Offshoring and productivity in the Spanish manufacturing industry

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Abstract (English)

The objective of this paper is to analyse the impact of offshoring on productivity for the Spanish manufacturing sector between 1994 and 2005. Offshoring can be defined in different ways but it usually implies the international fragmentation of production. The effects from this process on wages or employment have been studied in a number of recent papers. The analysis of its impact on productivity has been so far more limited.

Most of the literature has found a positive effect from outsourcing (buying inputs from external, domestic or foreign, providers) or offshoring (buying foreign inputs). Girma & Görg (2004) finds a positive effect of outsourcing on productivity for chemicals and engineering in the UK, using both labour and total factor productivity (TFP), and defining outsourcing as cost of services. In electronics, however, outsourcing is negatively related to labour and TFP. These results are not unusual, as the review by Olsen (2006) shows that the effect from offshore outsourcing on productivity does not follow a clear pattern and it depends on industry and firm characteristics. Siegel & Griliches (1991) found a negative, although not significant, relation between productivity and imported materials in the short run. Egger & Egger (2001b) also showed a negative effect in the short run from offshore outsourcing on productivity for workers with low qualification, but a positive impact in the long run.

From a different approach, Amiti & Wei (2004b), using a measure of broad outsourcing (Feenstra & Hanson, 1999), found a not clear effect on labour productivity from material outsourcing in contrast with services outsourcing. For the Spanish case, there is only a study by Fariñas & Martín-Marcos (2006), although they focus on the impact from total imports on productivity, rather than imports of intermediate goods and services. They concluded, in agreement with previous studies by Antràs & Helpman (2004), that importing firms are more productive than non-importing firms.

In our paper we will calculate different outsourcing measures (narrow, broad and difference, following Feenstra & Hanson) usually employed in recent literature, as well as an additional measure: offshoring of capital goods, defined as imported inputs of Machinery and mechanical equipment, and Electronic, electric and optical equipment. We will use data from input-output tables, manufacturing firms survey (INE) and capital services survey (IVIE), and follow Griliches' approach and Girma & Görg by

estimating an equation where labour productivity depends on capital services per worked hour, intermediate inputs per worked hour, and an offshoring measure, by fixed effects panel data techniques.

Keywords: Offshoring, productivity, manufactures, Spain.
Topic: 6 International trade.

Resumen (español)

El objetivo de este trabajo es analizar el impacto del offshoring sobre la productividad para la industria española entre 1994 y 2005. El offshoring puede definirse de distintas formas pero normalmente implica la fragmentación y deslocalización internacional de la producción. Las consecuencias de este proceso para los salarios y el empleo han sido estudiadas en varios artículos publicados recientemente. El análisis de su impacto sobre la productividad es sin embargo mucho más reducido.

La mayor parte de la literatura encuentra un efecto positivo del outsourcing (adquirir inputs de proveedores externos, tanto nacionales como extranjero) o del offshoring (importar inputs). Girma y Görg (2004) encuentran un efecto positivo del outsourcing en la productividad de los sectores químico y de ingeniería en el Reino Unido, usando productividad del trabajo y productividad total de los factores (TFP), y definiendo outsourcing como el coste de los servicios. En el sector electrónico, sin embargo, el outsourcing tiene un efecto negativo. Estos resultados no son extraños, ya que, tal y como muestra la revisión de Olsen (2006), el efecto del offshoring sobre la productividad no sigue un patrón claro y depende de características sectoriales y a nivel de empresa. Siegel y Griliches (1991) encontraron una relación negativa a corto plazo, aunque no significativa, entre productividad e inputs importados. Egger y Egger (2001b) también llegaron a ese resultado para la productividad de trabajadores de baja cualificación, aunque el impacto se volvía positivo a largo plazo.

Siguiendo un enfoque distinto y usando una medida amplia de outsourcing (como en Feenstra y Hanson, 1999), Amiti y Wei (2004b) no encontraron un efecto claro del outsourcing de bienes sobre la productividad laboral, al contrario que para servicios. Para el caso español, sólo hay un estudio de Fariñas y Martín-Marcos (2006), aunque se centra en el impacto de importaciones totales y no de bienes y servicios intermedios. Estos autores concluyen, como en los estudios previos de Antràs y Helpman (2004), que las empresas que importan son más productivas que las que no.

En nuestro trabajo calculamos diferentes medidas de outsourcing (estricto, amplio y diferencia, siguiendo a Feenstra y Hanson) habituales en la literatura, y una medida adicional: el offshoring de bienes de capital, que se define como inputs importados de maquinaria y equipo mecánico, y de equipo electrónico, eléctrico y óptico. Empleamos datos de las tablas Input-Output, la Encuesta Industrial de Empresas (INE) y la Encuesta de Servicios de Capital (IVIE) y seguimos el enfoque de Griliches y Girma y Görg al estimar una ecuación en la que la productividad laboral depende de los servicios de capital por hora trabajada, los inputs por hora trabajada, y una medida de offshoring, empleando técnicas de datos de panel de efectos fijos.

Palabras clave: Offshoring, productividad, industry, España.
Área temática: 6 Comercio internacional.

1. Introduction

The term "offshoring" has been used in the media for around fifteen years now. This concept has been linked to the closure of factories in the country of origin, with the aim of translating production to less developed countries, in order to profit from lower costs, particularly wages.

There is a number of papers originating from the seminal papers by Feenstra and Hanson (1996, 1999) studying the impact from offshoring on the labour market (either on wage differences, qualification differences or level of employment). Among this studies we can mention the theoretical work by Grossman and Rossi-Hansberg (2006) and Cadarso *et al*. (2007) for the Spanish economy. However, the literature analysing the impact from offshoring on productivity is still rare, although starting to grow. We should mention Girma and Görg (2004) and Olsen (2006), this last paper being a revision of papers on this topic. As for empirical studies for the Spanish economy, we can find Fariñas and Martín-Marcos (2006), although these authors do not focus on offshoring but they rather analyse the link between total imports and productivity. This is why the main objective of our paper is to provide a first approach to the empirical link between offshoring and productivity for the Spanish manufacturing industry.

