Offshoring, domestic outsourcing and productivity: a production function approach

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Abstract:
This paper explores the relationship between productivity and offshoring/domestic outsourcing using a sample of Spanish manufacturing firms. In the data set, we use domestic outsourcing and offshoring to refer to firms that decide to subcontract some stages of their production process to suppliers located either at home or abroad. Our results indicate that productivity and other firm characteristics differ systematically across groups of firms with a different domestic/international outsourcing status. The paper introduces a simple framework which justifies the use of variables that measure both domestic outsourcing and offshoring in a production function defined at the firm level. We measure the impact of both domestic outsourcing and offshoring on output and productivity at the firm level. The decision to outsource has a positive impact on the level of productivity as it permits relocating parts of the production process to suppliers that can be located at home and abroad. Over the period studied (1990-2005), this impact is larger than the impact associated with changes in a firm’s offshoring/domestic outsourcing intensities.

JEL codes: D24, F10, M20
Keywords: Total factor productivity, offshoring, domestic outsourcing.

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1. Introduction

Besides international trade and foreign direct investment, offshoring has grown in prominence in recent decades as a major international firm activity. Underlying this phenomenon is the growing fragmentation of production processes across firms and countries. To explain this kind of trade, Grossman and Rossi-Hansberg (2006, 2008) refer to what they call “trade in tasks,” which is different from trade in complete goods. A slightly different approach is offered by Antràs and Helpman (2004), which combines elements of the intra-industry heterogeneity setting of Melitz (2003) and the incomplete contract approach of Grossman and Hart (1986). In this setting, companies make two endogenous organizational choices, an integration decision and a location decision, and the model shows how a firm’s decisions to integrate or to outsource are a consequence of the level of firm technology. The prevalence of one way over the other to organize the production (integrate vs. outsource; outsource in the domestic market vs. outsource abroad) depends on the distribution of productivity across firms within an industry. Feenstra (2010) and Helpman (2011) offer a systematic account of the explanations and the empirical evidence available for offshoring.

Apart from the literature interested in the relationship between trade and firm performance, there is also the literature interested in the relationship between firm productivity and organizational innovation. The *Oslo Manual* (OECD, 2005) considers the introduction of new methods in a firm’s external relations to be an example of organizational innovation. In particular, the manual considers “the implementation of new ways of organizing relations with other firms….such as the outsourcing or subcontracting…of business activities in production” to be an organizational innovation. Since Griliches (1979), many empirical studies have focused on the link between innovation and productivity, and the link between productivity and outsourcing is an example of this interest.

There is empirical literature using firm-level data to investigate the causes and consequences of offshoring. In this literature, the most frequent use of the term offshoring refers to the outsourcing of a good or service in a foreign country, either from outside suppliers or from affiliated suppliers. Recent contributions include Görg

This paper explores the relationship between the firm’s decision to outsource either at home or abroad and firm productivity. This issue is addressed empirically using a sample of Spanish manufacturing firms taken from the Encuesta sobre Estrategias Empresariales (ESEE). The paper contributes to the literature with the introduction of a simple framework where domestic outsourcing and/or offshoring are introduced in a production function at the firm level. The production function offers a useful basis for measuring the effects that both offshoring and outsourcing have on output and productivity. Both phenomena, in the simplest sense, reflect a change in the input mix. When firms decide to offshore/outsource at home intermediate inputs, they relocate parts of their production stage to other locations. This relocation in the choice of inputs implies a compositional change which has an immediate and direct impact on firm productivity. This is the first effect. Additionally, for those firms already performing both activities, the elasticities of output with respect to offshoring/domestic outsourcing, which reflect the degree of substitutability between inputs, are the channel through which output and productivity are affected by changes in the intensity of offshoring/domestic outsourcing. This is the second effect. The paper offers estimates of both channels affecting output and productivity at the firm level.

A second contribution of the paper is to measure economic performance differences between offshoring firms and non-offshoring firms. We explore the magnitude of these differences for various performance measures such as size, productivity, wages, the composition of the labor force and R&D activities. Estimates of the offshoring premium are reported after controlling for year, size, age and other firm characteristics. Furthermore, within the group of offshoring firms, we test whether or not firms that
offshore in-house outperform those that offshore outside the firm, as predicted by Ántras and Helpman (2004).

The information available permits us to identify firms which make the decision to relocate some stages of their production process outside of their boundaries to the domestic market and/or abroad. Although there is not a commonly accepted terminology (see R. Crinò, 2009), we use the term domestic outsourcing to refer to the activity of a firm that subcontracts some stages of its production process to external suppliers which are located in the domestic market, and the term offshoring for a firm doing a similar operation in international markets. Furthermore, we are able to identify for firms performing offshoring if this activity is with an affiliated company or with an unaffiliated company. As in Ántras and Helpman (2004), we use the terms “intra-firm trade” and “arm’s length trade” to refer to offshoring with affiliated and unaffiliated suppliers, respectively. A similar use of the terms domestic outsourcing and offshoring can be found in Olsen (2006), Görg, Hanley and Strobl (2008), Feenstra (2010) and Wagner (2011). Ántras and Helpman (2004) and Helpman (2006) use the terms offshoring and foreign outsourcing indistinctly. As foreign outsourcing is already included in the term offshoring, in the rest of the paper we use the term outsourcing to refer to domestic outsourcing.

Our results indicate that firm characteristics differ systematically across groups of firms with different offshoring/domestic outsourcing statuses. The productivity of firms engaged in offshoring outperforms the productivity of firms either integrating at home or outsourcing in the domestic market. These differences are robust to the control of various firm characteristics. Furthermore, firms that offshore with an affiliated company outperform firms which send the production process abroad outside the boundaries of the firms. Finally, estimates confirm that outsourcing is a technological “shifter” of the production function. Firms’ decisions to relocate some stages of their production process to external suppliers result in a positive impact on the productivity level of these firms. Over the period studied (1990-2005), this impact is larger than the impact associated with changes in a firm’s offshoring/domestic outsourcing intensities.

The paper is organized as follows. Section 2 describes the main characteristics of the data set used in the analysis and presents a ranking of productivities across groups of
firms with different patterns in their outsourcing activity. Section 3 presents a simple empirical model that introduces measures of domestic outsourcing and offshoring into the framework of a traditional production function. Section 4 provides the main empirical results that are obtained when estimating the empirical model. Finally, Section 5 provides the main conclusions.

2. Data and descriptive evidence

This section describes the main characteristics of the data set used in the analysis and presents some basic descriptive evidence on the magnitude and evolution of offshoring and domestic outsourcing. This information is completed with an analysis of differences in performance between firms that are classified according to the choice they make: 1) firms integrating the production of intermediate inputs at home; 2) firms outsourcing in the domestic market; 3) firms offshoring.

We employ a longitudinal set of Spanish manufacturing firms taken from the Encuesta sobre Estrategias Empresariales (ESEE). The data base contains a longitudinal sample of firms from 1990 to 2005. The sample of firms used in this section is a panel of firms that contains 20,113 observations corresponding to an average number of 1,359 firms per year. The final sample is an unbalanced panel of firms that is representative of the population of Spanish manufacturing firms (see Fariñas and Jaumandreu (1999) for more details on the characteristics of this data set; Delgado, Fariñas and Ruano (2002), Fariñas and Martín-Marcos (2007, 2010) are examples of applications using the ESEE).

The measures of domestic outsourcing and offshoring are based on information reported directly by the firm in the survey. This information indicates whether or not the firm subcontracts some parts of its production process to external suppliers. In particular, firms report the value of their purchases of products and customized components subcontracted to external suppliers. Furthermore, we split the total amount of subcontracted purchases of products and components between the value that

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1Two conditions are imposed on the information that is required for a firm in the panel to be included in the sample that is used in this section: 1) it has to have all the information that is required for the estimation of the equation presented in Section 3; 2) it has to have information available for a sequence of three or more consecutive years over the period 1990-2005.
corresponds to purchases from suppliers located in the domestic market and the value that comes from purchases from suppliers located abroad. For the latter group, the survey provides information on the value of offshored inputs that come from both unaffiliated and affiliated suppliers.

The information available describes decisions of firms to relocate some stages of their production process outside of their boundaries, either in the domestic market or abroad. Although there is not a commonly accepted terminology (see R. Crinò, 2009), we use the term domestic outsourcing to refer to the activity of firms which subcontract some stages of their production process to external suppliers which are located in the domestic market, and the term offshoring for a firm doing a similar operation in international markets. Offshoring can be performed with either an affiliated or unaffiliated company. As in Ántras and Helpman, 2004, we use the term intra-firm trade to refer to the first type of offshoring and the term arm’s-length trade to refer to offshoring performed with a non-affiliated company. Given that foreign outsourcing is already included in the term offshoring, in the rest of the paper when we use the term outsourcing we refer exclusively to domestic outsourcing.

