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Our main results show that narrow international outsourcing has a negative impact on the demand for labour, while broad measures are not significant. We also include spillover effects to capture technological changes.

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ABSTRACT

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1. INTRODUCTION

The overwhelming entrance of Chinese imports in occidental economies in recent years has raised voices on the effects of low-wages-countries "*unfair*" competition on employment and production in developed countries, especially in labour-intensive industries (textile, shoes, etc). However this is not a new issue, low-wages countries have increasingly become more internationalised, in terms of trade, foreign direct investment, and vertical integration in the last two decades. Theoretical models of international economics conclude nevertheless that international openness can render benefits for all countries involved. A branch of empirical literature has focused in recent years in studying the effects of this process, both in developed and developing countries.

The greater international integration has increased the exchanges of intermediate inputs among countries. In Spain while domestic input purchases within the industry relative to production increased by 10% between 1995 and 2000, intra-industrial imports grew by 41%. This phenomenon is the focus of this paper and receives different names in the literature: foreign (or international) outsourcing, fragmentation, delocalisation, international vertical integration, etc.

This is an important but recent process in Spain compared to neighbouring countries: while the United Kingdom has experienced this foreign contracting out for the last twenty years, in our country it accelerated around five years ago. The Spanish later development and the still reduced number of Spanish manufacturing multinationals explain the lag in this evolution. It is nevertheless accelerating and it seems to involve a substitution between domestic and foreign outsourcing: inter-industry domestic input purchases over production have decreased by 24% in 1995-2000, while their foreign counterpart increased by 32%.

Firms respond to competition in wages by other countries transferring low-skilled stages of production to low-wages countries. Production processes have been fragmented so that certain steps can be moved looking for lowering costs. As explained by Feenstra and Hanson (1996), outsourcing requires two conditions to occur, first, the production process can be separated into self-contained stages, and, secondly, production stages vary considerably in the relative intensity with which they use labour of different skill types. These conditions are specially easy to meet in industrial production, where outsourcing is a natural development of subcontracting, since production stages are, firstly fragmented and, when possible, moved abroad.

This is not the only factor behind this evolution: 1) not only low-skilled labour, but also some types of skilled labour may be cheaper abroad (e.g. in the software industry in Ireland and India), 2) there might be economies of scale of specialised providers (e.g. automobile parts, transport), and 3) the uncertainty inherent to some product characteristics (changes in tastes, product innovation, etc) might give value to a greater flexibility in obtaining inputs. At the domestic level, other factors could favour contracting out: temporary employment involves cheaper types of contracts in smaller subcontracted firms. This can be especially the case in Spain due to the important differences in wages depending on collective agreements, firm characteristics (sector, size, etc), and type of contract (wages for temporary jobs are around 70% of those for permanent jobs)[1].

The aim of this paper is to investigate the effect of both, domestic and foreign outsourcing on level of employment. We will also distinguish between narrow outsourcing (intra-industrial purchases of inputs) and broad outsourcing (inputs from other sectors), following Feenstra and Hanson (1999). Narrow measures are closer to the concept of outsourcing as contracting out part of the production, while broad measures capture other effects (energy, raw materials).

The original contribution of this empirical analysis is: 1) our data comes directly from the import and domestic use matrices of input-output tables, rather than being indirectly estimated through weighting trade data; 2) we estimate a labour demand function at sector level, instead of focusing on skills or wages as most of the literature[2]; 3) we include in some of our regressions a measure of technological spillovers to isolate the effect of outsourcing from changes due to technological progress; 4) we use dynamic panel data techniques (GMM).

We estimate the effects of those different measures of outsourcing on employment for 28 manufacturing sectors, for the period 1993-2002. Our results indicate that there is a

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[1] See Segura (2001) and Palacio and Simon (2004).

[2] We are only aware of one study by Görg and Hanley (2005) that studies the effect of outsourcing on employment but at firm-level and using survey rather than input-output data.

negative effect of narrow outsourcing (intra-industry) on manufacturing sector employment, that becomes more evident when we include a proxy of spillovers from international R&D – intensive sectors. We find both domestic and foreign broad outsourcing (inter-industry) to be non-significant.

The remainder of this paper is as follows. In sections 2 we review the relevant literature on labour market and outsourcing. In section 3 we outline the basic model used and the calculation of outsourcing measures. Section 4 comments on the data and a number of important econometric issues. Section 5 contains the main empirical results and section 6 concludes.

2. OUTSOURCING AND EMPLOYMENT IN RECENT LITERATURE

The literature analysing the impact of outsourcing on the labour market originates mainly in the leading papers by Feenstra and Hanson (1996, 1999), that focused on sector wage inequality by skills. Later empirical developments on the topic substitute the original relative wage share by relative labour demand in terms of skills. Among the considered literature we will comment on the following: Falk and Koebel (2002), Hijzen et al. (2004), Egger and Egger (2003, 2005), Strauss-Kahn (2003), and Görg and Hanley (2005). Görg and Hanley is the only microeconomic study on the topic and the only one that focus on total heterogenous employment that we know of.