In the new globalised production processes, specialization can be achieved without the need for geographical concentration. This allows firms to distribute different stages of their productive process among several countries, profiting in this way from lower production costs (Grossman and Rossi-Hansberg, 2006). On one hand, this international fragmentation of production might increase efficiency as it searches for lower wages. On the other hand, other factors that can affect efficiency as a consequence of offshoring are: the use of inputs from specialised firms and the use of workers with higher qualifications with higher productivity levels.

This process of fragmentation of production and location of different stages at a world scale is called *offshoring*[1] in today's literature, and this is the term we will use in what follows. We define offshoring as imports of intermediate inputs per unit of production for each industry.

The reduction in transport costs, the growing liberalization of trade exchanges and the progress in ICT are factors pushing firms from developed countries to search for production strategies that allow them to increase their efficiency and ability to compete. International fragmentation of processes stands out among these new guidelines for production organization. The objective of our paper is to analyse the impact from offshoring on the evolution of production and labour productivity in the Spanish manufacturing industries between 1993 and 2005, starting from a three-factors production function (capital, labour and intermediate inputs).

[1] The term "offshoring" is progresively substituting "international outsourcing". When talking about offshoring, the literature refers exclusively to imports of intermediate inputs, that is to say, it is linked to the geographical dimension of fragmentation, regardless of firm property of the stages of the production process. On the other hand, the term "reallocation" seems to implicitly assume the closure of factories in the country of origin but it does not need to happen when talking about offshoring.

As pointed out by Girma and Görg (2004), an increase in offshoring, defined as the cost of services provided to manufacturing, leads to a decrease of employment in the short term in those firms that implement that offshoring, while output remains constant. This means an immediate and positive effect on labour productivity for those firms. However, in the revision of the empirical literature by Olsen (2006), we realize there is no clear link between those variables, as the results found by different authors depend on firm characteristics and involved industries. Offshoring does not necessarily imply firm closure and workers' dismissal in the country of origin, as the increase in input imports might be due to the inclusión of a new production stage that was not previously required (we can think of GPS devices provided nowadays in most cars). The search for specialized providers can justify the growth in input imports and it will allow for an increase in firm profitability with no need for a growth in labour productivity in the country of origin.

On the other hand, world scale specialization of industries in a country determines the impact from offshoring on labour productivity. If a country is specialised in chains of low or medium value added, as is Spain, it will need to import high value added inputs. In a process of growing imports of high technology inputs (in Spain they increase by 89.65% between 1993 and 2005), that they also substitute domestic inputs, this can cause the country to specialize in less productive stages and, therefore, the impact of this offshoring will be negative for the average labour productivity for manufactures. In a way, the most productive workers will be located abroad, either in subsidiary firms or in independent providers. To sum it up, the study of the impact of offshoring on labour productivity requires an empirical analysis, even more so if we take into account the peculiarities of the Spanish manufactures: it is specialized in medium-low technology goods and highly dependent on imports of intermediate goods and capital.

In order to implement and improve this analysis, we include different offshoring measures and define a new one, called "offshoring of capital inputs", that includes the imports of intermediate inputs provided by industries producing capital goods (electronic, electrical and optical equipment, and machinery). Our estimations show that the relevant increase in this type of offshoring has a negative impact on manufacturing productivity. However, the evidence for other measures of offshoring is more mixed.

The paper is structured as in six sections. After this introduction, the second section reviews the previous empirical literature. Section 3 studies the different offshoring measures and their recent evolution for the Spanish economy. Section 4 shows results for our estimations. The last section concludes.

2. Literature review: offshoring and productivity

The literature on the link between offshoring and productivity is still scarce. Even more, the few empirical papers on the topic use different measures for outsourcing/offshoring, micro or macroeconomic data and different econometric approaches. Olsen (2006) provides a first review of the studies on the effects from offshore outsourcing, understood as the reallocation of processes towards a foreign provider external to the firm, on productivity. His main conclusion is that there is no clear model of how

outsourcing affects productivity and results seem to depend as much on industry as firm specific characteristics.

The first theoretical references over the managerial decision to produce or outsource some tasks can be found in the original paper by Coase (1937), that established this choice over integration of different stages of production in the firm as the result of balancing production and transaction costs within firm theory. Not only costs, but also other aspects, like security and quality in provision, or the complexity in organization and management, are established as potential theoretical factors, in this line that links transaction costs, offshoring and productivity (see Butter & Pattipeilohy, 2007, for a literature review). From the point of view of the firm, the reduction in transaction costs will affect the choice between "producing within the firm" and "buying to an external provider", as it alters the balance between economies of scale and market proximity (Brainard, 1997).

This idea is particularly reflected in works by Arndt & Kierzkowski (2001) and Grossman & Rossi-Hansberg (2006), that introduce the concept of the difference between "trade in goods" and "trade in tasks", so in recent years trade in some intermediate goods and services has become possible, generating a disintegration of production in stages or tasks, with a different degree of intensity in factor use, and that may allocate where more profitable (in terms of the classical Dunning's location advantages). This becomes fundamental for the discussion which concerns us here, as this growing (intra-firm or between-firms) trade of tasks or intermediate goods (that we will call offshoring in what follows) is, for these authors, the cause of productivity effects (from cost reduction), effects on relative factor prices (for example, between more and less qualified workers) and changes in allocation of resources.

The link between offshoring and productivity has also been proposed in terms of Schumpeter's creative destruction (Antràs *et al.*, 2005). Offshoring can lead to closure for some firms or stages of production that may prove more profitable in other locations, and also to the appearance of new more competitive firms. We can extend this idea to the aggregate or industry level and take into account that offshoring may alter the productive structure or specialization for a country or region. In fact, we might need to start thinking on specialisation in productive stages, rather than specialization in goods (in line with the theoretical works by Deardorff, 2001, and Jones & Kierzkowski, 2001).