According to previous information, we are able to classify firms into the following groups from the point of view of their outsourcing activities:

[1] Firms that integrate at home
[2] Firms that outsource at home
[3] Offshoring firms
[3.1] Offshoring from unaffiliated suppliers (arm’s-length trade)
[3.2] Offshoring from affiliated suppliers (intra-firm trade)

Firms that neither outsource at home nor offshore abroad define group [1] of the firms that integrate at home. Group [2] includes firms that outsource in the domestic market exclusively. Finally, many firms included in group [3] also perform domestic outsourcing simultaneously (see Appendix 1 for details on the definition of these groups of firms).

We begin this section by presenting some basic empirical regularities concerning both the level and the evolution of foreign/domestic outsourcing over the period 1990-2005. According to Figures 1 and 2, there is no clear and explicit tendency over the period for
both the extensive and the intensive margins of domestic outsourcing. The extensive margin, i.e., the proportion of firms performing this activity, fluctuates around 40 percent. The intensive margin, conditional on the group of firms performing this activity, shows the magnitude of domestic outsourcing relative to the value of intermediate inputs. It fluctuates around 14 percent over the period with a slight reduction at the end of the period.

Figures 1 and 2 show a slight increase in the proportion of firms that perform offshoring over the period 1990-2005. Although there is a reduction in years 2003 and 2004, the extensive margin increases from 25.2 percent in 1990 to 31.4 percent in 2005. A similar pattern can be found for the intensity of offshoring: at the beginning of the period, intermediate inputs subcontracted from abroad represented 2.9 percent of the total purchase of intermediate inputs, and at the end of the period, the magnitude reached the level of 5.9. Therefore, foreign outsourcing has expanded through two channels: the participation rate has increased and so has the intensity of this activity within the group of firms that outsource abroad.

We are able to distinguish between the group of firms that perform offshoring with a subsidiary/parent company via intra-firm trade and the group of firms that uses other channels external to the firm. There is a large difference in the magnitude of the extensive margin between both groups of firms (see Figure 1). At the end of the period, only 6 percent of the firms perform offshoring via intra-firm trade; while 28.9 percent of the firms in the sample perform offshoring via transactions with non-related parties. In addition, the extensive margin of offshoring via intra-firm trade diminishes slightly over the period, whereas offshoring with non-affiliated suppliers to the firm has increased significantly over the period. The intensive margins of offshoring performed with either non-affiliated or affiliated suppliers show a continuous and systematic increase throughout the period.

According to Table 1, there is a positive relationship between outsourcing either at home or abroad and the size of the firm. In general terms, there is a positive and strong relationship between size and the probability of performing domestic/foreign outsourcing. This suggests that performing this activity involves significant fixed costs for the firm and, consequently, the larger ones are in better conditions to offshore.
Furthermore, after conditioning on offshoring, there is no significant relationship between the intensity of this activity and the size of the firm.

Across industries there is a positive relationship between the intensive and the extensive margins (see Figures 3 and 4). However, more interesting than this is the fact that there is a high degree of heterogeneity across industries. The extensive margin for domestic outsourcing ranges from 18.7 percent (meat and meat products) to around 63 percent (machinery and equipment and other transport equipment) and the intensive margin from 6 percent (meat and meat products) to 22 percent (machinery and equipment).

The group of industries where the intensive and the extensive margin is higher for foreign outsourcing include: other transport equipment; office machinery, computers and precision instruments; motor vehicles; machinery and equipment; textile and clothing; and electrical machinery and communication equipment.

A second aspect that is considered in this section is a comparison of some characteristics for various groups of firms that perform domestic outsourcing/offshoring and firms that do not perform these activities (see Appendix 1 for the exact definition of these firm characteristics). Table 2 reports the means for various groups of firms and performs two comparisons. The first one is the comparison between the group of non-offshoring firms (Groups 1+2) and the group of offshoring firms (Group 3). Table 2 reports their means and the corresponding difference test-statistics (column 3). Although many firms that perform offshoring are also domestic outsourcers, we include these firms in Group 3 of the offshoring firms.

Offshoring firms are larger and older than non-offshoring firms. Furthermore, they are more productive in terms of both labor productivity and TFP. They use more qualified workers and pay higher wages. Finally, looking at R&D activities, they have a higher R&D effort measured in terms of the ratio of R&D expenditure to sales and they obtain more product/process innovations than non-offshoring firms.

In Table 2 (column 6 reports difference test statistics) and for the group of offshoring firms, a second comparison between the group of firms that offshore from unaffiliated suppliers (arm’s-length trade) and the group that offshores from affiliated suppliers
(intra-firm trade) is reported. Firms engaged in intra-firm trade abroad are more productive; they use more qualified workers and pay higher wages than firms that perform offshoring via arm’s-length trade. Besides these differences, the percentage of firms with majority foreign capital participation is 71.6 percent in the group of firms that perform intra-firm trade, while in the group of firms that perform offshoring via conventional trade with unaffiliated suppliers, it is only 16 percent of the firms. This association between direct investment and offshoring performed via intra-firm trade suggests that inward foreign direct investment (form the point of view of the Spanish economy) is one of the factors stimulating offshoring.

Overall, comparisons between these groups of firms are consistent with the predictions of Antrás and Helpman’s (2004) model, as they show that a firm’s decisions to outsource vary with the characteristics of the firm. The model assumes that managerial fixed costs are higher under integration than under outsourcing, although this latter activity requires incurring search costs. Furthermore, the model also assumes that offshoring implies higher fixed costs than domestic outsourcing. Under these cost structures, the model shows that the decision to outsource and the decision to locate either at home or abroad depend on the distribution of productivity across firms. In increasing order of productivity, the least productive firms will either outsource in the domestic market or integrate all their activities within the boundaries of the firm in the domestic market, firms with a medium level of productivity will offshore in international markets from unaffiliated suppliers (arm’s-length trade) and, finally, the group of firms with the highest level of productivity will engage in offshoring via intra-firm trade involving foreign direct investment (FDI).

Table 2 reports average productivities for groups [1], [2] and [3], implying that TFP productivity of groups 1 and 2 is lower than firm productivity of group 3. This is basically consistent with the prediction that offshoring firms outperform firms either integrating at home or outsourcing in the domestic market.

Second, Table 2 also reports productivity levels of firms performing offshoring. These productivity levels imply that TFP of group 3.1 is lower than productivity of group 3.2, which is also consistent with the prediction that firms that offshore abroad via intra-firm
trade outperform firms that offshore through arm’s-length contracts with unaffiliated suppliers.

Findings reported in Table 2 are to a large extent consistent with the prediction of Antràs and Helpman’s (2004) model. To make the analysis more complete, we check for robustness of productivity differences between the groups of firms. In particular, to estimate productivity differences across groups of firms with a different offshoring status, we calculate the average difference between groups of firms after controlling for other firm characteristics. The objective is to check whether productivity differentials are robust to other firm characteristics.

Using a similar specification like ISGEP (2008) and Wagner (2007), the offshoring productivity premium is estimated from a regression of log productivity on the current outsourcing status of the firm (defined by a dummy variable) and a set of control variables:

$$\ln \text{Productivity}_{it} = a + \beta \text{Offshoring status}_{it} + c \text{Control}_{it} + \epsilon_{it}$$

where \( i \) is the index of the firm, \( t \) is the index of the year, Productivity can represent both labor productivity and TFP, Offshoring status is a set of dummy variables for current offshoring status (1 if the firm is included in any of the groups of firms that are considered, 0 otherwise), Control is a vector of control variables including year dummies, industry dummies, variables capturing the log size of the firm, the log of the firm’s age and foreign ownership status. The offshoring status productivity premium, computed from the coefficient \( \beta \) estimated as 100((exp(\beta))-1), shows the average percentage difference in productivity between offshoring and non-offshoring firms after controlling for industry, year, size, age and FDI participation. A variant of this premium equation is estimated including fixed firm effects (FE).

Table 3 reports various estimates of the premium equation. There are two sets of results. First, rows 1, 2, 5 and 6 report estimates of the premium equation for labor productivity and TFP for offshoring firms relative to non-offshoring firms. Offshoring firms have a labor productivity premium of 23.1 percent relative to non-offshoring firms, i.e., either integrating at home or outsourcing at home. The premium is 1.6 percent for TFP. The
labor productivity premium is robust to the inclusion of firm fixed effects. However, the TFP premium is not robust to the inclusion of FE.

Second, rows 3, 4, 7 and 8 report estimates of the premium equation for labor and TFP for the group of firms performing offshoring. In this case, the coefficient on offshoring status reports the productivity premium of firms performing intra-firm trade. The premium is 11.9 percent for labor productivity and 2.9 percent for TFP. When fixed effects are included, the premium is not statistically significant.

Overall, the results presented in this section confirm that characteristics of firms with a different status with respect to offshoring differ systematically across groups of firms. Furthermore, the productivity of firms engaged in offshoring outperforms the productivity of firms either integrating or outsourcing in the domestic market. These differences are robust to the control of other firm characteristics.

3. Empirical model

The aim of this section is to introduce a simple framework to justify the specification of a production function when the firm decides to outsource work previously conducted within the firm. We assume that firm $i$ produces a single output $Y$ at time $t$ with a Cobb-Douglas production function with constant returns to scale:

$$Y_{it} = A_{it} K_{it}^\alpha I_{it}^\beta L_{it}^{1-\alpha-\beta}$$ (1)

Dropping firm and time subscripts for simplicity, $A$ is an index of Hicks-neutral technical progress, $K$ is firm capital stock, $L$ is the labor input and $I$ corresponds to intermediate inputs.