Feenstra and Hanson (1996) analyse the way trade affects the relative demand for skilled labour by estimating a relative labour cost equation (see Berman et. al 1994) augmented by an outsourcing measure, built by combining import data for U.S. manufacturing industries with input purchases to construct industry-by-industry estimates of outsourcing for the period 1972-1994. Outsourcing is then considered as "an index of the extent to which U.S. firms contract non-skill-intensive production activities to foreigners."[3] They work with data for 435 industrial sectors and find out that on the period 1979-1990 the outsourcing has contributed substantially to the increase in relative nonproduction wage share, as a proxy for high-skilled wages share, however, results are non-significant for the period 1972-1979.

[3] Feenstra and Hanson (1996), pp. 244.

In a later paper, Feenstra and Hanson (1999), the authors develop a similar model enhanced by including technological variables, since these two factors, trade and technical change, are expected to alter wage inequality. Another novelty of the paper is the differentiation between three types of outsourcing, depending on whether the purchases come from the same sectors, *narrow outsourcing*, from other sectors, *ifference outsourcing*; and the sum of the two, *broad outsourcing*. This distinction allows the authors to show that the effects of intermediate inputs purchases change depending on their origin. Their results show that narrow outsourcing, intra-industrial intermediate inputs purchases, has a larger effect than the difference one, inter-industrial intermediate inputs purchases.

Falk and Koebel (2002) focus on the substitutability relationships between different types of labour and other inputs, working with data for 26 West German industries for the period 1978-1990. They find no evidence that different types of labour can be substituted for either imported materials or purchased services, so that outsourcing or subcontracting do not affect relative labour demand. Changes in imported materials or purchased services are not due to input substitution but a consequence of output growth.

Hijzen et al. (2004) extend the traditional framework by estimating a system of four variable factor demand function, including relative demand for skilled workers, for 50 U.K. industrial sectors for the period 1982-1996. The relative demand function is augmented to include an inter-industrial outsourcing measure and shows that international outsourcing has had a strong negative effect on the demand for unskilled labour.

Egger and Egger (2005) use a dataset for 20 Australian manufacturing industries between 1990 and 1998 to analyse Australian outsourcing to Central and Easter European Economies. They develop further previous studies by expressly considering the effect of inter-sectoral spillovers in the relationship between outsourcing and labour demand, so that they can take into account not just direct but also indirect effects of outsourcing on labour. They show that inter-sectoral relationships affect notably the effect of outsourcing on labour, so that models ignoring the spillover effect underestimate the role of outsourcing. In our empirical application we follow Egger and Egger in considering the input-output industrial linkages to better account for outsourcing. A previous work by both authors, Egger and Egger (2003), focuses on the geographical component of the outsourcing measure by analysing the outsourcing to Eastern countries, they find out that outsourcing to Easter economies accounts for about one quarter of the change in relative employment in favour of high-skilled labour.

Görg and Hanley (2005) propose a microeconomic focus on the topic. They estimate labour demand as a dynamic model for use 652 plant level data for the Irish Electronics sector during the period 1990-1995, and find out that, in the short run, outsourcing is linked to reductions in labour demand, however outsourcing of different kinds will affect employment in different manners, stronger negative effects appear from outsourcing of materials than from services' one.

Another study on the topic is Strauss-Kahn (2003), that working with 50 French industries for the period 1977-1993, focuses on relative unskilled demand. The author finds that outsourcing has a negative effect on unskilled labour demand, however skilled-biased technological progress seems more important than outsourcing in explaining the reduction in unskilled labour demand.

In all the aforementioned literature, except Görg and Hanley (2005), the analysis focuses on the effect of outsourcing on relative labour demand, since the effect of outsourcing is different for skilled and unskilled labour. Firms move production phases that are intensive in low-skill-labour, what has a positive effect on relative skilled labour demand. We follow Görg and Hanley and analyse the absolute effect on total labour.

Another common element in most articles is that the analysis does not account for the time element, all papers, except Görg and Hanley, consider a static relationship between outsourcing and labour. In our empirical application we follow Görg and Hanley since we consider that labour does not react automatically to changes in any of the variables considered, so that a dynamic analysis is more adequate.

3. LABOUR DEMAND EQUATIONS AND CALCULATION OF OUTSOURCING

Our paper differs from the above commented literature as we study the link between outsourcing and employment at sector level. This involves estimating a dynamic labour demand function from a CES production function, in the style of those estimated by on

Van Reenen (1997), Barrell and Pain (1997) and Piva and Vivarelli (2003)[4], that use this function to include technical change. We extend this framework to include both outsourcing and innovation activities.