The effects from offshoring on productivity can also take place through technology spillovers, as a result of trade in goods, particularly up and downstream. In this sense, we can quote papers analyzing the link between trade (Coe & Helpman, 1995; Keller, 2004) or foreign direct investment (Pottelsberghe de la Potterie & Lichtenberg, 2001) and technological spillovers. Imported intermediate inputs can be the vehicle for the transmission of embodied technology that allows introducing part of their advantages in terms of costs and quality to goods and services produced within the buying country. On the other hand, some authors point out that the possibility of reducing costs through offshoring can reduce the incentive to innovate (Butter & Pattipeilohy, 2007), while others argue it can increase competition for inputs providing firms, forcing them to innovate.

As for the effects from offshoring on factor relative demand and prices, most articles on offshoring are focused in studying its impact on several aspects of the labour

market. The original works by Feenstra & Hanson (1996, 1999), that define the offshoring concept in terms of measurement, study their effect on intensity and relative wages for more and less qualified workers in USA. These studies has been recently developed by applying their methodology to data for other countries, like the UK, (Hijzen, 2003, and Hijzen *et al.*, 2003), EU countries (Egger & Egger, 2001), France (Strauss-Kahn, 2002) and Japan (Head & Ries, 2002). If we assume higher productivity for qualified workers as a function of human capital, a rise in that share of qualified relative to less qualified workers could imply an increase in productivity.

Even scarcer is the literature on offshoring effect on the level of employment. We can mention Görg & Hanley (2005), Egger & Egger (2003, 2005), Geishecker (2005), Falk & Wolfmayr (2008b) and Cadarso *et al.* (2007b, 2008a). These are also interesting for our approach as they show the effect from offshoring in labour demand taking into account the output level. We can conclude by saying these effects depend basically on industries and countries considered, as well as on the origin or type of imported inputs. Also, the importance of including technological variables in this type of analysis comes as a result in some of those papers.

The most direct antecedents for our study are some international analyses on offshoring and productivity. These papers can be classified into two groups: firm-level and industry-level studies. Among the first class we can highlight (see Olsen, 2006, for a more extensive literature review) the studies by Görzig & Stephan, 2002 (with German data for the 90's, although they use outsourcing rather than offshoring), Girma & Görg, 2002, 2004 (with UK data they find a positive effect on productivity but not for all sectors), Görg & Hanley, 2003, 2005 (with Irish data in the first half of the 90's and focused on the electronics industry, they find a positive effect from material offshoring and also for services offshoring for some types of firms), Görg *et al.*, 2004 (they find a positive effect for manufacturing firms in the 90's but only for material offshoring), Cricuolo & Leaver, 2005 (with data for British firms in 2000-2003 they find a positive effect but only for services firms), and Hijzen *et al*., 2006 (for Japanese data in the 90's, they find a positive effect on TFP growth).

With respect to the studies on offshoring and productivity at industry level, the topic of our paper, the most important are those of Egger *et al.* (2001), Amity & Wei (2004b, 2006), Egger & Egger (2006), Butter & Pattipeilohy (2007), and Daveri & Jona-Lisinio (2008). Egger & Egger (2006) studies the impact from a intra-industry (narrow) offshoring measure on the level of productivity (value added/employment) for less qualified workers with data for 22 manufacturing industries from 12 EU countries in 1992-1997. Their results show a significant negative effect in the short term while the impact in the long term becomes positive and greater in absolute value. They explain this as the result of a rigid labour market, so offshoring reduces production (that is moved abroad) more than employment in the short term, while in the long term productivity increases as reducing less qualified employment becomes feasible.

Siegel & Griliches (1992) find a similar result for manufacturing US industries, with a negative (albeit non significant) for the ratio of imported goods / output on productivity growth, although their calculation method is different from Egger & Egger.

Amiti & Wei (2004b) study the impact from the change of a inter-industry (broad) offshoring measure on labour productivity growth (for all workers, regardless their qualification), using data on 96 US industries in 1992-2001. Although they did not

find significant results for imported inputs, they get a significant positive result for services offshoring. In a more recent paper (Amiti & Wei, 2006), where they use a more complex econometric technique, they do find a significant positive effect for intermediate inputs offshoring, but far lower than the impact for services.

Butter & Pattipeilohy (2007) use data for the Netherlands provided by the EUKLEMS database for a long period (1972-2001) and realize that the effect from vertical specialization (as an offshoring measure and calculated from input-output tables) on TFP is positive and higher than the one from R&D expenditures. Even further, dividing data into manufacturing and services industries, they find that offshoring of manufacturing goods is significant both for the aggregate and the manufacturing industries, while services offshoring only has a positive effect for productivity in services industries.

A more recent paper, with a similar methodology to our study, is Davery & Jona-Lasiniio (2008). They use an intra-industry (narrow) offshoring measure calculated from Italian input-output tables for 1995-2001 and 21 industries, and they compare its effect on labour productivity growth with a broad measure, more similar to that of Feenstra & Hanson (1999). This Italian analysis becomes especially interesting as it shows the differences between both types of measure for a country with comparative advantages very similar to those of Spain, in a period of study close to ours and with an evolution both for offshoring (growing) and productivity (decreasing) not very different from ours. While the narrow offshoring measure from IOT has a positive effect on productivity growth, the broad measure is not significant. Another interesting element from this paper is its inclusion of technological progress variables (proxy by ICT use and R&D intensity for each industry), a key question in our study.

Finally, we can mention a recent work by Falk & Wolfmayr (2008a), that calculates the impact from offshoring (using IOT and distinguishing high and low income countries from trade data) on TFP growth for manufacturing industries in 14 OECD countries. A broad measure for low-income countries shows a negative impact on productivity, while a narrow measure has no significant effects and imported services have a positive impact.