The framework offered by the production function is useful for discussing the implications of offshoring/outsourcing. Intermediate products used as inputs in the production process (input $I$) are classified in two groups. Firstly, firms can subcontract

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2 A similar framework can be found in López (2008).
elaborated products and customized components to external suppliers. These purchases of intermediate inputs from external suppliers can be located either in the domestic market or in a foreign market. We call these two alternatives domestic outsourcing ($I_{DO}$) and offshoring ($I_{FO}$), respectively. Secondly, input $I$ can be produced within the firm ($I_W$). We assume that input $I$ can be obtained combining in-house production and outside sources. To control for substitution between domestic outsourcing, offshoring and in-house production, we express $I$ as follows:

$$I = I_{DO}^a I_{FO}^b I_W^{1-a-b}$$  \hspace{1cm} (2)

In-house production of $I$ can be written as follows:

$$I_W = K^\gamma L^\phi M^{1-\gamma-\phi}$$  \hspace{1cm} (3)

where $M$ corresponds to raw materials and external services excluding subcontracted purchases. Note that we are assuming that $M$ needs to be combined with some quantity of capital and labor in the production process of the final good as captured by equation (1).

We define the ratios $S_{DO} = \frac{I_{DO}}{I_W}$ and $S_{FO} = \frac{I_{FO}}{I_W}$, which measure the amount of subcontracted purchases from domestic and foreign suppliers relative to the total amount of non-subcontracted intermediate inputs, respectively. Given these ratios, we can rewrite equation (3) as follows:

$$I = S_{DO}^a S_{FO}^b I_W$$  \hspace{1cm} (4)

To permit identification, we restrict our attention to those firms either integrating at home or active in both types of outsourcing (i.e., domestic outsourcing and offshoring) in each period. A large proportion of offshoring firms perform domestic outsourcing simultaneously. Only a small proportion of firms, 11 percent, do domestic outsourcing exclusively. This group of firms is excluded from the analysis. Therefore, considering each of the two groups of firms, we can write equation (4) as follows:
Substituting (3) and (5) in (1), we can write:

\[
Y = \begin{cases} 
AK^{\theta}L^{\beta}M^{\gamma}, & \text{for firms integrating at home} \\
AK^{\theta}L^{\beta}M^{\gamma}S_{DO}^{a}S_{FO}^{b}, & \text{for firms active in both offshoring/domestic outsourcing}
\end{cases}
\]

Where \( \theta_1 = \alpha + \phi (1 - \alpha - \beta); \quad \theta_2 = \beta + \gamma (1 - \alpha - \beta); \quad \theta_3 = (1 - \phi - \gamma)(1 - \alpha - \beta); \quad \theta_4 = a(1 - \alpha - \beta) \) and \( \theta_5 = b(1 - \alpha - \beta). \)

Furthermore, \( \theta_1 + \theta_2 + \theta_3 = 1. \) This constraint implies constant returns to scale in the conventional inputs \((K, L, M). \)

Taking logarithms in equation (6), we can write:

\[
y = \begin{cases} 
\lambda + \theta_1k + \theta_2l + \theta_3m, & \text{for firms integrating at home} \\
\lambda + \theta_1k + \theta_2l + \theta_3m + \theta_4S_{DO} + \theta_5S_{FO}, & \text{for firms active in both offshoring/domestic outsourcing}
\end{cases}
\]

where lowercase letters represent logs and \( \lambda = \log A. \) The variable \( s_{OD} \) is equal to 0 for firms integrating at home and equal to \( \log(I_{DO}/I_W) \) for firms performing domestic outsourcing. The variable \( s_{FO} \) is equal to 0 for firms integrating at home and equal to \( \log(I_{FO}/I_W) \) for firms performing offshoring.

The term \( \lambda \) can be interpreted as TFP. We assume that \( \lambda \) can be decomposed as \( \lambda_{it} = \eta_i + os_{it} + \epsilon_{it}, \) where \( \eta_i \) is a time-invariant term that accounts for the heterogeneity across firms. The term \( os_{it} \) captures the domestic outsourcing/offshoring status of the firm. We assume that firms relocating parts of their production process to domestic or foreign suppliers can experience a higher unexplained contribution to output (i.e. have a higher TFP) than the rest of firm integrating at home. This will be reflected in a permanent effect as long as the firm persist performing this activity. Finally, the term
\( \varepsilon \) captures firm-specific productivity shocks and it is assumed to be an uncorrelated zero mean error term. Defining \( os \) as equal to 1 for firms active in both domestic outsourcing and offshoring at time \( t \) and 0 for firms integrating at home at time \( t \), and dropping firm and time subscripts for simplicity, we can write equation (7) as follows:

\[
y = \eta + \theta_1 k + \theta_2 l + \theta_3 m + \theta_4 s_{DO} + \theta_5 s_{FO} + \delta os + \varepsilon \quad (8)
\]

Overall, expression (8) offers a useful basis for measuring the effects that both offshoring and outsourcing have on output and productivity. For the group of firms already performing both activities, the elasticities of output with respect to offshoring/outshoring, which reflect the degree of substitutability between inputs, are the channel through which output and productivity are affected from changes in the intensity of offshoring/outshoring. Coefficients \( \theta_4 \) and \( \theta_5 \) in equation (8) are reduced form parameters of both the original production function (1) and parameters capturing the degree of substitutability between domestic outsourcing, offshoring and in-house production, equation (2). When firms decide to offshore/outsource intermediate inputs, they relocate parts of their production stage to other locations. This relocation in the choice of inputs implies a compositional change which has an immediate, direct and permanent impact on firm productivity that is captured by \( \delta \).

We will estimate equation (8) in differences. The variable \( os \) in differences is equal to 1 at the time period the firm starts domestic outsourcing/offshoring, equal to 0 when there is no change in the outsourcing/offshoring decision, and equal to -1 when the firm stops outsourcing/offshoring. We define two dummy variables containing this information. The dummy \( dstart \) is equal to 1 if the firm starts outsourcing/offshoring activities with respect to the previous period and 0 otherwise. The dummy \( dstop \) is equal to 1 if the firm stops performing outsourcing/offshoring and 0 otherwise.

Furthermore, \( s_{DO} \) and \( s_{FO} \) are not continuous variables and, hence, we take first differences of these variables as follows: \( \bar{s}_{OD} \) is equal to \( s_{DO} - s_{DO_{t-1}} \) if there is domestic outsourcing at \( t \) and \( t-1 \) and zero otherwise; \( \bar{s}_{FO} \) is equal to \( s_{FO} - s_{FO_{t-1}} \) if there is offshoring at \( t \) and \( t-1 \), and zero otherwise.
Finally, the specification in first differences implies that the term $\eta_i$ is eliminated from the residual, and $\tilde{e}_u = e_u - e_{u-1}$. Therefore, the final expression to be estimated is

$$\tilde{y} = \theta_1 \tilde{k} + \theta_2 \tilde{I} + \theta_3 \tilde{m} + \theta_4 \tilde{s_{DO}} + \theta_5 \tilde{s_{FO}} + \delta_1 \text{dstart} + \delta_2 \text{dstop} + \tilde{e} \quad (9)$$

where $\tilde{y}, \tilde{k}, \tilde{I}, \tilde{m}$ are, respectively, logarithmic differences of output, capital, labor and intermediate inputs (excluding subcontracted purchases).

To summarize, the framework developed leads to the estimation of an “augmented” production function where besides “traditional” inputs (labor, capital and materials), the production function to be estimated depends on two variables which measure the intensity of domestic outsourcing and offshoring, and two dummy variables controlling the decisions to start/stop offshoring/offsourcing. Both phenomena, offshoring and domestic outsourcing, in the simplest sense, reflect a change in the input mix (see Görg, Greenaway and Kneller, 2008). Equation (9) helps to identify two different channels of influence from offshoring/offsourcing to output and productivity. When firms decide to offshore/outsourcing at home intermediate inputs, they relocate parts of their production stage to other locations. This relocation in the choice of inputs implies a compositional change which has an immediate and direct impact on firm productivity. This is the first channel and is captured by dummy variables $\text{dstart}$ and $\text{dstop}$. Additionally, for those firms already performing both activities, the elasticities of output with respect to offshoring/offsourcing, which reflect the degree of substitutability between inputs, capture the influence on output and productivity. This second channel is captured by $\tilde{s_{DO}}$ and $\tilde{s_{FO}}$.

4. Results

This section presents the main results from the estimation of equation (9). Only firms with three or more consecutive observations for the whole set of variables were included in these estimations. This general rule has been changed in some particular specifications. In these cases, the notes to Tables 4 and 5 give specific details. Appendix 1 gives a full description of the variables used in the estimation of equation (9). This section reports the results obtained from the estimation of equation (9) for the whole set
of firms and for nine industries defined at the two-digit level of the NACE classification: food industry, textiles and clothing, leather and footwear, publishing and printing, metal products, machinery and equipment, machinery and electrical goods, motor vehicles and furniture.

