport, improvements in telecommunication, reduction in computing costs and improvements in trade and investment liberalisation, the tradability of international services has risen (Gage and Leshner, 2005). However, although services outsourcing is growing, its overall weighting in the basket of imported intermediates is still relatively low (Amiti and Wei, 2004; Görg et al., 2005). According to Amiti and Wei (2004), in the US imports of computing and business services as a percentage of GDP comprised only 0.4 percent in 2003. However the case for future growth in services outsourcing is compelling.

According to recent research by the Deutsche Bank (DB Research, 2004) the hourly rates for computer programmers in Germany were €54 in 2004 comparable with rates of €44 in the US. In industrialising countries the same labour could be provided for €9.24 in Russia, €4 in Portugal and China €7 in India. Of course, these statistics hide any underlying productivity differences but they do nonetheless highlight wage differences and provide compelling reasons for the outsourcing of international services.

Another phenomenon is the more integral part played by services in many industries hitherto considered as manufactures of tangible goods. A case in point is the car making industry. According to recent research by

² More specifically, Egger and Egger (2004) find in a “thought experiment” that EU price cost margins are falling, but that industries which had availed of international outsourcing had decelerated this downward trend. International outsourcing was seen as a stabilising force rather than a cause for a reversal in the fortunes of EU manufacturing

³ We should qualify this by saying that positive benefits from international outsourcing are expected to tail off after a certain point. As ever more activities closer to the technical frontier are outsourced abroad, so too does the ease at which foreign manufacturers pose a competitive threat to the North.

Gage and Leshner, the global car industry earns much of its profits by providing services, such as vehicle leasing or car loan financing.

We first deal with the unique nature of service inputs. Service inputs are very particular and yet share many features of material inputs such as economies of scale in provision. First to the more distinctive features of international services outsourcing. Instead of conforming to the traditional textbook approach to outsourcing where the North outsources low technology intermediates from the South, outsourced service inputs increasingly comprise inputs rich in knowledge, complexity and originality.

This is particularly the case of outsourcing from the IT sector. Economies of scale often necessitate the outsourcing of this function. However, instead of outsourcing the function to a local domestic producer, firms are increasingly turning to overseas firms to fill this need. A case in point is the extensive provision of IT services such as programming and system design to Indian cities such as Hyderabad. Accordingly, the traditional dichotomy between skilled and unskilled labour assumed in some of the models of outsourcing can break down in the context of international services outsourcing where industrialising countries such as India have decided a priori to chase this lucrative market by investing heavily in the education of engineers, physicists and other skilled employees. It may be true therefore, that in some instances, North and South are very close to the technical frontier in the context of services outsourcing but models of differential capital endowments (e.g. Feenstra and Hanson, 1996) better explain the separation of expertise. It could be argued that traditional services outsourced by firms such as Janitorial and Maintenance (outsourced domestically) contribute less to innovative output than Product design which can increasingly now be outsourced abroad. If this is true, there is a de facto case for innovation to rise in response to increases in international outsourcing.

4 Methodology

Does the international outsourcing of wages raise a firm's innovation rate?

We recall from the theory that international outsourcing is predicted to drive down wages, at least in the short run when labour is less mobile. These wage savings in turn are used to build a firm's innovation capacity and ultimately the quality of a firm's product. Such reinvestment can be proxied as R&D expenditure. Accordingly, the theory predicts that short run wages are decreasing in international outsourcing. Moreover, the theory predicts a tradeoff between wages per worker and R&D expenditure (otherwise innovation if actual outcomes are measured).

Applying the theory of international outsourcing, our most basic estimation equation predicting innovation as a function of wages per worker and international outsourcing of services is:

$$\Delta innov_{it} = \mathbf{b}_1 wages1_pw_{it} + \mathbf{b}_2 serv_os_{it-1} + \mathbf{b}_3 size_{it} + \mathbf{b}_4 domestic_i + fixed\ effects + e_{it}$$