A number of papers analyse the effect of outsourcing, defined as the cost of services (both foreign and domestic) required by each industry, rather than offshoring, on productivity. Girma and Görg (2004) study the effect of outsourcing on manufacturing productivity in the UK, both for labour productivity and total factor productivity (TFP). These authors estimate their model separately for three manufacturing industries: chemical, electronics and engineering. Outsourcing is found to be positively related to labour productivity for chemical and engineering. TFP levels seem to respond to changes in outsourcing intensity, defined as the ratio of the cost of services required by the industry to total labour costs, also for chemical and engineering. Besides, this effect is stronger for foreign-owned establishments. For the electronics industry, outsourcing is negatively linked to labour productivity and TFP, although this relationship is not significant.

In a similar line, the paper by Fariñas and Martín-Marcos (2006) is the only one as far as we know that analyses empirically for the Spanish economy the impact from imports on TFP at firm level, but they use total imports rather than imported intermediate inputs, as in our study. These authors use data from the Survey of Firm

Strategy (Encuesta sobre Estrategias Empresariales). Entry costs linked to search and communication with a foreign country require high levels of productivity to profit from offshoring. That is why, according to the results of their study and Antràs and Helpman (2004), importing firms show higher productivity than non-importing firms.

We can conclude by saying that, even though there is evidence in favour of a positive effect from offshoring on productivity, it is possible to find differences in results depending on the type of offshoring, country, and industries or firms. Furthermore, these papers show important methodological differences that make comparing them very difficult in some cases, as they use different offshoring measures and regression techniques. This also indicates the convenience of studying this question with alternative formulations to check for robustness of the results to the use of different offshoring and productivity measures and techniques for potential endogeneity, as well as measurement error for some inputs when calculating productivity. The restricted offshoring measures (intra-industry, or offshoring of some particular goods or services) are also an interesting topic without definitive conclusions.

3. Offshoring measures and their recent evolution for the Spanish manfuctaring industry

Offshoring is a recent process in Spain but it has achieved great relevance in the last years. Spanish studies on this phenomenon and its recent evolution can be found in Myro y Fernández-Otheo (2004), Canals (2006), Gómez *et al.* (2006a), Gandoy y Díaz-Mora (2007), Díaz-Mora *et al.* (2007) y Cadarso *et al.* (2007a, b, 2008a).

Different data from several statistics allows us to calculate different measures that capture the international fragmentation of production. The measures we will focus on reflect a ratio of imported intermediate goods relative to a measure of production or total intermediate inputs.

Two possibilities, depending on the source of data, are available: 1) Purchases of foreign goods and services to produce (from the Industrial Survey), and 2) imported inputs (IOT). The first type of data includes imported inputs from all industries, while the second type has the advantage of allowing us to distinguish the industry of origin.

Table 1

In this fashion, the Industrial Survey provides data from 1999 on inputs purchased by the manufacturing sector by their geographical origin. They are classified into three categories: Spain, other European Union countries and rest of the world. Using those data we have calculated the ratio of those imported inputs and the total of inputs required for production. We also present the evolution of the ratio of imported inputs to production (measured by net value of sales, **Table 1**). The evolution of those two ratios show a growing international fragmentation of production both in high, medium-high technological intensity industries and some low technological intensity industries.

We observe a high dependence on imported intermediate inputs in high and medium-high technological intensity industries, reaching a ratio of 48.93% for *transport material*. On the other hand, electronic, electric and optical equipment, with 36.78% of

imported inputs over total sales in 2005. This share of imported inputs on total sales has increased between 1999 and 2005 by an annual 7.24% and 5.46% for *transport material* and *electronic, electric and optical equipment*, respectively. The growth for *mechanical machinery and equipment* has been 5.58%.

The medium-low technological intensity industries import less inputs, but they are quite important in some industries: *rubber and plastics* and *metallurgy and metallic products* (around 20%). Exceptions are the mining industries that have experimented a decrease of imported inputs in this period. Even then, *coke, refined petroleum and nuclear fuel* reached a figure of 63.53% of imported inputs in 2005.

The ratio for low technological intensity industries have changed very little in this period 1999-2005 and they oscillate around 10%, far below the average for total manufactures. Within this group, the industry with higher growth is *textile and clothing* (16.57%).

The offshoring measure can be divided into two ratios, so we can distinguish between international fragmentation of production strictly speaking and the substitution of domestic by foreign providers (Díaz-Mora *et al.*, 2007). The first ratio show imported inputs by total inputs used in production, while the second ratio measures total inputs (both domestic and imported) in relation to total production (net sales).

If both ratios increase, there would be a growth of imported input over total inputs and simultaneously total inputs would be more important on total production, and therefore we could speak of growing international fragmentation of production. On the other hand, if the first ratio increases but the second remains constant we could think of a substitution of domestic by foreign providers. Although interesting, we must be cautious in interpreting these ratios, as we cannot identify if the increase in imported inputs is due to a change in production methods or if direct labour is substituted by imported inputs.

Figure 1

Figure 1 reflect that the process of international fragmentation is widespread among almost all industries between 1999 and 2005. Exceptions concentrate in mining industries, that reduce their inputs, in some cases domestic and in other imported inputs.

A more detailed analysis by industry shows that international fragmentation of production strictly speaking takes places in high and medium-high technological intensity industries. In 2005, 53.78% of total inputs for *electronic, electrical and optical equipment* were imported. These imported inputs, together with domestic inputs, amounted to 68.8% of total production value. A similar behaviour can be seen for *transport materials*, with 57.77% of imported over total inputs and 83.25% of total inputs over net sales.

Within medium-low technological intensity industries we can point out, on one hand, to industries that show a growth in international fragmentation of production: *rubber*, *metallurgy and metallic products*, *non-metallic minerals* and *other manufactures*. On the other hand, industries like *extraction of energetic products and other minerals*, and *electrical energy, gas and water*, have decreased their imported

over total inputs. *Coke, refined petroleum and nuclear fuel*, despite being an importing sector, as there are no oilfields in Spain, has seen a decrease in offshoring.

Low technological intensity industries show in this period an increase in both ratios and therefore they experience an important process of international fragmentation of production. In *textile and clothing*, *leather and shoes*, and *wood and cork*, the share of imported over total inputs is more important, growing around 4%, while in *food and beverages* and *paper* this increase has been lower.