Table 4 presents the estimations of equation (9) for the whole set of manufacturing firms. All estimates take into consideration two issues: unobserved heterogeneity and potential simultaneity in the estimation of production functions. Both issues have been addressed using the GMM first-difference estimator (Arellano and Bond, 1991). All columns present first-difference GMM estimates that consider lagged levels, (t-2) and (t-3), of labor and intermediate inputs to be instruments, as well as lagged differences of the capital input (predetermined) plus a set of industry dummies.

The three specifications presented in Table 4 consider the issue of endogeneity of both offshoring and domestic outsourcing variables. Column (1) reports coefficients under the assumption that outsourcing variables are exogenous. Column (2) uses lagged levels of both domestic and international intensity of outsourcing as instruments. And, finally, column (3) considers the same set of instruments as (2) plus two additional variables at the firm level: the proportion of temporary workers and a price index of purchased external services.

The consistency of the GMM estimators depends on whether lagged values of the explanatory variables and the rest of the instruments are valid instruments. Three specification tests are reported to address this issue (see Arellano and Bond, 1991). The Sargan test rejects the non-validity of the instruments. Even with an uncorrelated original error term, first-order serial correlation of the differenced error is expected and confirmed. The test fails to reject the absence of second-order serial correlation in specification (3). At 4.1 percent, second-order correlation is confirmed. In specification (2), second-order correlation is confirmed at 7.4 percent. Overall, we interpret that specification test confirms the validity of the moment conditions used in the GMM estimation reported in column (2). To check for the robustness of these results, later on we report estimates of a dynamic representation of the production function where the idiosyncratic shock $\epsilon_{it}$ adopts an autoregressive form, which permits rejecting second-order correlation quite easily.
Results of the static representation of the production function show plausible values for the estimated elasticities of traditional inputs. The low but significant coefficient attached to physical capital is consistent with standard results of the literature using GMM techniques (Blundell and Bond, 2000, and Griliches and Mairesse, 1998).

Concerning the coefficients attached to the variables that measure the intensity of domestic outsourcing and offshoring, the first one is positively and significantly associated with output. After conditioning on the rest of the inputs, firm output is higher the higher the intensity of domestic outsourcing is. The coefficient attached to $s_{OD}$ (the intensity of domestic outsourcing) is equal to 0.137 in specification (2) of Table 4. This elasticity implies that a one percent increase in the intensity of domestic outsourcing increases the level of output conditional on the rest of the inputs by the amount of the coefficient. As the intensity of domestic outsourcing has been reduced over the period 1990-2005 at an average annual rate of -0.6 percent, this implies a small negative contribution (-0.08 percent) from domestic outsourcing to output conditional on the rest of the inputs. Furthermore, the coefficient is positive but not significantly different from zero for the intensity of offshoring.

In addition to the intensity of domestic outsourcing, the decision to outsource itself has a positive impact on productivity when the firm starts performing domestic outsourcing and/or offshoring. This second effect is associated with the dummy variable $d_{start}$. The positive effect is consistent with the relocation of production within the firm due to external subcontracting, which produces a positive impact on the level of total factor productivity. The coefficient attached to $d_{start}$ implies that firms that decide to offshore and/or to outsource parts of their production stages domestically experience an increase in TFP of 15.2 percent relative to the rest of the firms (continuing offshoring/domestic outsourcing firms and firms integrating at home). The opposite result holds for those firms which stop in their outsourcing activity. In this case, the coefficient is negative although not significant.

Overall, these results confirm that outsourcing is a “shifter” of the production function at the aggregate level. In particular, a change in the intensity of domestic outsourcing has a positive influence on productivity at the firm level. We do not find a similar and significant influence of international outsourcing on productivity. The greater effect on
the level of TFP corresponds to those firms that start performing either domestic outsourcing or offshoring.

Test statistics applied to the static representation of the production function somewhat reject the null hypothesis of no second-order serial correlation at the limit. As an alternative to the previous specification, we consider a dynamic representation of the production function based on the adoption of an autoregressive form for the error term (see Appendix 2 for more details of this specification). This autoregressive term might be capturing factors such as omitted characteristics that persist over time or non-instantaneous adjustments.

Table A1 presents the estimates of the dynamic specification for the whole set of manufacturing firms. Expression (a6) in Appendix 2 is the relevant equation to be estimated. Expression (a6) is obtained assuming that the error term $\varepsilon_{it}$ is serially correlated. As in the previous estimation, column (1) reports coefficients under the assumption that outsourcing variables are exogenous. Column (2) uses lagged levels of both domestic and international outsourcing as instruments. And, finally, column (3) adds two additional instruments to the previous lagged variables: the proportion of temporary workers and a price index of purchased external services.

According to specification tests reported in Table A1 for the dynamic specification of the production function, the null hypothesis of second-order serial correlation can be rejected at the usual probability levels, and the Sargan test rejects the non-validity of instruments at usual levels of significance. Overall, these tests and the first-order correlation test confirm the consistency of the GMM estimators, which consider the outsourcing variables to be endogenous. An additional specification test refers to the restrictions between the coefficients of explanatory variables. The pattern of signs on current and lagged regressors is, in general terms, not always consistent with the AR(1) error specification. This is confirmed by applying a common factor restrictions test, reported in Table A1, which rejects the dynamic specification in columns (2) and (3).

When using the dynamic representation of the production function, the main difference with respect to Table 4 is that both domestic and international outsourcing intensity have a positive and significant effect on total factor productivity. Additionally, the set of
variables which capture the decision to enter into and exit from an offshoring/domestic outsourcing activity have no significant impact on the level of productivity.

As the common factor restrictions tests strongly reject the dynamic specification, our preferred results correspond to specification (9). Therefore, we report additional results from the estimation of the static production function for nine industries defined at the two digit level of the NACE classification. These results are presented in Tables 5a to 5c.

With respect to the specification tests, second-order serial correlation persists in two of the nine industries: food and leather and footwear. In the rest of the industries, the test does not fail to reject second-order autocorrelation. Furthermore, estimated elasticities of conventional inputs show plausible values. Low and non-significant coefficients for physical capital are obtained in four industries: metal products, machinery and equipment, motor vehicles and furniture, which is somewhat frequent in the context of the estimation of production functions with firm-level data and GMM techniques. Overall, we feel that the specifications selected in Tables 5(a) to 5(c) offer a good basis for examining the impact of outsourcing at the industry level.

Regarding the variables that capture the intensity of domestic outsourcing and offshoring, in five out of the nine industries, domestic outsourcing has a positive and significant impact on total factor productivity. In the rest of the industries, the coefficient is not significantly different from zero. In the case of offshoring, results are in line with those obtained at the aggregate level (see Table 4). Only in two industries, publishing and printing and motor vehicles, a significant effect of international outsourcing on productivity can be identified. Overall, these findings suggest that production behavior varies across industries and that they exhibit some heterogeneity in the influence of outsourcing on productivity across industries. However, the fact that the elasticity of domestic outsourcing with respect to productivity is positive and the fact that the elasticity of international outsourcing is not significantly different from zero are in general terms confirmed at a disaggregated level for the nine industries, in Tables 5(a) to 5(c).
Finally, the variables which capture the decision to enter into and exit from an outsourcing activity, at both the domestic and international level, also have a non-significant effect at the industry level. The pattern in the sign of these variables is always the same: positive for the variables which capture the decision to enter into this activity, either at home or abroad, and negative for variables which capture the decision to exit from performing outsourcing. In most of the cases, both effects are non-significant.

6. Conclusions

This paper explores the relationship between firm decisions to outsource either at home or abroad and firm productivity. This issue is addressed empirically using a sample of Spanish manufacturing firms taken from the Encuesta sobre Estrategias Empresariales (ESEE).

Although there is not a commonly accepted terminology, we use the term domestic outsourcing to refer to the activity of a firm that subcontracts some stages of its production process to external suppliers which are located in the domestic market and the term offshoring for a firm doing a similar operation in international markets. Furthermore, we are able to identify whether firms that perform offshoring do this activity with an affiliated company (intra-firm trade) or with an unaffiliated company (arm’s-length trade).

Section 2 presents descriptive evidence on the magnitude and evolution of offshoring and domestic outsourcing, as well as a systematic analysis of productivity differences between offshoring and non-offshoring firms. The results presented in Section 2 confirm that firm characteristics differ systematically across groups of firms with different offshoring statuses. In particular, the productivity of firms engaged in offshoring outperforms the productivity of firms either integrating or outsourcing at home. These differences are robust to the control of various firm characteristics.

Section 3 of the paper develops a simple framework which permits the introduction of variables which measure both domestic outsourcing and offshoring in a traditional
production function at the firm level. This permits the estimation of elasticities which measure the impact of both activities on output and TFP. Section 4 offers the main results. At the aggregate level, results confirm that offshoring/domestic outsourcing is a “shifter” of the production function. In particular, a change in the intensity of domestic outsourcing has a positive influence on output at the firm level. We do not find a similar and significant impact of offshoring on output. Furthermore, those firms that start performing either domestic outsourcing and/or offshoring experience a positive impact in their level of productivity. This result is consistent with the fact that engaging in domestic outsourcing/offshoring would improve productivity by relocating relatively inefficient parts of the production process to an external supplier that can be located at home or abroad. Both effects have a positive influence on output and productivity. According to the estimates shown in Section 4, the decision to outsource at home/offshore has the greatest impact as it implies a compositional change with an immediate and direct impact on TFP.