The starting point is the assumption of firms maximising profits in a perfect competition environment. From there it is possible to obtain the demand function for the labour factor from the first order condition, which states that each factor's marginal product has to equal its real price (that may or may not be adjusted by some kind of mark-up). Applying logarithms, a linear relationship between employment, output, real wage and other factors (as we will see) results.

The formulation by Piva and Vivarelli (2003) starts from a CES function like

$$Y = A\left[(\beta K)^{-\rho} + (\alpha N)^{-\rho}\right]^{-\left(1/\rho\right)} \quad (1)$$

where Y is output, K is capital stock, N is employment, A is a potential Hicks-neutral technological change, α and β are technical parameters and $0 < \rho < 1$. Solving the first order condition commented above (quantity of labour input that maximises profits), taking logarithms and regrouping, it is possible to obtain an expression like:

$$n = y + \sigma w - (1-\sigma)\ln\alpha \quad (2)$$

where $\sigma = 1/1-\rho$ is the elasticity of substitution between K and N, small letters denote logarithms, and w is the log of (real) labour cost.

This labour demand function can be augmented by including variables of outsourcing and technical progress (*inno*), and estimated using panel data:

$$n_{it} = \alpha_0 y_{it} + \alpha_1 w_{it} + \alpha_2 outsourcing_{it} + \alpha_3 inno_{it} + (\varepsilon_i + u_{it}) \quad (3)$$

for $i = 1, ..., N$ firms or sectors and $t = 1,..., T$ years or periods, and where ε are firm – specific (time – invariant) effects and u are the usual error term.

[4] Several articles combine a neoclassical production function with spillovers calculated from input – output tables or patent matrices, where intersectoral links are fixed. Most of these studies (Van Meijl, 1997; Sakurai et al, 1997; Verspagen, 1997) start from a Cobb-Douglas production function (with several production factors) and analyse the impact of different measures of spillovers, calculated from input – output tables and patent matrices, on total factor productivity (TFP) obtained in the traditional fashion. Our study is similar to those papers as we also start from a neoclassical (CES) production function but it is different as we derived a labour demand function, instead of studying TFP as the above mentioned authors.

When estimating either of those functions (2 and 3), we would calculate a static or long-term relationship between the studied variables. We would however neglect the potential dynamic links between these variables. In terms of time series or static panel data estimations, this involves considering equation (1) as a long-term relation and including it in an error correction model as:

$$\Delta n_t = \alpha + \beta_1 \Delta y_t + \beta_2 \Delta w_t + \beta_3 \left(n_{t-1} - n_{t-1}^{*}\right) + \varepsilon_t \tag{4}$$

where only dynamic elements in output and wages, and not in outsourcing or technology variables, are included.

In the case of panel data, the equation can be transformed in a dynamic specification as:

$$n_{it} = \alpha_0 n_{it-1} + \alpha_1 y_{it} + \alpha_2 w_{it} + \alpha_3 outsourcing_{it} + \alpha_4 inno_{it} + \left(\varepsilon_i + u_{it}\right) \tag{5}$$

for $i = 1, ..., N$ sectors or firms and $t = 1,..., T$ years or periods. Furthermore, we will also include lags of all these variables to investigate the dynamic structure of that specification.

Calculation of outsourcing measures

In our case, to calculate different measures of outsourcing we employ the use matrices of the Spanish input-output tables, instead of the inter-industry symmetrical (commodity by commodity) matrices[5]. Our decision is justified by data availability for the period 1993-2002, as we have at our disposal six use tables (1995-2000)[6] for one symmetrical table. Using those six tables allows us to take into account changes in the use table coefficients. In measuring international and domestic outsourcing directly from the use matrices we follow the same line of research as Hijzen et al. (2004). This is considered superior to other measures, like those of Feenstra and Hanson (1996, 1999), Egger and Egger (2003, 2005) and Strauss-Kahn (2003) that combine input-output tables and trade data to proxy imported inputs by sector.

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[5] The **use matrix** shows in columns the input structure for the different sectors (including secondary production), as it includes intermediate consumption and remuneration to primary inputs, adding up to the output value. Its main difference with respect to the symmetrical matrix is that the last one includes intersectoral flows, both by columns and by rows, in terms of “pure industries” or “commodities”. In this fashion, secondary production for each sector is relocated in its corresponding “pure industry”.

[6] It is possible to observe a very important change in the coefficients from 1995 to 2000. This is why to fill the gaps we estimate the data for 1993 and 1994 by extrapolating the growth rates of 1995-1998, and for 2001 and 2002 we apply the growth rates of 1998-2000.