We might hypothesize, following Díaz-Mora *et al.* (2007), that those firms that place a greater share of their sales in foreign markets need to be more competitive. The saving in production costs from offshoring allows them to reach a greater productive efficiency, increasing their competitiveness at international level. By analysing the data in **Table 1** about the share of exports over total sales in 2005 by industry and comparing with the offshoring measure (ratio of imported inputs over net sales), we find a positive link between both indicators. High and medium-high industries, that show a higher dependence of imported inputs, also allocate around 30% of their sales to foreign markets, reaching 52.73% for *transport materials*. A simple cross-section linear regression between the exports ratio and the offshoring measure for 2005 indicates they seem to be positively related[2].

One of the advantages of Input-Output Tables (IOT) is that they show both the direct and indirect needs for imported intermediate inputs by each industry. Even more, as IOT classify inputs by different types of goods, it is possible to distinguish between narrow, difference and broad offshoring (following the methodology by Feenstra and Hanson, 1999), depending on whether inputs are imported from the same industry, other industries or both. Narrow offshoring is defined as inputs imported from the same industry per unit of production (in IOT terms this is measured by the diagonal coefficient in the use matrix). Broad offshoring means inputs imported from all industries per unit of production (in IOT terms this is the column sum of coefficients in the use matrix). Difference offshoring is broad minus narrow offshoring.

Those measures improve the analysis of international fragmentation, as narrow offshoring may capture activities that were previously implemented within the firm and are now divided in different stages and imported. In our analysis we propose a new additional measure: capital goods offshoring. This is the ratio of imported inputs of capital goods to unit of production in manufactures. In terms of IOT, this measure is the sum of the coefficients for the products of *Mechanical machinery and equipment* and *Electronic, electric and optical equipment* in the use matrix.

The empirical evidence shows the relevance of offshoring in the Spanish economy, as Díaz-Mora *et al.* (2007) and Cadarso *et al.* (2007) prove using data from IOT and the Industrial Survey of Firms (Encuesta Industrial de Empresas). Díaz-Mora *et al.* (2007) find that narrow offshoring grows by 32% between 1995 and 2004, while broad offshoring increases by 29%. From a sector perspective, the industries with higher offshoring in that period are: *office machines and computers, electronic and electric goods, motor vehicles, medical and surgical instruments and textile*. Cadarso *et al.* (2007) find an annual growth of 6.38% for narrow offshoring in 1995-2000.

[2] Exports/sales = 0.3729 imported inputs/sales + 0.1504. R^2 = 0.2221.

Offshoring is highest for *office machines and computers, electronic components, mechanic machinery and equipment, and textile and clothing*. We can conclude that different data concur and point out to high technological intensity sectors and textile and clothing as those increasing offshoring the most.

3.1 Offshoring of capital goods for the Spanish manufactures

Comparing the general offshoring ratio with the measure using imported capital goods, we observe that this last measure has increased by 89.65% from 1999 to 2005 (**Figure 2**), while the broad offshoring for the rest of goods has only grown by 24.14%. The relevance of these imports of intermediate capital goods is justified, as indicated in Gómez *et al.* (2006), by the concentration of ICT in a reduced number of firms and countries and the inability by the Spanish economy to generate competitive firms that provide this type of goods. As Spain is specialised in production stages of lower value added, the manufacturing industry depends on innovation developed in other countries and qualified workers abroad, explaining an important part of why offshoring takes place.

Figure 2

Offshoring of capital inputs grows for most manufacturing industries (Table 2). The industries with a higher ratio in 2005 are: *electronic, electrical and optical equipment*, and *mechanic machinery and equipment*. By analysing the annual growth rate in this offshoring, we find that high technological intensity industries with a higher increase are: *transport material*, *electronic, electrical and optical equipment*, and *mechanic machinery and equipment*. Papers like Myro and Fernández-Otheo (2004), in a first qualitative approach, hypothesize that the first wave of international fragmentation of production affected especially firms in technological advanced industries. Medium-low technological intensity industries with higher annual increase in imports of capital inputs in this period are: *extraction of energetic products, rubber and plastics,* and *other manufactures*. Within low technological industries, we can highlight *food and beverages* that reaches an annual growth for this share of 19.07%.

Table 2

4. Offshoring and its effect on production and labour productivity

Our starting point is a Cobb-Douglas production function with three factors of production and constant returns to scale:

$$Q_i = K_i^{\alpha} L_i^{\beta} M_i^{\gamma} \qquad (1)$$

where Q_i is the value of production, K_i is capital services, L_i is employment measured by worked hours, M is inputs, all variables for industry i, α, β, γ, are the respective production elasticities that measure each factor's relative contribution to production.

From the different ways to measure and approach technological change, we will use Griliches'. This implies including technological change as an endogenous rather than as an exogenous variable. Traditional neoclassical theory considered by a process of elimination that technology was responsible for the growth in production that

cannot be explained by increases in employment or inputs. In this fashion, its contribution to technology could be calculated as the difference between the estimated productivity from the increase in inputs and labour and the "real" productivity.

Griliches' approach of including technical change as an endogenous variable has been implemented including different R&D measures since the 70's, like the number of patents or R&D expenditure. A clear positive link between productivity and that variable can be observed, but it is not so easy to capture technological changes just by using that measure. In the 80's and 90's the analysis was extended to different countries and time periods, with not so clear results. As a consequence, the relation between R&D and productivity is not stable, and it seems affected by firm cycles and macroeconomic supply shocks.

The search for variables that capture effects from technological change on production and productivity is still open and a promising line of research on this topic is the division of capital goods into high technology and the rest and/or imported and domestic inputs. This paper is a contribution from that approach by including imported capital inputs (offshoring of capital inputs) and the rest of inputs (offshoring of other inputs) as variables. We also include different offshoring measures to check our results and give a clearer explanation by comparing them.