In the above equation, *wages1_pw* denotes logged wages per worker for firm *i* at time *t*, *serv_os* is the lagged ratio of internationally outsourced service inputs as a proportion of totally outsourced service inputs, *size*, firm size is captured as both number of employees and turnover. The domestic dummy denotes whether or not a firm is indigenous or not given the previously mentioned differences between R&D intensities between domestic and foreign owned firms in the Republic of Ireland (Cassidy et al., 2005). The panel nature of the regression allows us to capture firm specific fixed effects while the remaining noise is captured by *e*, an i.i.d error term. The dependent variable is defined to be either innovation as represented by the proportion of sales from innovative products to total sales turnover, in which case we revert to a cross-section regression for 2004 only.⁴ We also proxy innovation, perhaps more generally as R&D intensity expressed as R&D expenditure as a proportion of a firm's sales. The inclusion of fixed effects is crucial for our purpose since we seek to isolate changes induced by higher global engagement in services (higher proportions of internationally outsourced services) on wages and ultimately on a firm's capacity to innovate.

Consistent with the framework enunciated in the Glass-Saggi (2001) model where international outsourcing feeds into wages which in turn feed into a firm's innovation capacity, we instrument for wages in the first stage. We do this in order that in the second stage we can use the instrumented value for wages, having being purged of its relationship with international services outsourcing in the second stage. We also test whether this assumption of endogeneity is necessary by examining whether the standard fixed effects approach produces systematically different estimates from the instrumental variables fixed effect method. Hausman-type testing procedures are used to this end, and we fail to accept the null hypothesis that wages per worker are exogenous.

We were also careful to check the appropriateness of the instrumental variable candidates in two respects. First, their *validity* in the sense of having no correlation with the equation error is tested, using the classical Hansen's test for overidentifying restrictions (which is the robust version of the ubiquitous Sargan test statistic). Second, we ascertain that the instruments used are *relevant* in that they exhibit sufficiently strong correlation with the instrumented variable. It is generally accepted that when the partial correlations between the instruments and the endogenous variable are low, instrumental variables regression is biased in the direction of the OLS estimator. Accordingly

⁴ This question was only included in the survey in 2004.

it is recommended that the F-statistic for the excluded instruments⁵ (and associated p-value) from the first-stage regression be routinely reported in applied work. When the F-statistic is small (or the corresponding p-value is large), the instrumental variable estimates and confidence intervals would be unreliable. Reassuringly, we find that our instruments are appropriate on this criterium.

5 Data description and Analysis

For the econometric part of our paper, we use recent micro-data that relates to the Republic of Ireland. As such we should note a few points regarding the composition of Irish industry.⁶ The landscape in Ireland is very much dominated by a phalanx of large multinational firms who account for much of overall output (Cassidy et al., 2005). Many of these firms are especially active in a small number of knowledge intensive, export oriented manufacturing sectors including electrical and electronic equipment, medical instruments, chemicals and pharmaceuticals. Against this background of high foreign FDI, it seems anomalous that Ireland registers a relatively low level of R&D intensity, a fact noted by the OECD (1998). Total business expenditure on R&D in total amounted to only 0.8 percent of GDP which leaves Ireland closer to Mediterranean countries which in general are characterised by low-technology output than the Northern European countries which tend to have higher technological intensities and higher R&D expenditures.

We utilise plant level information from data collected by Forfás, the Irish policy and advisory board with responsibility for enterprise, trade, science, and technology in Ireland. Specifically, our data source is the Annual Business Survey, covering the period from 2000 until 2004. This is an annual survey of plants in Irish manufacturing with at least 10 employees, although a plant, once it is included, is generally still surveyed even if its employment level falls below the 10 employee cut-off point. The response rate to the survey is estimated by Forfás to be around 55 to 60 percent of the targeted population. This data set provides information on services purchases, distinguishing imported and domestically procured services, as well as total R&D expenditure at the plant level. Further data available from this source that is relevant to the current paper are total sales (as a measure of output), employment, the total wage bill, exports, nationality of ownership, and four digit sector of production.

Table 1 outlines the median and mean values for the firms in the Irish data over the 5 year period from 2000 to 2004 for which we have available data. The key variables in our subsequent estimations, foreign services outsourcing, R&D intensity and wages are worth commenting on. The average ratio of foreign outsourced services to total outsourced services is approximately 13 percent with very little variation over the 5 year

⁵ The F-statistic tests the hypothesis that the instruments should be excluded from the first-stage regressions.