To calculate the measures of outsourcing, we distinguish domestic inputs and imported inputs from the **use matrices of coefficients**, obtained by dividing each element from the use table by the effective output (*q*) for each column[7]. The typical element of the domestic matrix, d_{ij}, indicates the amount of domestic input *i* (D_i) required per euro of output in sector *j*, while for the imported matrix, m_{ij}, indicates the amount of imported input *i* (M_i) required per euro of output in sector *j*.

$$d_{ij} = \frac{D_{ij}}{q_j}; \qquad m_{ij} = \frac{M_{ij}}{q_j}$$

Feenstra and Hanson (1999) identify two measures of outsourcing: narrow outsourcing and broad outsourcing. The measure of *broad* outsourcing for each industry relates to imports of intermediate inputs from all industries (in terms of input-output tables this is measured by the sum of the column of the use matrix of coefficients):

$$domestic \quad broad \quad outsourcing_j = \sum_{i=1}^{N} d_{ij} \; ; \; foreign \quad broad \quad outsourcing_j = \sum_{i=1}^{N} m_{ij}$$

A second measure of outsourcing, denoted as *narrow* outsourcing, is obtained by restricting to inputs purchased from the same industry (in terms of input-output tables this is measure by the coefficient in the diagonal of the use matrix of coefficients):

$$domestic \quad narrow \quad outsourcing_j = d_{jj} \; ; \; foreign \quad narrow \quad outsourcing_j = m_{jj}$$

The narrow measure seems more appropriate, as it reflects intra-industrial links. This is closer to the definition of outsourcing as "contracting out of activities that were previously performed within a production unit" (Hijzen et al., 2004). Nevertheless, it would not include some activities that, when contracted outside the firm, are classified in a different industry (transport, accountancy, computing services, etc). On the other hand, the broad measure includes also other intermediate inputs that could never be produced by the sector considered (energy, raw materials)[8]. In social sciences, paraphrasing Joe E. Brown and Jack Lemmon in *Some Like It Hot*, "no measure's perfect".

[7] We divide by effective production, as in Egger and Egger (2003) and Strauss-Kahn (2003), while Hijzen et al. (2004) divide by added value, Görg and Hanely divide by total wages, and Feenstra and Hanson (1996) divide by total non-energy purchases.

[8] Feenstran and Hanson (1999) identify another measure of outsourcing: the *difference* between the narrow and the broad measures.

As described above, we calculate these narrow and broad measures both for domestic and foreign outsourcing. Most papers restrict the concept of outsourcing to purchases from abroad, as new technologies and globalisation have allowed for an explosive growth of trade and fragmentation in recent years. Domestic outsourcing or subcontracting (purchasing inputs to other domestic firms/sectors that were previously produced inside the firm/sector) could also be important.

Following Hijzen et al. (2004), we have also included in some of our regressions a measure of technology, to prevent our outsourcing measures from picking up the effects of technological change in the sector. In our case, we have included a measure of international spillovers from R&D intensive sectors that we have found to be significant in a previous detailed study on the impact of different types of spillovers on employment, using the same database, the use matrices of input-output tables and estimated R&D stocks [9]. Other possible measures as sectoral R&D stocks were tried and found not significant.

4. DATA AND ESTIMATION ISSUES

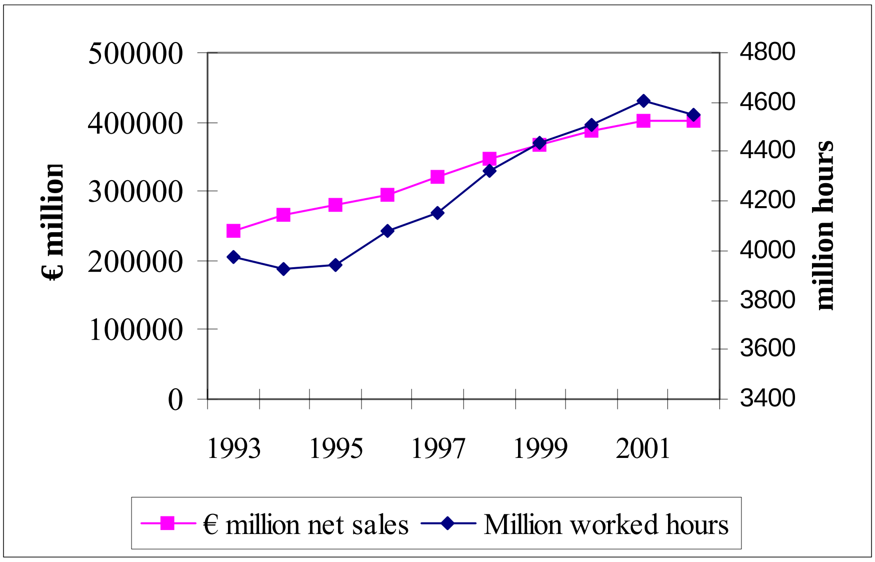
In this section we present some of the data used in this paper. The calculation of the different technological variables has been explained in section 4. **Employment** is measured by thousands of worked hours yearly for each sector. **Production** is added value (net sales minus buying of intermediate goods) in € thousands. **Labour cost** is measured by labour related expenditure per worked hour in euros. These data are provided by the *Encuesta Industrial* (INE) and they are deflated for each sector by its industrial price index. As commented above, the use input – output tables allow us to include information on how much of the **inputs** required by one sector are originated domestically or imported from the rest of the world. All variables are deflated in base 2000.