Section 4 reports additional results from the estimation of the static production function for nine industries defined at the two-digit level of the NACE classification. Overall, at a more disaggregated level, results exhibit some degree of heterogeneity in the influence of domestic outsourcing/offshoring on productivity across industries, but it remains the basic result that has been obtained at the aggregate level.
References:


Appendix 1  
(Data)

The data set is a longitudinal survey of Spanish manufacturing firms that comes from the Encuesta sobre Estrategias Empresariales (ESEE), collected by the Fundación Empresa Pública and sponsored by the Spanish Ministry of Industry. This data set contains a longitudinal sample of firms from 1990 to 2005.

The panel of firms contains 24,272 observations that correspond to an average number of 1,517 manufacturing firms. From this set of firms, 16,495 observations that correspond to 1,339 firms were available for estimation. The units included for estimation were required to contain information on the whole set of the variables that were used in the analysis for at least three consecutive years. Furthermore, we only use information of non-outsourcing firms and of firms active in domestic and international outsourcing. The definition of the variables used in the analysis is as follows:

- **Age**: computed as the difference between the calendar year at \( t \) and the birth-year reported by the firm.
- **Capital input** (K): net capital stock at current replacement value calculated from an initial estimate of the capital stock according to the perpetual inventory formula for each firm:

\[
K_{it} = I_{it} + K_{i,t-1} (1 - d_{it}) \frac{P_t}{P_{t-1}}
\]

where \( I_{it} \) corresponds to the value of investment in equipment of firm \( i \) at time \( t \), \( d_{it} \) stands for depreciation rates, and \( P_t \) is an aggregate price index for equipment investment published by the Spanish Institute of Statistics. The initial value of capital stock is estimated considering the book value of the capital stock and the average age of the equipment. Replacement values of the capital equipment are expressed in real terms.
- **Capital per hour**: is defined as the ratio between the net capital stock at current replacement value and the number of effective hours of work per year.
- **Employment**: is the average number of workers during the year.
- **Foreign ownership**: dummy variable indicating that foreign ownership is 50 per cent or more of total equity.
- **Intermediate inputs** \( (I) \): measured by the cost of intermediate inputs, which includes raw materials purchases, energy and fuel costs and other services paid for by the firm. Intermediate inputs are expressed in real terms using individual price indexes of intermediate inputs reported by the firm.

- **Intermediate inputs non-subcontracted** \( (M) \): intermediate inputs excluding subcontracted purchases.

- **Labor input** \( (L) \): measured by the number of effective hours of work per year, which is equal to normal hours plus overtime hours minus non-working hours.

- **Labor productivity**: defined as the ratio of value of gross production of goods and services expressed in real terms to the number of yearly effective hours of work.

- **Output** \( (Y) \): measured by the annual value of gross production of goods and services expressed in real terms using price indexes for each firm reported by the ESEE.

- **Price index of purchased external services**: Paasche-type price index computed from the variations in the price of external services reported by the firm.

- **Product and/or process innovation**: dummy variable with value equal to 1 if during the year the firm obtained product innovations (completely new products or with such modifications that they are different from those produced earlier) and/or introduced a process innovation (some important modification in the process).

- **Proportion of temporary workers**: percentage ratio between temporary workers and total workers on December 31st.

- **Qualified worker/Total employment**: ratio defined by the quotient between the number of highly qualified workers (engineers and graduates) and the average number of workers during the year.

- **R&D effort**: defined by the ratio between total R&D expenditures and gross production. Total R&D expenditures reflect the cost of R&D activities plus expenditures on imported technology (patent licenses and technical assistance).

- **Size**: log of employment defined by the average number of workers.

- **Subcontracted purchases**: value of purchases of elaborated products and customized components from external suppliers. These purchases in current prices are deflated by a firm’s specific price index of intermediate inputs.

The distinction between subcontracted purchases in the domestic market \( (I_{DO}) \) and in foreign markets \( (I_{FO}) \) is not reported directly by firms. We approximate this with additional information from the ESEE. In particular, we assume that the distribution of subcontracted purchases between domestic and foreign markets is equal to the
distribution of total purchases of intermediate inputs between domestic and foreign markets.

Firms provide information about the value of total imports, including imports of intermediate inputs (materials and services) and imports of capital equipment goods. Firms also report the percentage of capital goods that have been manufactured abroad and used by the firm, as well as the annual investment in capital goods. We use this information to approximate the value of imports of capital goods. Therefore, the value of imported intermediate inputs is equal to total imports minus the value of imported capital goods. Furthermore, firms provide information that permits to distribute the total value of imported intermediate inputs in two components: the value of imports from affiliated suppliers (intra-firm trade) and the value from unaffiliated suppliers (arm’s length trade).

- **Total factor productivity**: index that follows the framework developed by Aw et al. (2001) and it is an extension of the multilateral total factor productivity index proposed by Caves et al. (1982). The index takes a hypothetical firm as a reference and measures productivity in each year relative to this reference firm. In particular, the index uses the average firm of the industry and the size group the firm belongs to as the reference point, and then chain-links the average firm for both size groups to preserve transitiveness between firms of different size groups within the same industry. Reference firms are defined in terms of the industry and the size group the firm belongs to in order to take advantage of the characteristics of the data set. Then the expression of total factor productivity for firm \( i \), at time \( t \), in a given industry is:

\[
\lambda_{it} = \bar{y}_t - \bar{y}_r - \frac{1}{2} \sum_{r=1}^{R} (\bar{\sigma}_{it} + \bar{\sigma}_{r})(x_{it} - x_{ir}) + \bar{y}_r - \bar{y} - \frac{1}{2} \sum_{r=1}^{R} (\bar{\sigma}_{it} + \bar{\sigma}_{r})(x_{ir} - \bar{x}_r)
\]

where \( y_t \) is the log of output, \( x_r \) is the log of input \( r \), and \( \sigma_{r} \) is the cost share of input \( r \). Firms are classified in two size groups of small and large firms. A bar over a variable indicates the arithmetic mean of the variable. The average value of variables with index \( \tau \) refers to a given size group of firms; otherwise, the average refers to the entire sample of small and large firms. The estimation of this index considers three inputs: labor, intermediate inputs and capital input. Input cost shares, \( \sigma_{r} \), are defined as the fraction of the cost of each input in total input costs. Total input costs are defined by the sum of labor costs, intermediate input costs and the cost of capital. The cost of labor is measured by the sum of wages, social security contributions, and other labor costs paid.
by the firm. The cost of intermediate inputs is measured by the sum of costs of raw materials purchases, energy and fuel costs and other services paid for by the firm. The user cost of capital is measured for each firm by the cost of the long-term external debt of each firm as reported by the ESEE plus the depreciation rate, $d_u$, minus the variation of the aggregate price index for capital goods. Details of the definition of output and inputs can be found in this Appendix.

- *Wage per hour*: ratio of labor cost to the number of yearly effective hours of work. The labor cost is measured by the sum of wages, social security contributions, and other labor costs paid for by the firm.
Appendix 2
Additional Results

To estimate the dynamic representation of the production function we proceed as follows: let us assume that the term \( \varepsilon \) in Equation (8) in Section 3 may persist over time (i.e., \( \varepsilon \) may not be idiosyncratic). Hence, we assume that this error term is serially correlated.

\[
y_{it} = \eta_i + \theta_1 k_{it} + \theta_2 l_{it} + \theta_3 m_{it} + \theta_4 s_{D_Oit} + \theta_5 s_{F_Oit} + \delta os_{it} + \varepsilon_{it} \quad (a1)
\]

\[
\varepsilon_{it} = \rho \varepsilon_{i,t-1} + u_{it} \quad (a2)
\]

where \( u_{it} \) is an uncorrelated zero mean error term. Lagging (a1) by one period and multiplying by \( \rho \) gives

\[
\rho y_{i,t-1} = \rho \eta_i + \rho \theta_1 k_{i,t-1} + \rho \theta_2 l_{i,t-1} + \rho \theta_3 m_{i,t-1} + \rho \theta_4 s_{D_Oi,t-1} + \rho \theta_5 s_{F_Oi,t-1} + \rho \delta os_{i,t-1} \quad (a3)
\]

Subtracting (a3) from (a1) yields a dynamic form of the production function

\[
y_{it} = y_{i,t-1} + \gamma_1 k_{it} + \gamma_2 k_{i,t-1} + \gamma_3 l_{it} + \gamma_4 l_{i,t-1} + \gamma_5 m_{it} + \gamma_6 m_{i,t-1} + \gamma_7 s_{D_Oi,t} + \gamma_8 s_{D_Oi,t-1} + \gamma_9 s_{D_Oi,t-1} + \gamma_{10} s_{F_Oit} + \gamma_{11} s_{F_Oi,t-1} + \gamma_{12} os_{it} + \gamma_{13} os_{i,t-1} + (1 - \rho) \eta_i + u_{it} \quad (a4)
\]

where

\[
\begin{align*}
\gamma_1 &= \rho; \gamma_2 = \theta_1; \gamma_3 = -\rho \theta_1; \gamma_4 = \theta_2; \gamma_5 = -\rho \theta_2; \gamma_6 = \theta_3; \gamma_7 = -\rho \theta_3; \gamma_8 = \theta_4; \\
\gamma_9 &= -\rho \theta_4; \gamma_{10} = \theta_5; \gamma_{11} = -\rho \theta_5; \gamma_{12} = \delta; \gamma_{13} = -\rho \delta
\end{align*}
\]