⁶ See Cassidy et al. (2005) for a good summary of Irish industry

period. This average masks a lot of firms who perform little or no foreign services outsourcing, as seen in the median value remaining at 0 percent for the 5 years. R&D per worker shows more variation over the years and its average value varies between approximately €3,000 and €11,000 per worker. Wages per worker increase steadily over the 5 year period from a low starting value of €25,000 (median) to finish at €34,000 in 2004.

Since we are investigating the relationship between wages per worker and the intensity of R&D inputs as the firm's consumption of internationally outsourced services is increased, it is more interesting to format the same information across the group of firms who do not procure any internationally outsourced services at all and those who do (Table 2). In this way we have a first impression of what the regressions may yield: the relationship between wages and R&D once internationally outsourced services are held constant. We see from Table 2 that firms reporting at least some internationally outsourced services, have higher R&D intensities, wages, and exports. They are also bigger in terms of employee numbers, than their counterparts who do not report any internationally outsourced services. However, we should note that there is a high standard deviation for these average values and therefore to investigate any systematic differences between wage per worker and R&D intensities, we really need to control for all the covariates simultaneously and filter out any noise that is associated with such high standard deviations.

Before we move on to the results from our regressions, it is worthwhile looking briefly at which sectors are most actively engaged in procuring internationally outsourced services (Table 3). The first impression we get is that there is considerable sectoral variation in endowments of internationally outsourced services. If we assumed no sectoral variation we should observe about 50 percent of firms in each sector engaged in foreign services outsourcing (recall that approx. 50 percent of firms do not engage in any foreign services outsourcing from the median value earlier). Within the service sector, Transport and Storage and Financial Intermediation register the highest levels of internationally outsourced services. However, our data do not capture many service firms in general but rather are biased towards manufacturing. Within the set of manufacturing firms, at 64 percent the Transport Equipment subsector has the highest proportion of firms purchasing service inputs on foreign markets. However Chemicals at 62 percent and Textiles and Machinery and Equipment at 61 percent respectively are well in excess of the 50 percent median value.

Table 4 reports the results from our basic regression of wage per worker on R&D intensity having controlled for the level of internationally outsourced services. Since all variables are logged, the coefficients for the non-discrete variables can also be interpreted as percentage changes. The most important point to note is that the sign on the coefficient for wages per worker is positive, a result inconsistent with the GS model

prediction that there should be a tradeoff between the two.⁷ Also, firms who have higher proportions of internationally outsourced services are significantly associated with higher R&D intensities. The other result is that domestic firms are associated with higher R&D intensities, a result which suggests that foreign firms in the Republic of Ireland conduct R&D in their country of origin.⁸ This result is clearly the case from a perusal of the aggregate data. Officially published aggregate data for Ireland cited in Cassidy et al. (2001) show that R&D intensities of foreign owned firms are somewhat lower than the corresponding value for indigenous firms but very low by international standards.⁹

In Table 5 we attempt to align the methodology with the G-S model where now R&D intensity is modelled as a function of wages per worker. These in turn are a function, inter alia, of the proportion of internationally outsourced services. As such, workers' wages occupy a "halfway" position between services outsourcing and ultimate R&D intensity. Accordingly, workers' wages, being endogenous to foreign services inputs, are instrumented on foreign services inputs as well as a set of purely exogenous instruments. R&D intensity is now expressed as a function of the instrumented variable, wages per worker, along with the vector of strictly exogenous covariates. In the first version of this model, we apply the variable internationally outsourced services in the first but not second stage of the 2-stage least squares estimation. We recall that in the second stage outsourcing intensity is modelled as a strictly exogenous covariate. In the second version of our model, we relax this strict constraint and allow internationally outsourced services to enter the model both as an instrument for wages per worker as well as an independent covariate directly explaining R&D intensity rather than being strictly intermediated by wages per worker.