In this section we will also briefly comment on the behaviour of the main variables included in our regressions. The time period considered (1993-2002) shows the end of a recession (1993-1994), a recovery (1995-2001) and the beginning of a soft slowdown (2002) in Spain. Figure 1 shows how sales and employment reflect that cyclical evolution of the Spanish economy for the manufacturing sectors. It is also interesting to

[9] See appendix for an explanation to how this variable is constructed.

note that both variables have a similar behaviour as we expect employment to be crucially determined by production. Especially in the case of Spain, where the easy terms for dismissal in the case of temporary jobs favours that close link[10].

Figure 1: Net sales and worked hours for the manufacturing sectors (prices of 2000).



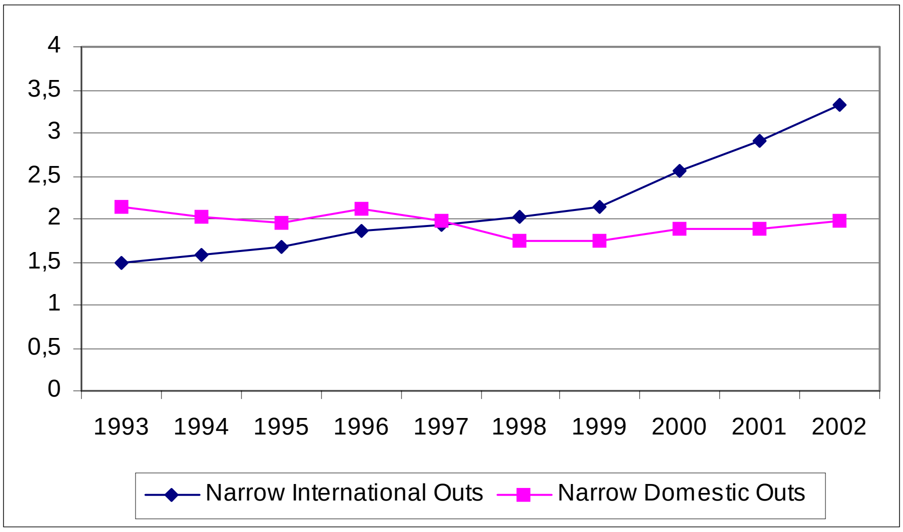
Source: Data from the *Encuesta Industrial*, *Índices de Precios Industriales* and *Contabilidad Nacional* (INE), calculated as explained in this section.

From our constructed measures of outsourcing, it is possible to observe that foreign outsourcing, both in narrow and broad terms, has greatly increased in the period considered: intra-industrial imported inputs have escalated from 1.5% to 3.5% of total production. Nevertheless, the Spanish manufacturing industry is simultaneously generating employment in this period, and therefore we can regard outsourcing as an additional factor for competitiveness: it allows firms to reduce costs and consequently to keep and even increase their production and employment.

On the contrary, narrow domestic outsourcing has been roughly stable, while broad domestic outsourcing has decreased, especially since 1996. As explained by López (2002), total purchases of intermediate consumptions and services have become roughly stable since 1993.

[10] According to Segura (2001), this high share of temporary jobs in Spain (33%, three times higher than EU average), is due to its relative lower cost relative to permanent jobs. This can be explained by. 1) the lower relative wages of temporary workers; 2) the wide range of dismissals legally considered as wrongful; and 3) the higher cost of dismissal compensation for permanent jobs.

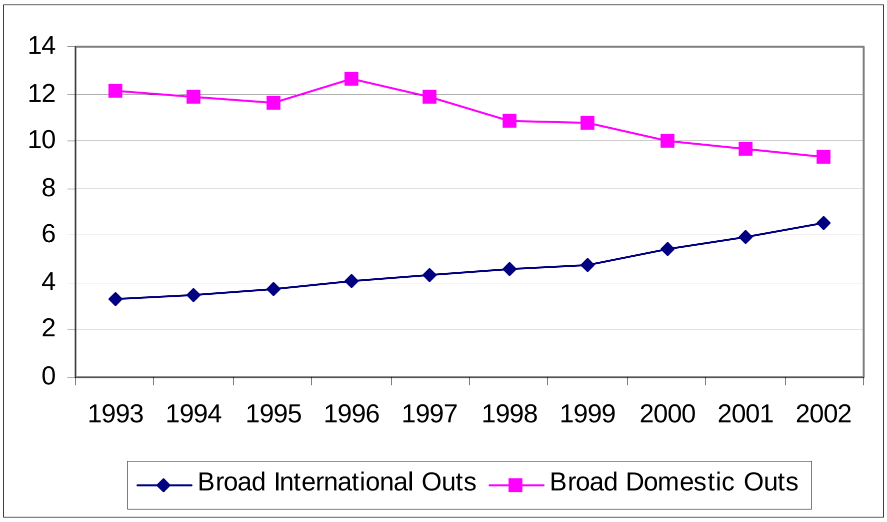
Figure 2: Narrow outsourcing measures



Source: Data from the *Use matrices in the Input –Output Tables* (INE), calculated as explained in this section.