We will estimate firstly the increase in production explained by a growth in production factors by using a logarithmic difference version of the initial equation[3]:

$$\Delta q_{it} = a_0 + a_1 \Delta k_{it} + a_2 \Delta l_{it} + a_3 \Delta m_{it} + D_t + \varepsilon_{it} \qquad (2)$$

We estimate the equation using ordinary least squares (OLS) and static panel data (fixed effects), including time dummies (D_t) and an error term ε. The results for data on 17 manufacturing industries show as expected significant and positive coefficients for the four factors of production.

We then include in the regression the different offshoring measures in order to study the impact from offshoring on the evolution of production in the Spanish economy. The augmented version of the equation to estimate becomes:

$$\Delta q_{it} = a_0 + a_1 \Delta k_{it} + a_2 \Delta l_{it} + a_3 \Delta m_{it} + a_5 Offshoring_{it} + D_t + \varepsilon_{it} \qquad (3)$$

Next, and following Girma and Görg (2004), we estimate the effect from offshoring on labour productivity using the following equation:

$$\Delta(q/l)_{it} = a_0 + a_1 \Delta(k/l)_{it} + a_2 \Delta(m/l)_{it} + a_4 Offshoring_{it} + D_t + \varepsilon_{it} \qquad (4)$$

As we explained above, those authors propose this equation as an increase in offshoring brings a decrease in employment in the short term in those firms reallocating production, while output remains constant, and therefore an immediate positive effect in productivity could be found for those firms.

Secondly, we have studied the impact of offshoring in value added productivity[4]. This measure has the advantage of deducting from the value of output the

[3] Small letters denote logarithms.

inputs required for production, so productivity measured in this fashion will correspond exclusively to what is generated within the industry.

Sources for data are IOT, the Industrial Survey of Firms (both from the National Statistical Institute, INE) and the capital services published by the Valencia Institute of Economic Research (IVIE). The IVIE provides data on productive capital stock for 25 industries (both manufacturing and services), and allow to calculate the capital services for our 17 manufacturing industries of our analysis from the stock of capital and the cost of use. All data has been deflated using deflator from INE[5], with the exception of capital data that are already deflated by IVIE.

5. Results

In this section we present results for offshoring and its impact on output and labour productivity, using data for 17 Spanish manufacturing industries in 1994-2005. Results from fixed effects regressions can be found in Table 3. They show that all factors of production (capital services, labour and intermediate inputs) have the expected positive significant effect on output. We have included different offshoring measures for comparison. Most of those measures indicate a positive effect on production (narrow, broad, and CIM/Q), consistent with previous literature on the topic.

Table 3

The offshoring of capital inputs shows a significant but negative effect on the evolution of Spanish manufacturing output for 1994-2005. This negative impact might be due to the substitution of domestic by foreign production, if the value added that is reallocated abroad is lower than its equivalent in Spain.

We have also estimated the regressions in first differences to check for robustness of those results (Table 4). In these estimations we no longer find a clear positive effect from offshoring, and we even obtain a negative significant coefficient for CIM/CT. We must remember this ratio is an indicator of substitution between domestic and imported inputs, and this could explain the negative impact on production.

Table 4

Results for estimations on labour productivity (output per worked hour) are shown in Table 5. We find a positive effect from the use of inputs (total) per worked hour, but the offshoring measures have a negative sign and CIM/CT is significantly negative, while the offshoring of capital inputs becomes non-significant.

Table 5

[4] The equation for estimating value added productivity is the following:

$$\Delta(VA/l)_{it} = a_0 + a_1\Delta(k/l)_{it} + a_2\Delta(a/l)_{it} + a_3 Offshoring_{it} + D_t + \varepsilon_{it}$$

Where VA is value added for sector i, calculated from data in the Industrial Survey as the difference between net sales and total of inputs and services.

[5] Both data from IOT and the Industrial Survey have been deflated by using indexes of industrial prices for domestic goods and foreign trade price indexes for imports, all of them provided by INE, and using 2000 as the year of reference.

We have also estimated the relationship between productivity and offshoring using value added (**Table 6**). In this case, the negative impact is clearer, especially for substitution between domestic and foreign inputs term (CIM/CT) and the offshoring of capital inputs (by contrast, the offshoring of other inputs have a positive significant coefficient). Data show that the Spanish economy is reallocating capital intensive activities, that are more productive, while it is getting even more specialized in labour intensive activities, that provide a lower value added. Imported capital inputs increase between 1993 and 2005 by 89.65%, while imports of the rest of inputs only grow by 24.14%. Besides, part of those imports substitute for domestic output, as their production is more efficient abroad. On one hand, the purchase of Spanish inter-industry inputs per unit of production has decreased by 24% between 1995 and 2000, while foreign purchases grew by 32%. On the other hand, the purchases of domestic intra-industry inputs per unit of production have increased by 10% in that period, and their imported equivalent grew by 41% (Cadarso *et al.*, 2008).

The result of that offshoring process is that the Spanish manufacturing industry is increasingly importing inputs and capital goods with high labour productivity, but this reduces labour productivity in the Spanish industries. We must remember, as pointed out by Estrada *et al.* (2006), that the Spanish economy presents lower levels of productivity than the rest of the EU-25 countries in 1996-2004. Even more, the level of efficiency of the manufacturing and services industries has drifted apart in this time period from the rest of the EU-25. This can be explained by the international specialisation of the Spanish economy in medium-low value-added stages of production.

Table 6

6. Conclusions

This paper analyses how offshoring, meaning the reallocation to other countries of part or some functions of the chain of value, is a pattern of production management that has become more important in the last years for the Spanish manufactures. Our results show that, both for high and medium-high technological intensity industries as for low and medium-low technological intensity industries, are implementing this international fragmentation of production in this period. The process is more intense in *electronic, electrical and optical equipment*, and *transport material*. The exception is the mining industries where imported intermediate inputs are decreasing.

Our results also suggest that the importance of this offshoring process, measured in terms of imported capital inputs, has a negative effect on labour productivity. Nevertheless, the impact on productivity of capital services and total inputs is generally positive. The negative link between offshoring and productivity might be explained by the Spanish firms reallocating abroad those stages of production more efficient, more capital intensive, decreasing the generation of those high productivity activities in the Spanish economy. This way the Spanish economy is developing labour intensive processes, those that are less productive. This idea seems reinforced by negative coefficients for the narrow and CIM/CT offshoring measures, as these two variables tend to capture the substitution between domestic and foreign inputs. This is the case for the intra-industry variable as those inputs could have been produced within the industry.