(a5)

Taking differences in equation (a4) and using the variables \( \tilde{s}_{D_O}, \tilde{s}_{F_O}, dstart, dstop \) introduced in Section 3, the relevant dynamic equation to be estimated is:

\[
\tilde{y}_{it} = y_{i,t-1} + \gamma_{14} \tilde{k}_{it} + \gamma_{15} \tilde{k}_{i,t-1} + \gamma_{16} \tilde{l}_{it} + \gamma_{17} \tilde{l}_{i,t-1} + \gamma_{18} \tilde{m}_{it} + \gamma_{19} \tilde{m}_{i,t-1} + \gamma_{20} \tilde{s}_{D_Oit} + \gamma_{21} \tilde{s}_{D_Oi,t-1} + \gamma_{22} \tilde{s}_{D_Oi,t-1} + \gamma_{23} \tilde{s}_{F_Oit} + \gamma_{24} \tilde{s}_{F_Oi,t-1} + \gamma_{25} \tilde{dstart}_{it} + \gamma_{26} \tilde{dstop}_{i,t-1} + \gamma_{27} \tilde{dstop}_{i,t-1} + \gamma_{28} \tilde{dstart}_{i,t-1} + \tilde{u}_{it} \quad (a6)
\]

where \( \gamma_1 \) to \( \gamma_{14} \) are defined in expression (a5) and

\[
\begin{align*}
\gamma_{14} &= \delta_1; \gamma_{15} = -\rho \delta_1; \gamma_{16} = \delta_2; \gamma_{17} = -\rho \delta_2
\end{align*}
\]

These common factor restrictions can be tested.
Table A1

Estimates for all industries
Dynamic specification: static form (16) plus autoregressive idiosyncratic shock
(Dependent variable: output $y_{it}$)

<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>GMM (Differences)</td>
<td>GMM (Differences)</td>
<td>GMM (Differences)</td>
</tr>
<tr>
<td>$y_{i,t-1}$</td>
<td>0.254*** (0.050)</td>
<td>0.221*** (0.057)</td>
<td>0.259*** (0.053)</td>
</tr>
<tr>
<td>$k_{i,t}$</td>
<td>0.269*** (0.094)</td>
<td>0.244*** (0.087)</td>
<td>0.206** (0.082)</td>
</tr>
<tr>
<td>$k_{i,t-1}$</td>
<td>-0.026* (0.014)</td>
<td>-0.035** (0.014)</td>
<td>-0.030** (0.014)</td>
</tr>
<tr>
<td>$l_{i,t}$</td>
<td>0.361*** (0.116)</td>
<td>0.312*** (0.111)</td>
<td>0.291*** (0.096)</td>
</tr>
<tr>
<td>$l_{i,t-1}$</td>
<td>-0.085 (0.091)</td>
<td>-0.011 (0.089)</td>
<td>-0.001 (0.084)</td>
</tr>
<tr>
<td>$m_{i,t}$</td>
<td>0.443*** (0.062)</td>
<td>0.472*** (0.055)</td>
<td>0.437*** (0.051)</td>
</tr>
<tr>
<td>$m_{i,t-1}$</td>
<td>-0.028 (0.022)</td>
<td>0.013 (0.033)</td>
<td>-0.008 (0.031)</td>
</tr>
<tr>
<td>$sDO_{i,t}$</td>
<td>0.058*** (0.008)</td>
<td>0.062* (0.036)</td>
<td>0.067** (0.034)</td>
</tr>
<tr>
<td>$sDO_{i,t-1}$</td>
<td>-0.010*** (0.005)</td>
<td>0.025 (0.017)</td>
<td>0.014 (0.016)</td>
</tr>
<tr>
<td>$sFO_{i,t}$</td>
<td>0.010*** (0.003)</td>
<td>0.056** (0.026)</td>
<td>0.045* (0.024)</td>
</tr>
<tr>
<td>$sFO_{i,t-1}$</td>
<td>-0.0001 (0.002)</td>
<td>-0.005 (0.011)</td>
<td>-0.010 (0.011)</td>
</tr>
<tr>
<td>dstart$_{i,t}$</td>
<td>0.067*** (0.012)</td>
<td>-0.006 (0.079)</td>
<td>-0.037 (0.075)</td>
</tr>
<tr>
<td>dstart$_{i,t-1}$</td>
<td>-0.004 (0.008)</td>
<td>0.094 (0.069)</td>
<td>0.096 (0.065)</td>
</tr>
<tr>
<td>dstop$_{i,t}$</td>
<td>-0.072*** (0.012)</td>
<td>-0.087 (0.065)</td>
<td>-0.065 (0.062)</td>
</tr>
<tr>
<td>dstop$_{i,t-1}$</td>
<td>0.010 (0.008)</td>
<td>0.005 (0.046)</td>
<td>0.029 (0.045)</td>
</tr>
<tr>
<td>time dummies</td>
<td>Included</td>
<td>included</td>
<td>Included</td>
</tr>
<tr>
<td>Sargan test (p-value)</td>
<td>110.673 (0.115)</td>
<td>116.028 (0.430)</td>
<td>133.469 (0.128)</td>
</tr>
<tr>
<td>$m_t$ (p-value)</td>
<td>-9.016 (0.000)</td>
<td>-6.791 (0.000)</td>
<td>-7.730 (0.000)</td>
</tr>
<tr>
<td>$m_t$ (p-value)</td>
<td>-0.506 (0.613)</td>
<td>-1.310 (0.190)</td>
<td>-1.146 (0.252)</td>
</tr>
<tr>
<td>CFR (p-value)</td>
<td>3.633 (0.820)</td>
<td>44.050 (0.000)</td>
<td>47.566 (0.000)</td>
</tr>
<tr>
<td>N. of observations (firms)</td>
<td>11,830 (1,824)</td>
<td>11,830 (1,824)</td>
<td>11,830 (1,824)</td>
</tr>
</tbody>
</table>

Notes:
- Standard errors robust to heteroskedasticity of estimated coefficients are given in parentheses. ***, ** and * indicate significance at the 1, 5 and 10 percent confidence levels, respectively.
- Estimates (1), (2) and (3) require at least 4 consecutive observations.
- Instruments are: lagged log-differences of $k$, $y$, $l$ and $m$ lagged levels t-2 and t-3 for all estimates, and industry dummies.
- Estimate (1) considers all outsourcing variables to be exogenous variables.
- Estimate (2) considers all outsourcing variables to be endogenous variables and includes $sDO$ and $sFO$ lagged levels t-2 as instruments.
- Estimate (3) considers all outsourcing variables to be endogenous variables and includes $sDO$ and $sFO$ lagged levels t-2, and the proportion of temporary workers and a price index of purchased external services (both defined at the firm level) as instruments.
Figure 1
Participation rate for domestic outsourcing and offshoring firms (%)

Figure 2
Offshoring and domestic outsourcing intensities (conditional on performing these activities, %)
Figure 3
Domestic outsourcing across industries: intensive and extensive margins

Notes:
- The size of the markers is proportional to the weight of each industry in total subcontracted purchases from the domestic market in 1990.
Figure 4
Offshoring across industries: intensive and extensive margins

Notes:
- The size of the markers is proportional to the weight of each industry in total subcontracted purchases from foreign markets in 1990.
Table 1
Domestic outsourcing and offshoring vs. firm size

<table>
<thead>
<tr>
<th></th>
<th>Firms with ≤ 200 employees</th>
<th>Firms with &gt; 200 employees</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Participation rate (%)</td>
<td>Intensity (%)</td>
</tr>
<tr>
<td>Domestic outsourcing</td>
<td>37.2</td>
<td>16.0</td>
</tr>
<tr>
<td>Offshoring</td>
<td>20.9</td>
<td>2.9</td>
</tr>
<tr>
<td>With affiliated suppliers</td>
<td>2.6</td>
<td>4.2</td>
</tr>
<tr>
<td>(intra-firm trade)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>With unaffiliated suppliers</td>
<td>20.3</td>
<td>2.5</td>
</tr>
<tr>
<td>(arm’s length trade)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Table 2
Mean characteristics for groups of firms and test-statistics for differences between groups
(year 2000)