The greater globalisation, both in terms of trade and multinational activities, especially in the case of the Spanish economy in recent years, can also explain that different behaviour: there seems to be some degree of substitution between domestic and imported inputs, particularly in broad measures, as can be seen in Figure 3.

Figure 3: Broad outsourcing measures



Source: Data from the *Use matrices in the Input –Output Tables* (INE), calculated as explained in this section.

Once we have constructed our variables, we need to consider the most appropriate method of estimation. We have panel data for 28 sectors and 10 years. It is a short panel in terms of observations and it also has an important dynamic component.

The existence of a lagged dependent variable among the regressors generates problems in OLS estimations. Furthermore our model contains endogenous and predetermined variables what points to the use of differences GMM technique (DIF-GMM) as the most suitable one (see, for example, Arellano and Bond, 1991). This is an instrumental variable method that estimates the equation in differences and includes lagged values of the variables as instruments. The order and number of lags included for each variable depends on whether they are considered endogenous, predetermined or exogenous.

Since we work with a short panel and strong autocorrelation is likely in most variables, the difference GMM technique could be affected from a weak instruments problem, leading to biased regressors. For that reason, GMM system technique (SYS-GMM) is expected to be preferred (see Blundell and Bond, 1998). The system GMM estimator combines the standard set of equation in first-differences that uses suitably lagged levels as instruments, with an additional set of equations in levels with suitably lagged first-differences as instruments. The validity of these additional instruments can be tested using standard Sargan test of over-identifying restrictions.

This technique improves the difference GMM by estimating the regression in difference and levels, and using lagged levels as instruments for the differenced equation and lagged differences for the levels equations. The chosen instruments are included in each table.

Validity for this estimation technique depends on the existence of negative first order autocorrelation and the absence of second order autocorrelation. This requisite is tested using m1 and m2 Arellano and Bond tests, as showed in Arellano and Bond (1991). Instrument validity is tested by Sargan tests, reported for each case. We must be cautious about out results: these techniques are optimal for large samples, while in sectoral studies like this one we only have at our disposal a limited number of observations[11].

To apply this econometric technique (and to compare it with other alternative panel data methods), we will use the econometric software PcGive version 10.0, that includes the specific package DPD (dynamic panel data). To control for alterations in the general macroeconomic environment time dummies are included in all regressions.

[11] The reduced number of observations renders the 2-step estimations non- reliable, and therefore we show the 1-step estimated coefficients.

5. EMPIRICAL ANALYSIS

Table 1 summarizes the results from our empirical application. For the standard labour demand equation variables results in table 1 show consistent coefficients for added value, wages and the lag of labour. All three coefficients keep approximately constant in all regressions, with values close to those found by previous empirical studies and are significant in all cases.

<Table 1 around here>

We discuss in detail results for the outsourcing variables. Three different proxies have been tried to capture outsourcing effects. Column (1) considers a narrow outsourcing measure which does not control for the geographical element, ***narrow total***, composed by domestic and international outsourcing. Column (2) refines the previous proxy by considering international intra-sectoral outsourcing, ***narrow international***, while column (3) considers a general measure of foreign outsourcing, ***broad international***. Columns (4) and (5) further investigates the narrow measures by considering them together with a proxy aimed to capture changes in technology, ***spillovers***, so that the outsourcing measure does not pick up technology effects.

There is a negative effect of narrow outsourcing on labour demand, with a similar coefficient for total and foreign outsourcing, columns (1) and (2), although it is only significant for the total measure. A similar result was found in most of the literature (for example in Hizjen et al, 2004, for UK sectors, and Grög and Hanley, 2005 for Irish electronic firms), as outsourcing has a negative effect on employment. The broad foreign measure, in column (3), also with a negative coefficient, is not significant, probably because this is reflecting a number of different structural changes, not all of them related to outsourcing (secondary production, energy, raw materials, etc), so its effect gets blurred. This seems consistent with Feenstra and Hanson (1999) that point out to narrow measures as the most important variables, although they focus on their effect on wage inequality, rather than employment.