There is no clear result for the effect of offshoring on productivity and literature is still reduced. This paper is a first empirical approach to this topic using these data and we must be cautious about our results. A greater disaggregation of industries or the use of firm data may help in the future to develop this analysis. The advances in measuring offshoring distinguishing between subsidiaries and external providers is another interesting future line of research, as well as using regional data.

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Tables:

Table 1

INDUSTRY	Imported inputs/sales			Exports/sales
	1999(%)	2005(%)	Annual growth rate 1999-2005 (%)	2005(%)
HIGH TECHNOLOGICAL INTENSITY				
Electronic, electrical and optical equipment	26.73	36.78	5.46	34.92
MEDIUM-HIGH TECNOLOGICAL INTENSITY				
Chemical industry	24.23	27.58	2.19	32.53
Mechanical machinery and equipment	13.38	18.53	5.58	31.85
Transport material	32.17	48.93	7.24	52.73
MEDIUM-LOW TECHNOLOGICAL INTENSITY				
Rubber and plastics	16.86	22.21	4.70	31.39
Metallurgy and metallic products	14.04	18.34	4.55	25.80
Other non-metallic minerals	4.16	5.51	4.80	15.19
Other manufactures	7.73	10.70	5.58	16.64
Coke, refined petroleum and nuclear fuel	109.02	63.53	(-) 8.61	11.51
Extraction of energetic products	1.44	0.81	(-) 9.14	0.24
Other mining	2.77	1.98	(-) 5.41	15.06
Electrical energy, water and gas	6.72	8.02	2.98	1.03
LOW TECHNOLOGICAL INTENSITY				
Food and beverages	10.74	11.75	1.51	14.76
Textile and clothing	12.30	16.57	5.10	23.90
Leather and shoes	7.72	10.19	4.73	34.81
Paper, printing and publishing	10.77	11.52	1.13	16.97
Wood and cork	7.77	10.68	5.45	17.00
Total manufacturing	**18.74**	**22.64**	**3.20**	**24.02**

Offshoring (imported inputs/net sales) and exports over sales

Source: Own elaboration using data from the Industrial Survey.

Table 2

INDUSTRY	Offshoring of capital inputs		Offshoring of other inputs	
	2005(%)	Annual growth rate 1993-2005(%)	2005(%)	Annual growth rate 1993-2005(%)
	HIGH TECHNOLOGICAL INTENSITY			
Electronic, electrical and optical equipment	29.77	6.48	16.01	8.67
	MEDIUM-HIGH TECHNOLOGICAL INTENSITY			
Chemical industry	1.05	-0.14	40.87	7.32
Mechanic machinery and equipment	11.83	6.48	9.21	0.63
Transport material	5.85	8.64	54.55	5.58
	MEDIUM-LOW TECHNOLOGICAL INTENSITY			
Rubber and plastics	2.66	7.86	26.22	-0.13
Metallurgy and metallic products	2.24	0.39	19.94	4.41
Other non-metallic minerals	2.45	4.23	9.84	12.28
Other manufactures	1.80	7.48	13.99	2.96
Coke, refined petroleum and nuclear fuel	0.37	3.06	71.61	-4.28
Extraction of energetic products	2.69	14.66	3.48	15.78
Extraction of other minerals	1.51	-0.13	8.78	13.59
Electric energy, gas and water	1.57	4.99	18.40	3.63
	LOW TECHNOLOGICAL INTENSITY			

Foods, beverages and tobacco	0.58	19.07	12.68	2.92
Textile and clothing	0.75	1.93	22.68	2.23
Leather and shoes	0.36	1.75	20.70	6.12
Paper and publishing	1.10	5.52	17.15	0.20
Wood and cork	1.21	2.92	23.39	6.05
Total manufactures	**3.99**	**5.99**	**22.91**	**1.99**

Offshoring of capital inputs and offshoring of other inputs

Note: Offshoring of capital inputs is the ratio of imported capital inputs to production at basic prices for each industry. Offshoring of other inputs is the ratio of imported inputs other than capital goods per unit of production by industry.
Source: Own elaboration from IOT data.

Table 3

Dependent variable Q	(1)	(2)	(3)	(4)	(5)	(6)
K	0.1129	0.1395	0.1607	0.1828	0.1116	0.1097
	[.026]***	[.029]***	[.025]***	[.037]***	[.029]***	[.024]***
L	0.3662	0.3552	0.3486	0.3693	0.3552	0.3809
	[.035]***	[.035]***	[.033]***	[.038]***	[.035]***	[.034]***
M	0.6766	0.6805	0.6823		0.6805	0.6714
	[.019]***	[.019]***	[.020]***		[.019]***	[.019]***
Domestic inputs				0.3048		
				[.028]***		
Imported inputs				0.3036		
				[.021]***		
Offshoring variable	Narrow	CIM/CT	Capital inputs		Broad	CIM/Q
	0.1675	-0.0073	-0.4028		0.1509	0.154
	[.059]**	[.082]	[.136]**		[.059]**	[.060]**
Constant	-0.3848	-0.6726	-0.9135	0.2636	-0.467	-0.4517
	[.294]	[.296]**	[.286]**	[.44]	[.270]*	[.270]*
R^2	0.944	0.954	0.958	0.954	0.942	0.942
Hausman	37.29***	13.56***	11.13**	15.43***	15.25***	15.21***

Results for estimations for output and offshoring

Note: Fixed effects estimates. *Q* is output value, *K* is capital services, *L* is total worked hours, *M* is intermediate inputs. Standard errors, in brackets, are heterokedasticity robust. Time dummies included. *** denotes significant at 1% level, ** at 5% level, * at 10% level. All variables in logs. CIM/CT is imported inputs over total inputs and CIM/Q is imported inputs over output.