In column 1, we report the results for the first stage of the two-stage least squares regression where we instrument for wages per worker. The results in column 2 relate to the second stage. From the first stage results it appears that increasing service inputs induces a corresponding increase in wages per worker. This latter result is at variance with the G-S prediction that foreign outsourcing induces lower per worker wages. In terms of the other exogenous instruments, larger firms (in terms of turnover) are associated with higher income per worker while manufacturing and domestic firms are associated with lower income per worker. More interestingly, when the coefficient of the instrumented value of wages per worker is observed in the second stage of the 2-stage least squares estimation, it has a negative coefficient for its relationship with R&D intensity. This latter result is in line with the G-S prediction that reduced income per worker expenditure makes possible higher R&D expenditure.

⁷ We also tried with industry wages per worker on the basis that all firms face a common price for labour irrespective of whether they outsource or not but the result was insignificant.

⁸ The accompanying Hausman test reported in Table 4 comparing the signs and magnitudes of the coefficients for the OLS with the subsequent 2-stage regression approach, shows the firm ownership dummy switching to a expected negative sign.

⁹ The aggregate data released by the Irish Government linked institution Forfás merely report R&D intensities by firm ownership and therefore the switch in the sign for the ownership coefficient in our regressions is most likely a result of us reporting the effect of ownership on R&D intensity when netted of the wage per worker effect.

In column 3 we include internationally outsourced services both as instruments for wages per worker as well as independently as a regressor for R&D intensity. We see that higher proportions of internationally outsourced services raise R&D intensity. This direct and positive effect is additional to the indirect and positive effect already seen when internationally outsourced services influence R&D through instrumented wage per worker.

Up to now we have used current values of internationally outsourced services. It could be argued that rather than use contemporaneous values for this variable, we should allow for sufficient time to elapse for its effect to be observed on wage per worker. Accordingly, in the final column we include lagged internationally outsourced services. The direction of all effects is the same as that already observed when we applied current values for the variable.

It can be argued that R&D intensity is only a crude approximation of real innovation since expenditure on R&D might not necessarily translate into new and better products produced at lower cost i.e. innovation. Our data includes a measure for the percentage of sales generated from new products. This measure may well provide a better gauge of the outcome of higher R&D intensity and is more in the spirit of the G-S model. We have only 1 year of data for the percentage of sales from new products and so we estimate a cross-section for the year 2004 alone. Table 6 reports the findings for the second stage regressions of instrumented wages on this new measure of innovation. Similar to what we observed earlier when modelling the effect of wage per worker on R&D intensity, we find that higher wages induce lower innovation. In other words, there is a tradeoff between worker income and innovation. We can now conclude that a tradeoff between R&D intensity (innovation) and wages is observable in the data irrespective of whether when innovation is modelled as R&D intensity or possibly more appropriately as the percentage of sales from new products. In column 2 we see that the extent to which a firm outsources internationally outsourced services positively affects innovation. From this we can conclude that the outsourcing of international services appears to exert a positive affect on innovation.

6 Conclusion

Recent breakthroughs in information technology and the wholesale adoption of purchasing media such as the Web have provided scope for an explosion in the proportions of services that are outsourced internationally. The theory has something to say about the predicted effect of internationally outsourced inputs on the ability of a firm to sustain growth through its growth in innovative outputs. Current thinking posits that a firm becomes more innovative as the proportion of internationally outsourced inputs increases through the mechanism of wages where labour savings translate into higher expenditure on innovative outputs.

Our empirical analysis agrees in part with the stylised facts of the effects of internationally outsourced inputs on innovation. Consistent with the predictions of Glass and Saggi (2001), we observe a tradeoff between wages per worker and innovation. However, more importantly, we do not find that the proportion of internationally outsourced service inputs reduces a firm's wage per worker. Indeed we find that higher proportions of internationally outsourced service inputs are associated with higher wages per worker. However, when we look at the direct effect between international outsourcing of service inputs on innovation (as opposed through its indirect effect mediated through wages) we see that higher rates of outsourced services are conducive to higher rates of innovation.

We should qualify our findings by noting that theorised effects of international outsourcing on innovation as developed by Feenstra and Hanson (1996) and Glass and Saggi (2001) describe international outsourcing in general rather than the specific case of services outsourcing. It may also well be the case that our result departs from the theoretical predictions if we admit the possibility that firms could use international services outsourcing as a means to improve skills levels within a firm (and hence per worker wages are seen to rise) and so allow for higher levels of specialisation. Our data cannot directly the effects of outsourcing on skills changes however.