Columns (4) and (5) combine outsourcing and a spillover variable to correctly account for technological effects, following Hijzen et al. (2004) and Egger and Egger (2005). However we use a proxy based on knowledge stock and inter-industry inputs instead of R&D expenditures or labour skills. We observe that, when the spillover proxy is included in the model, results for the outsourcing proxies become more significant, as in previous literature. The measure for spillovers indicates in our regressions a positive impact from absorbed technology on the level of employment. The purchases of R&D-intensive inputs favours industrial employment.

We further investigated the effects of domestic outsourcing variables but they were found not significant, which is consistent with the observation from the data that this type of outsourcing, very important in the late 80s and early 90s, has decreased in recent years.

6. CONCLUDING REMARKS

Most of the recent literature is focused on foreign (or international) outsourcing, as they consider that the major reason for contracting out some activities is to benefit from lower wages in other countries. In particular, some of those papers point to the substitution of low –skilled labour for imported inputs from abroad. We consider this is not the only case that justifies outsourcing. The fundamental point is that firms will outsource some of their activities if that reduces their costs. This can also be the result: 1) if not only low-skilled labour, but also some types of skilled labour are cheaper abroad, 2) if we think of economies of scale of specialised providers, and 3) if flexibility in purchasing inputs becomes an important factor to reduce costs due to uncertainty derived from the product characteristics (changes in tastes, product innovation, etc).

It is common belief that outsourcing destroys jobs at home, but this is not necessarily the case. It can nevertheless generate adjustment problems that need to be studied and probably tackled by economic policy and institutions. The impact of outsourcing on employment depends on the type of labour considered (high and low-skilled), types of activities subcontracted, sector specific characteristics, price and elasticity effects, short or long term, localisation, etc.

In this paper we have considered different measures of outsourcing and we conclude that outsourcing seems to have a negative impact on the level of employment for the narrow measures: foreign and total (domestic plus foreign). This is especially the case when we include technological measures as international spillovers in the equation. Foreign outsourcing in Spain has greatly increased in recent years and from our estimations it has provoked a decrease in industrial employment. Nevertheless, the

Spanish manufacturing industry is simultaneously generating employment in this period, and therefore we can regard outsourcing as an additional factor for competitiveness: it allows firms to reduce costs and consequently to keep and even increase their production and employment.

Broad outsourcing measures are not found to be significant. As mentioned above, narrow measures are closer to the concept of outsourcing as contracting out part of the main production, while broad measures capture other effects (secondary production, energy, raw materials).

Domestic outsourcing is not significant in our regressions, which is consistent with the observation from the data since this type of outsourcing, very important in the late 80s and early 90s, has reached a stable level, even falling by 10% in the time period considered.

Further lines of investigation would include distinguishing different types of labour (high and low-skilled) and wages as in Feenstra and Hanson (1996, 1999), Egger and Egger (2003, 2005) and Hijzen et al. (2004), the inclusion of institutional variables (as share of temporary jobs, type of collective agreement, etc), the use of panel data from a number of countries (distinguishing between developed and developing countries, as in Egger and Egger, 2003), and of micro-data as in Head and Ries (2002) and Görg and Hanley (2005).

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APPENDIX

Calculation of international R&D spillovers

Most of the statistical sources provide data for flow variables: they measure the increase per year in technology or R&D for a firm or sector. We believe it is important to take into account that the effects from that technology are not restricted to one year, and it is more appropriate to include this variable as a stock (Coe and Helpman, 1995; and Beneito, 2001, also follow this direction).

First, we calculate R&D stocks for main sectors and a number of countries (Finland, France, Germany, Ireland, Italy, Japan, Netherlands, Sweden, United Kingdom and United States) that concentrate the majority of Spanish imports (75-80%). We use data on R&D expenditures from OECD ANBERD database (in OECD STAN Industrial

Structural Analysis), that provides data for main manufacturing and services sectors in millions of current PPP dollars, deflated using national GDP deflators, for the period 1987-2001. In order to calculate sectoral R&D stocks for each country, we deflate the R&D expenditures by GDP prices, and use Griliches formula,

$$SR\&D_{t=0} = FR\&D_{t=1} / (g+d) \quad (7)$$

where *S* denotes stock, *F* denotes flow, *g* denotes the average annual logarithmic growth rate of the flow of R&D expenditure in real terms over the available period (since 1986), $t = 0$ refers to the year before the first year for which the R&D expenditure estimates are available, and *d* is the depreciation rate, assumed to be 11%. Again this assumption over the depreciation rate for R&D stock is discussed by different authors. Cameron and Muellbauer (1996) explain that many researchers have chosen a zero rate, while others have argued that if knowledge becomes obsolescent the knowledge capital stock must fall. Some of the articles commented before use very different rates of depreciation: 6% (Coe and Helpman, 1995), 11% (Hubert and Pain, 1999) and 15% (Beneito, 2001; García *et al.*, 2002).