<table>
<thead>
<tr>
<th></th>
<th>(1)+(2)(^a)</th>
<th>(3)(^a)</th>
<th>Equality of means (1) vs. (3)(^b)</th>
<th>(3.1)(^a)</th>
<th>(3.2)(^a)</th>
<th>Equality of means (3.1) vs. (3.2)(^b)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Production (000€)</td>
<td>30,680</td>
<td>67,900</td>
<td>0.009</td>
<td>55,494</td>
<td>124,261</td>
<td>0.136</td>
</tr>
<tr>
<td>Employment (number)</td>
<td>141</td>
<td>303</td>
<td>0.000</td>
<td>273</td>
<td>439</td>
<td>0.124</td>
</tr>
<tr>
<td>Capital per hour (€ per hour)</td>
<td>13.9</td>
<td>15.9</td>
<td>0.082</td>
<td>15.6</td>
<td>17.0</td>
<td>0.531</td>
</tr>
<tr>
<td>Labor productivity (€ per hour)</td>
<td>63.5</td>
<td>79.7</td>
<td>0.001</td>
<td>72.6</td>
<td>111.9</td>
<td>0.000</td>
</tr>
<tr>
<td>Total factor productivity</td>
<td>-0.048</td>
<td>-0.007</td>
<td>0.004</td>
<td>-0.023</td>
<td>0.068</td>
<td>0.002</td>
</tr>
<tr>
<td>Wage per hour (€ per hour)</td>
<td>11.1</td>
<td>13.9</td>
<td>0.000</td>
<td>13.0</td>
<td>18.0</td>
<td>0.000</td>
</tr>
<tr>
<td>Qualified workers / Total employment, (%)</td>
<td>8.0</td>
<td>13.2</td>
<td>0.000</td>
<td>11.9</td>
<td>19.2</td>
<td>0.000</td>
</tr>
<tr>
<td>Product and/or Process innovation (% of firms)</td>
<td>37.8</td>
<td>64.1</td>
<td>0.000</td>
<td>63.4</td>
<td>67.9</td>
<td>0.437</td>
</tr>
<tr>
<td>R&amp;D effort (%)</td>
<td>3.9</td>
<td>14.0</td>
<td>0.000</td>
<td>14.1</td>
<td>13.8</td>
<td>0.962</td>
</tr>
<tr>
<td>Age (years)</td>
<td>22</td>
<td>29</td>
<td>0.000</td>
<td>28</td>
<td>33</td>
<td>0.035</td>
</tr>
<tr>
<td>Foreign ownership (% of firms)</td>
<td>11.4</td>
<td>25.8</td>
<td>0.000</td>
<td>16.0</td>
<td>71.6</td>
<td>0.000</td>
</tr>
<tr>
<td>Number of firms</td>
<td>1,451</td>
<td>449</td>
<td>368</td>
<td>81</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes:

\(^a\) The number in parentheses identifies the group of firms: (1) Firms that integrate at home, (2) Firms that outsource at home, (3) Offshoring firms, (3.1) Firms offshoring from unaffiliated suppliers (arm’s length trade) and (3.2) Firms offshoring from affiliated suppliers (intra-firm trade).

\(^b\) P-Value of the two-group comparison test. The null hypothesis is \(H_0: mean(\#1) - mean(\#2) = 0\).
<table>
<thead>
<tr>
<th>Model</th>
<th>Firms Dummies</th>
<th>Control variables</th>
<th>No. of observation</th>
<th>R²</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Offshoring</td>
<td>Offshoring (intra-firm trade)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Labor productivity</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(1) Pooled</td>
<td>23.061***</td>
<td>0.139*** 0.001 0.049*** 0.349***</td>
<td>20,113</td>
<td>0.344</td>
</tr>
<tr>
<td></td>
<td>(1.330)</td>
<td>(0.023) (0.002) (0.007) (0.015)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(2) FE</td>
<td>2.783***</td>
<td>-0.367*** 0.018** 0.010 0.046*</td>
<td>20,113</td>
<td>0.218</td>
</tr>
<tr>
<td></td>
<td>(0.965)</td>
<td>(0.070) (0.009) (0.024) (0.024)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(3) Pooled</td>
<td>11.899***</td>
<td>-0.251*** 0.032*** 0.06 0.203***</td>
<td>5,776</td>
<td>0.269</td>
</tr>
<tr>
<td></td>
<td>(2.202)</td>
<td>(0.036) (0.004) (0.010) (0.020)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(4) FE</td>
<td>1.909</td>
<td>-0.702*** 0.051*** 0.056 0.020</td>
<td>5,776</td>
<td>0.326</td>
</tr>
<tr>
<td></td>
<td>(1.937)</td>
<td>(0.124) (0.013) (0.049) (0.024)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Factor Productivity</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(5) Pooled</td>
<td>1.562***</td>
<td>0.042*** -0.003*** 0.031*** 0.062***</td>
<td>20,009</td>
<td>0.139</td>
</tr>
<tr>
<td></td>
<td>(0.391)</td>
<td>(0.008) (0.001) (0.002) (0.005)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(6) FE</td>
<td>0.187</td>
<td>-0.086*** 0.009** 0.025* 0.005</td>
<td>20,009</td>
<td>0.138</td>
</tr>
<tr>
<td></td>
<td>(0.526)</td>
<td>(0.030) (0.004) (0.014) (0.013)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(7) Pooled</td>
<td>2.862***</td>
<td>-0.011 0.001 0.026*** 0.037***</td>
<td>5,759</td>
<td>0.137</td>
</tr>
<tr>
<td></td>
<td>(0.826)</td>
<td>(0.012) (0.001) (0.004) (0.008)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(8) FE</td>
<td>1.532</td>
<td>-0.172*** 0.017*** 0.037 -0.017</td>
<td>5,759</td>
<td>0.144</td>
</tr>
<tr>
<td></td>
<td>(1.207)</td>
<td>(0.057) (0.006) (0.025) (0.018)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes: this table presents the estimated coefficients from an OLS-regression of productivity on dummy variables for outsourcing firms and some control variables. Pooled model includes a full set of year dummies and a full set of industry dummies. Numbers in parentheses are standard errors robust to heteroskedasticity of estimated coefficients. ***, ** and * indicate significance at the 1, 5 and 10 percent confidence levels, respectively. The fixed effect model (FE) includes a full set of year dummies and firm fixed effects. In order to facilitate the interpretation, the estimated coefficients for the Firms dummies have been transformed by 100(exp(β)-1) where β is the OLS-regression coefficient.
### Table 4.
**Static production functions.**
**All industries**
*(Dependent variable: output $y_{it}$)*

<table>
<thead>
<tr>
<th></th>
<th>(1) GMM (Differences)</th>
<th>(2) GMM (Differences)</th>
<th>(3) GMM (Differences)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$k_{it}$</td>
<td>0.140** (0.059)</td>
<td>0.121** (0.056)</td>
<td>0.115** (0.055)</td>
</tr>
<tr>
<td>$l_{it}$</td>
<td>0.371*** (0.077)</td>
<td>0.384*** (0.078)</td>
<td>0.388*** (0.059)</td>
</tr>
<tr>
<td>$m_{it}$</td>
<td>0.649*** (0.052)</td>
<td>0.629*** (0.051)</td>
<td>0.585*** (0.049)</td>
</tr>
<tr>
<td>$sDO_{it}$</td>
<td>0.085*** (0.009)</td>
<td>0.137*** (0.031)</td>
<td>0.141*** (0.030)</td>
</tr>
<tr>
<td>$sFO_{it}$</td>
<td>0.011*** (0.003)</td>
<td>0.011 (0.021)</td>
<td>0.004 (0.021)</td>
</tr>
<tr>
<td>$dstart_{it}$</td>
<td>0.100*** (0.012)</td>
<td>0.152*** (0.054)</td>
<td>0.137*** (0.053)</td>
</tr>
<tr>
<td>$dstop_{it}$</td>
<td>-0.094*** (0.011)</td>
<td>-0.086 (0.054)</td>
<td>-0.069 (0.052)</td>
</tr>
<tr>
<td>Time dummies</td>
<td>Included</td>
<td>Included</td>
<td>Included</td>
</tr>
<tr>
<td>Sargan test</td>
<td>81.426 (0.187)</td>
<td>90.931 (0.599)</td>
<td>108.343 (0.203)</td>
</tr>
<tr>
<td>$m_1$ (p-value)</td>
<td>-10.390 (0.000)</td>
<td>-10.398 (0.000)</td>
<td>-10.562 (0.000)</td>
</tr>
<tr>
<td>$m_2$ (p-value)</td>
<td>-1.619 (0.106)</td>
<td>-1.789 (0.074)</td>
<td>-2.040 (0.041)</td>
</tr>
<tr>
<td>N. of observations (firms)</td>
<td>12,169 (2,163)</td>
<td>12,169 (2,163)</td>
<td>12,169 (2,163)</td>
</tr>
</tbody>
</table>

Notes:
- Estimates corresponds to specification (17) in section 3.
- Standard errors robust to heteroskedasticity of estimated coefficients are given in parentheses. ***, ** and * indicate significance at the 1, 5 and 10 percent confidence levels, respectively.
- Instruments are: lagged log-differences of $k$, $l$ and $m$ lagged levels $t-2$ and $t-3$ for all estimates, and industry dummies.
- Estimate (1) considers all outsourcing variables to be exogenous variables.
- Estimate (2) considers all outsourcing variables to be endogenous variables and includes $s_{DO}$ and $s_{FO}$ lagged levels $t-2$ as instruments.
- Estimate (3) considers all outsourcing variables to be endogenous variables and includes $s_{DO}$ and $s_{FO}$ lagged levels $t-2$, and the proportion of temporary workers and a price index of purchased external services (both defined at the firm level) as instruments.
Table 5(a)
Static production functions.
Estimates at the industry level
(Dependent variable: output yit)