Overall, the outsourcing of international services is seen in our analysis as a force for the good: a firm's innovation rates rise. However this positive effect of international services outsourcing on innovation is not mediated through wages but more likely to result from cost savings or even increased scope for specialisation.

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Table 1: Summary statistics of key variables in the data

	median	mean	N	sd	median	mean	N	sd
	2000				2001			
Ratio of foreign services outsourcing to sales (serv_os)	0.05	0.13	2312	0.20	0.05	0.13	2366	0.20
Total R&D (rd_total)	0	446.15	2357	3802.38	10	469.33	2424	3503.44
Total R&D per worker (rd_pw)	0.00	4.08	2350	17.32	0.27	8.93	2406	154.08
Total wages (wages)	872	3342.14	2357	9646.92	936	3623.24	2424	11158.99
Total wages per worker (wages_pw)	25	29.11	2350	26.38	27.81	32.66	2406	21.77
Number of employees (employ)	35	103.16	2357	255.73	33	96.84	2424	237.76
Export intensity (exp_int)	25.45	129.27	2350	517.82	27.08	134.66	2406	549.06
Median sales in the firm's industry (ind_me~1)	7.94	8.18	3202	0.91	8.11	8.20	3197	1.02
	2002				2003			
Ratio of foreign services outsourcing to sales (serv_os)	0.05	0.13	2386	0.20	0.05	0.13	2339	0.21
Total R&D (rd_total)	13.76	510.17	2441	3374.54	16.6	496.93	2373	3151.91
Total R&D per worker (rd_pw)	0.40	11.48	2430	184.10	0.48	8.01	2364	23.44
Total wages (wages)	909	3639.80	2441	10205.62	950	3728.39	2373	11005.56
Total wages per worker (wages_pw)	30.22	35.19	2430	21.90	32.24	36.98	2364	22.59
Number of employees (employ)	31	95.17	2441	237.92	30	93.23	2373	241.22
Export intensity (exp_int)	28.46	160.75	2430	826.88	30.48	199.44	2364	1357.10
Median sales in the firm's industry (ind_me~1)	7.94	8.12	3193	1.02	7.98	8.09	3194	0.95
	2004							
Ratio of foreign services outsourcing to sales (serv_os)	0.05	0.14	2022	0.21				
Total R&D (rd_total)	25	567.54	2042	3467.92				
Total R&D per worker (rd_pw)	0.64	8.10	2036	22.34				
Total wages (wages)	1039.5	4311.97	2042	12657.55				
Total wages per worker (wages_pw)	34.32	39.19	2036	32.39				
Number of employees (employ)	32	101.92	2042	264.78				
Export intensity (exp_int)	35.99	225.61	2036	1511.05				
Median sales in the firm's industry (ind_me~1)	8.30	8.26	3184	0.96				

Table 2: Relationship between Services Outsourcing, R&D and Wages

	No Foreign Services Outsourcing (median is 0%)				Firm has some Foreign Services Outsourcing (median is 0%)			
	median	mean	N	sd	median	mean	N	sd
Total R&D (rd_total)	0	211.81	5307	2445.87	30	753.74	6118	4181.22
R&D per worker (rd_pw)	0	4.58	5291	16.94	0.714286	8.58	6114	25.08
Total wages (wages)	700	2351.91	5307	7238.57	1340	4965.60	6118	13297.51
Wages per worker (wages_pw)	27.5	31.82	5291	20.29	31.68716	37.02	6114	28.60
Number of employees (employ)	26	67.77	5307	173.33	42	126.20	6118	296.93
Exports per worker (exp_int)	11.07	87.58	5291	478.56	50.82	238.16	6114	1323.37

Table 3: Percentage of firms in sector outsourcing at least some internationally outsourced services