The stock data for the remaining sample years are calculated following the perpetual inventory model: $(SR\&D)_{i,t} = (1-d)(SR\&D)_{i,t-1} + (FR\&D)_{i,t}$ (8)

Finally, we convert those sectoral R&D stocks into euros and construct a measure of sectoral R&D stocks for the total of countries considered to proxy the "world" R&D stock for each sector with respect to Spain, as the average of those stocks weighted by the relative importance of each country out of the ten in the Spanish imports from each sector. These weights were calculated using data from the Bilateral Trade Database (also from OECD STAN Industrial Structural Analysis).

We then used those stocks to calculate international R&D spillovers, using the imported inputs from the use tables for Spain (1995-2000). The variable included in some of our regressions is restricted to international spillovers from R&D intensive sectors, constructed as mentioned above, adding up by columns[12].

[12] R&D – intensive sectors according to OECD, corresponding to the 1995 input – output tables classification: Pharmaceutical products; Office machinery and computers; Electronic products; Medical, precision and optical instruments, watches and clocks; Manufacture of aircraft and spacecraft; Telecommunications services; Computer and related services.

Table 1: Main results for different outsourcing and technological variables

Estimation	SYS-GMM				
Dependent variable: employment Lt					
L_{t-1}	0.8146 (10.5)***	0.8247 (11.0)***	0.8297 (12.4)***	0.8030 (11.8)***	0.8119 (12.5)***
$(Q\text{-}CI)_t$	0.2034 (2.51)**	0.1907 (2.46)**	0.1897 (2.59)**	0.2183 (3.01)***	0.2056 (2.97)***
GPH_t	-0.2465 (2.74)***	-0.2163 (2.71)***	-0.2102 (3.03)***	-0.2655 (3.58)***	-0.2347 (3.24)***
$Narrowtotal_t$	-0.2129 (1.67)*			-0.2455 (2.17)**	
$Narrowinternac_t$		-0.1906 (1.31)			-0.2716 (1.97)**
$Broadinternac_t$			-0.1145 (0.876)		
$Spillovers_t$				0.00439 (2.88)***	0.00547 (3.61)***
Sargan test	0.089	0.024	0.090	0.087	0.020
m (1)	-3.532 (0.000)	-3.546 (0.000)	-3.535 (0.000)	-3.578 (0.000)	-3.605 (0.000)
m (2)	-0.0609 (0.951)	-0.0598 (0.952)	0.0126 (0.990)	-0.2568 (0.595)	-0.3272 (0.744)

Notes:

1. The GMM-SYS estimates combine a system of equations in first differences with a system of equations in levels using as instruments respectively the variables in levels and in first differences.
2. Test shown are: *p* values for the null hypothesis of joint validity of the instruments for Sargan test of overidentified restrictions, and autocorrelation tests *m* (1) and *m* (2) (they are tests - with distribution N (0,1) - on the serial correlation of residuals; p values in parentheses). The Sargan-test has a $\chi 2$ distribution under the null hypothesis of validity of the instruments.
3. The GMM-SYS estimates shown are *one-step*, consistent with possible heteroscedasticity and more reliable than the *two-step* ones.
4. Asymptotic standard errors, asymptotically robust to heteroskedasticity, are reported in parentheses.
5. Data for 28 sectors and 10 years.
6. Year dummies are included in all specifications.
7. The equations are estimated using DPD for PcGive
8. The instruments used in column 1: $L_{i,t-2}$, $L_{i,t-3}$, $L_{i,t-4}$, $(Q-CI)_{i,t-2}$, $(Q-CI)_{i,t-3}$, $(Q-CI)_{i,t-4}$, $w_{i,t-1}$, $W_{i,t}$, $Narrowtotal_{it}$, $\Delta\ L_{i,t-1}$ and $\Delta\ (Q-CI)_{i,t-1}$.
9. Instruments for column 2: same as in column 1 but $Narrowinternac_{it}$ instead of $Narrowtotal_{it}$.
10. Instruments for column 3: same as in column 1 but $Broadinternac_{it}$ instead of $Narrowtotal_{it}$.
11. Instruments for column 4: same as in column 1 and $Spillovers_{i,t}$.
12. Instruments for column 5: same as in column 2 and $Spillovers_{i,t}$.
13. *** denotes the variable is significant at 1% level, ** significant at 5%, and * significant at 10%.

Variables:

- L: (log) total worked hours horas in each considered sector, thousands.

- VA (Q-CI): (log) net sales minus intermediate consumption (inputs) (€ thousands).
- W: (log) labour cost per worked hour (€ thousands).
- Spillovers: (log) indirect R&D absorbed from foreign technology – intensive sectors (weighted average).
- Narrowtotal: narrow domestic and foreign outsourcing.
- Narrowinternac: narrow foreign outsourcing.
- Broadinternac: broad foreign outsourcing.