<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>GMM</td>
<td>GMM</td>
<td>GMM</td>
</tr>
<tr>
<td></td>
<td>(Differences)</td>
<td>(Differences)</td>
<td>(Differences)</td>
</tr>
<tr>
<td>Food industry</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ki</td>
<td>0.107* (0.063)</td>
<td>0.163* (0.093)</td>
<td>0.161* (0.096)</td>
</tr>
<tr>
<td>li</td>
<td>0.310*** (0.111)</td>
<td>0.470*** (0.129)</td>
<td>0.402*** (0.154)</td>
</tr>
<tr>
<td>m0</td>
<td>0.609*** (0.077)</td>
<td>0.205*** (0.059)</td>
<td>0.423*** (0.086)</td>
</tr>
<tr>
<td>sDOit</td>
<td>0.077*** (0.021)</td>
<td>-0.001 (0.038)</td>
<td>0.103*** (0.027)</td>
</tr>
<tr>
<td>sFOit</td>
<td>0.013 (0.020)</td>
<td>0.008 (0.017)</td>
<td>0.015 (0.021)</td>
</tr>
<tr>
<td>dstarti</td>
<td>0.045 (0.067)</td>
<td>0.050 (0.093)</td>
<td>0.002 (0.107)</td>
</tr>
<tr>
<td>dstopi</td>
<td>-0.013 (0.046)</td>
<td>-0.132 (0.096)</td>
<td>-0.178*** (0.070)</td>
</tr>
<tr>
<td>time dummies</td>
<td>included</td>
<td>included</td>
<td>Included</td>
</tr>
<tr>
<td>Sargan test</td>
<td>73.887 (0.547)</td>
<td>67.253 (0.753)</td>
<td>56.179 (0.255)</td>
</tr>
<tr>
<td>m1 (p-value)</td>
<td>-3.850 (0.000)</td>
<td>-3.352 (0.001)</td>
<td>-2.345 (0.019)</td>
</tr>
<tr>
<td>m2 (p-value)</td>
<td>-1.676 (0.094)</td>
<td>0.206 (0.837)</td>
<td>-1.744 (0.081)</td>
</tr>
<tr>
<td>N. of observations (firms)</td>
<td>1,395 (218)</td>
<td>1,359 (241)</td>
<td>381 (72)</td>
</tr>
</tbody>
</table>

Notes:
- Estimates corresponds to specification (17) in section 3.
- Standard errors robust to heteroskedasticity of estimated coefficients are given in parentheses. ***, ** and * indicate significance at the 1, 5 and 10 percent confidence levels, respectively.
- Estimates (1), (2) and (3) consider all outsourcing variables to be endogenous variables.
- Instruments are:
  - Estimates (1) and (2): lagged log-differences of k, l and m lagged levels t-2 and t-3; and sDO and sOM lagged levels t-2.
  - Estimate (3): lagged log-differences of k, l, m, sDO, and sOM lagged levels t-2.
### Table 5(b)

**Static production functions.**  
Estimates at the industry level  
(Dependent variable: output $y_a$)

<table>
<thead>
<tr>
<th></th>
<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>GMM (Differences)</td>
<td>GMM (Differences)</td>
<td>GMM (Differences)</td>
</tr>
<tr>
<td><strong>Publishing and printing</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$k_{it}$</td>
<td>0.167** (0.058)</td>
<td>0.087 (0.101)</td>
<td>-0.057 (0.100)</td>
</tr>
<tr>
<td>$l_{it}$</td>
<td>0.248*** (0.111)</td>
<td>0.270** (0.127)</td>
<td>0.540*** (0.198)</td>
</tr>
<tr>
<td>$m_{it}$</td>
<td>0.377*** (0.095)</td>
<td>0.616*** (0.080)</td>
<td>0.203*** (0.070)</td>
</tr>
<tr>
<td>$s_{DOit}$</td>
<td>0.060* (0.038)</td>
<td>0.158** (0.063)</td>
<td>0.059** (0.029)</td>
</tr>
<tr>
<td>$s_{FOit}$</td>
<td>0.023* (0.013)</td>
<td>-0.030 (0.037)</td>
<td>-0.030 (0.026)</td>
</tr>
<tr>
<td>$d_{startit}$</td>
<td>0.012 (0.060)</td>
<td>0.057 (0.074)</td>
<td>0.075 (0.086)</td>
</tr>
<tr>
<td>$d_{stopit}$</td>
<td>-0.042*** (0.082)</td>
<td>-0.053 (0.063)</td>
<td>-0.074 (0.065)</td>
</tr>
<tr>
<td>time dummies</td>
<td>included</td>
<td>included</td>
<td>Included</td>
</tr>
<tr>
<td>Sargan test</td>
<td>59.87 (0.913)</td>
<td>64.184 (0.870)</td>
<td>78.8 (0.390)</td>
</tr>
<tr>
<td>m1 (p-value)</td>
<td>-1.988 (0.047)</td>
<td>-5.248 (0.000)</td>
<td>-3.920 (0.000)</td>
</tr>
<tr>
<td>m2 (p-value)</td>
<td>-1.254 (0.210)</td>
<td>-0.799 (0.420)</td>
<td>0.391 (0.696)</td>
</tr>
<tr>
<td>N. of observations (firms)</td>
<td>394 (93)</td>
<td>1,062 (202)</td>
<td>743 (110)</td>
</tr>
</tbody>
</table>

Notes:  
- Estimates corresponds to specification (17) in section 3.  
- Standard errors robust to heteroskedasticity of estimated coefficients are given in parentheses. ***, ** and * indicate significance at the 1, 5 and 10 percent confidence levels, respectively.  
- Estimates (4), (5) and (6) consider all outsourcing variables to be endogenous variables.  
- Instruments are:  
  - Estimates (4) and (6): lagged log-differences of $k$, $l$ and $m$ lagged levels $t-2$ and $t-3$; and $s_{DO}$ and $s_{FO}$ lagged levels $t-2$.  
  - Estimate (5): lagged log-differences of $k$, $l$ and $m$ lagged levels $t-2$ and $t-3$; and the proportion of temporary workers and a price index of purchased external services (both defined at the firm level).  
- Estimate (6) requires at least 4 consecutive observations.
Table 5(c)
Static production functions.
Estimates at the industry level
(Dependent variable: output $y_t$)

<table>
<thead>
<tr>
<th></th>
<th>(Dependent variable: output $y_t$)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(7)</td>
</tr>
<tr>
<td></td>
<td>Machinery and electrical goods</td>
</tr>
<tr>
<td></td>
<td>GMM</td>
</tr>
<tr>
<td></td>
<td>(Differences)</td>
</tr>
<tr>
<td>$k_{it}$</td>
<td>0.177* (0.101)</td>
</tr>
<tr>
<td>$l_{it}$</td>
<td>0.455*** (0.153)</td>
</tr>
<tr>
<td>$m_{it}$</td>
<td>0.268*** (0.128)</td>
</tr>
<tr>
<td>$s_{DOit}$</td>
<td>0.054 (0.049)</td>
</tr>
<tr>
<td>$s_{FOit}$</td>
<td>-0.022 (0.030)</td>
</tr>
<tr>
<td>$dstart_{it}$</td>
<td>0.035 (0.119)</td>
</tr>
<tr>
<td>$dstop_{it}$</td>
<td>-0.309*** (0.086)</td>
</tr>
<tr>
<td>time dummies</td>
<td>included</td>
</tr>
<tr>
<td>Sargan test</td>
<td>47.844 (0.560)</td>
</tr>
<tr>
<td>(p-value)</td>
<td></td>
</tr>
<tr>
<td>$m_1$ (p-value)</td>
<td>-1.963 (0.050)</td>
</tr>
<tr>
<td>$m_2$ (p-value)</td>
<td>-0.976 (0.329)</td>
</tr>
<tr>
<td>N. of observations (firms)</td>
<td>648 (91)</td>
</tr>
</tbody>
</table>

Notes:
- Estimates corresponds to specification (17) in section 3.
- Standard errors robust to heteroskedasticity of estimated coefficients are given in parentheses. ***, ** and * indicate significance at the 1, 5 and 10 percent confidence levels, respectively.
- Estimates (7), (8) and (9) consider all outsourcing variables to be endogenous variables.
- Estimate (7) requires at least 5 consecutive observations.
- Instruments are:
  - Estimates (7) and (8): lagged log-differences of $k$, $l$ and $m$ lagged levels t-2 and t-3; and the proportion of temporary workers and a price index of purchased external services (both defined at the firm level).
  - Estimate (9): lagged log-differences of $k$, $l$ and $m$ lagged levels t-2 and t-3; and $s_{DO}$ and $s_{FO}$ lagged levels t-2; and the proportion of temporary workers and a price index of purchased external services (both defined at the firm level).