Food products, beverages and tobacco (1)		Textiles, textile products, leather and footwear (2)		Wood and products of wood and cork (3)		Pulp, paper, paper products, printing and publishing (4)		Chemical, rubber, plastics and fuel products (5)		Other non-metallic mineral products (6)		Basic metals and fabricated metal products (7)		Machinery and equipment (8)		Transport equipment (9)	
n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
668	45	278	61	150	48	204	41	733	62	145	48	420	42	1388	61	143	64
Other manufacturing and recycling (10)		Wholesale and retail trade (11)		Hotels and restaurants (12)		Transport and storage (13)		Post and telecommunications (14)		Financial intermediation (15)		Real estate, renting and business activities (16)		Community, social and personal services (17)		Total	
n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
294	52	86	52	7	37	47	72	23	47	40	56	1313	54	152	56	6091	54

Notes:

Sectors are aggregated using the conventional STAN (OECD/Eurostat) classification system

Table 4: Relationship between per worker wage and R&D intensity, controlling for Foreign services outsourcing

Ordinary Least Squares	
	rd_int1
Wages per worker (wages1_pw)	0.442
	(3.08)**
Foreign services o/s (serv_os1)	0.084
	(4.92)**
Number of employees (employ1)	0.763
	(10.04)**
Turnover (sales1)	-1.050
	(26.63)**
% purchases transacted on Web	0.162
	(3.12)**
Manufacturing sector (manuf)	-0.137
	(0.80)
Domestic firm	1.064
	(6.28)**
Year dummies	yes
Constant	-1.377
	(2.15)*
Observations	4051
Number of firms	1611
R ²	0.36
Wald chi2(9)	1073.75
χ^2 p value	0.0000
Hausman: H0 (Difference between coefficients for OLS and 2SLS is unsystematic)	124.22
χ^2 p value	0.0000

Table 5 Effect of wages per worker on R&D intensity

Two-stage least squares				
	(1)	(2)	(4)	(5)
	wages1_pw	rd_int1	rd_int1	rd_int1
Wages per worker (wages1_pw ¹)		-14.173	-16.284	-14.642
		(5.42)**	(5.24)**	(4.69)**
Foreign services o/s (serv_os1)	0.013		0.356	
	(2.58)***		(3.33)**	
Foreign services o/s lagged 1.(serv_os1)				0.305
				(3.02)**
Number of employees (employ1)	-0.014	0.491	0.597	0.52
	(-0.82)	(2.06)*	(2.22)*	(2.00)*
Turnover (sales1)	0.068			
	(5.53)***			
% purchases transacted on Web	-0.002			
	(-0.20)			
Manufacturing sector (manuf)	-0.34	-5.083	-5.676	-5.161
	(-12.58)***	(4.96)**	(4.77)**	(4.23)**
Domestic firm	-0.150	-1.242	-1.442	-0.992
	(-6.00)***	(1.96)*	(2.04)*	-1.49
Year dummies	Yes	yes	yes	yes
Constant	3.38	47.292	55.681	49.426
	(40.38)***	(4.91)**	(4.81)**	(4.24)**
Observations	4051	4051	4051	3709
Number of firms	1,607	1,607	1,607	1,619
Hansen J-statistic (H ₀ : overident. of instruments)		14.84***	2.21	4.60**
χ^2 p value		0.001	0.14	0.03
F(3, 1271)	7.60			
Prob > F	0.0000			

Notes:

Robust z statistics in parentheses

***significant at 10%; **significant at 5%; * significant at 1%

Table 6 Effect of wages per worker on innovation (2004 only)

Two-stage least squares	(1)	(2)
	Percentage of sales from new products (new_prod_percl)	Percentage of sales from new products (new_prod_percl)
Wages per worker (wages1_pw ¹)	-2.391	-3.835
	(2.75)**	(2.81)**
Foreign services o/s (serv_os1)		0.128
		(2.31)*
Number of employees (employ1)	0.042	0.118
	(0.55)	(1.12)
Manufacturing sector (manuf)	-0.743	-1.140
	(2.24)*	(2.28)*
Domestic firm	-0.372	-0.557
	(1.85)	(1.98)*
Constant	10.382	15.872
	(3.25)**	(3.12)**
Year dummies		
Observations	1272	1272
Number of firms	1272	1272
Hansen J-statistic (H ₀ : overidentification of instruments)	12.34***	0.70
χ^2 p value	0.002	0.40
F(2, 1271)	8.85	
Prob > F	0.0002	

Notes:

¹ instrumented

Robust z statistics in parentheses

***significant at 10%; **significant at 5%; * significant at 1%