Table 4

Dependent variable Q	(1)	(2)	(3)	(4)	(5)	(6)	(7)
K	0.1685	0.1698	0.1638	0.167	0.167	0.169	0.2143
	[.031]***	[.029]***	[.032]***	[.030]***	[.030]***	[.030]***	[.063]***
L	0.1166	0.1112	0.1208	0.1076	0.1076	0.1164	0.1417
	[.011]***	[.011]***	[.014]***	[.013]***	[.013]***	[.0104]***	[.0406]***
M	0.7003	0.7211	0.7199	0.7159	0.7159	0.6984	
	[.019]***	[.023]***	[.027]***	[.023]***	[.023]***	[.019]***	
Domestic inputs							0.4179
							[.047]***
Imported inputs							0.2592
							[.049]***
		Narrow	CIM/CT	Broad	CIM/Q	Capital inputs	
Offshoring variable		-0.2137	-0.2121	-0.181	-0.18	-0.095	
		[.133]	[.118]*	[.111]	[.110]	[.144]	
Constant	-0.0052	-0.0038	-0.0033	-0.0031	-0.003	-0.0048	0.0072
	[.004]	[.004]	[.004]	[.004]	[.004]	[.004]	[.011]

Results for estimations for offshoring and output. First differences regressions.

Note: See Table 3.

Table 5

Dependent variable is Q/L	(1)	(2)	(3)	(4)
K/L	0.1968	0.1978	0.1968	0.1953
	[.047]***	[.050]***	[.047]***	[.051]***
M/L	0.6789	0.6818	0.679	0.6792
	[.032]***	[.035]***	[.033]***	[.032]***
			Broad	Capital inputs
Offshoring variable	Narrow	CIM/CT		
	-0.0001	-0.047	-0.0039	0.0035
	[.0000]	[.021]**	[.037]	[.021]
Constant	-0.0071	-0.0052	-0.0069	-0.0073
	[0.0043]	[.0043]	[.0046]	[.0042]
R^2	0.962	0.967	0.962	0.962

Results for estimations for productivity and offshoring

Note: Variables are growth rates. See table 3.

Table 6

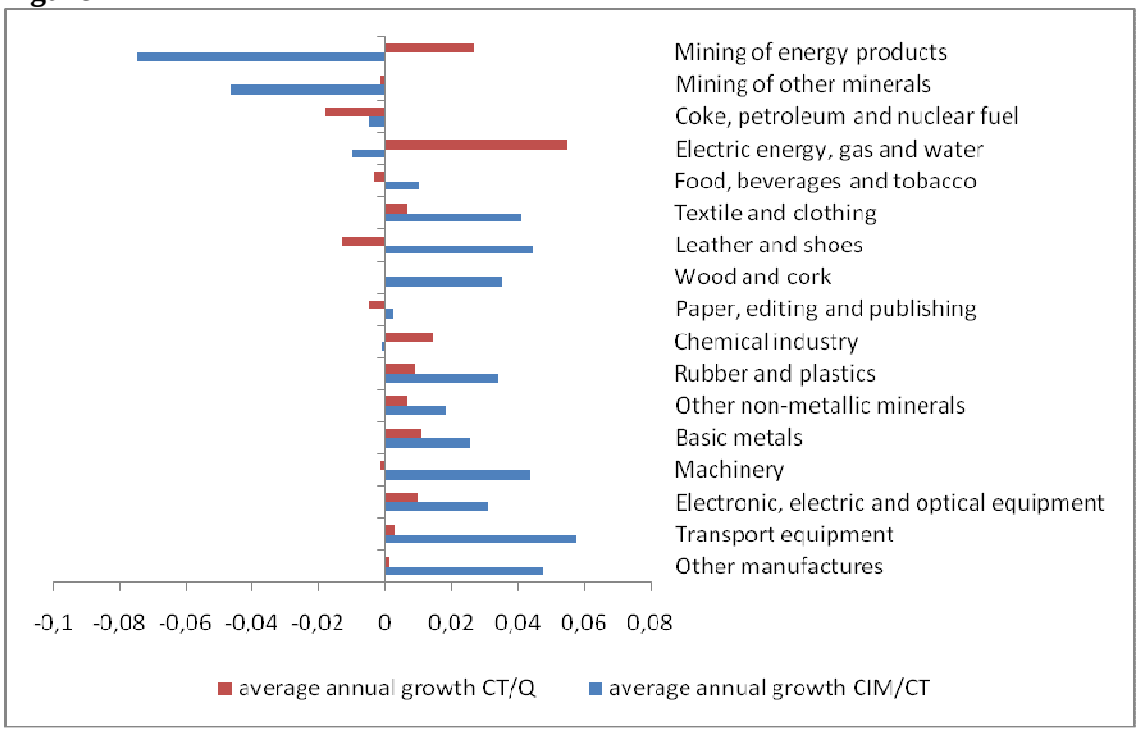
Dependent variable VA/L	(1)	(2)	(3)	(4)	(5)	(6)	(7)
K/L	2.9952	3.037	3.019	3.02	3.1323	2.6856	2.6207
	[.664]***	[.704]***	[.672]***	[.6724]***	[.700]***	[.8034]***	[.810]***
Offshoring variable	Narrow	CIM/CT	CIM/Q	Broad	Capital inputs/L	CIM/L	Capital inputs/L
	-28.233	-49.33	-13.682	-12.686	-0.6672	0.1564	-0.7986
	[18.32]	[29.11]*	[16.200]	[15.657]	[.328]**	[.122]	[.316]**
							Rest of imported inputs/L
							0.2714
							[.123]**
Constant	42.7	54.725	42.044	41.747	40.237	37.5972	39.884
	[6.656]***	[7.78]***	[5.887]***	[5.903]***	[6.730]***	[6.665]***	[6.641]
R^2	0.944	0.928	0.947	0.947	0.946	0.956	0.952

Results for estimations for productivity and offshoring: value added

Note: Variables are growth rates. See table 3.

Figures:

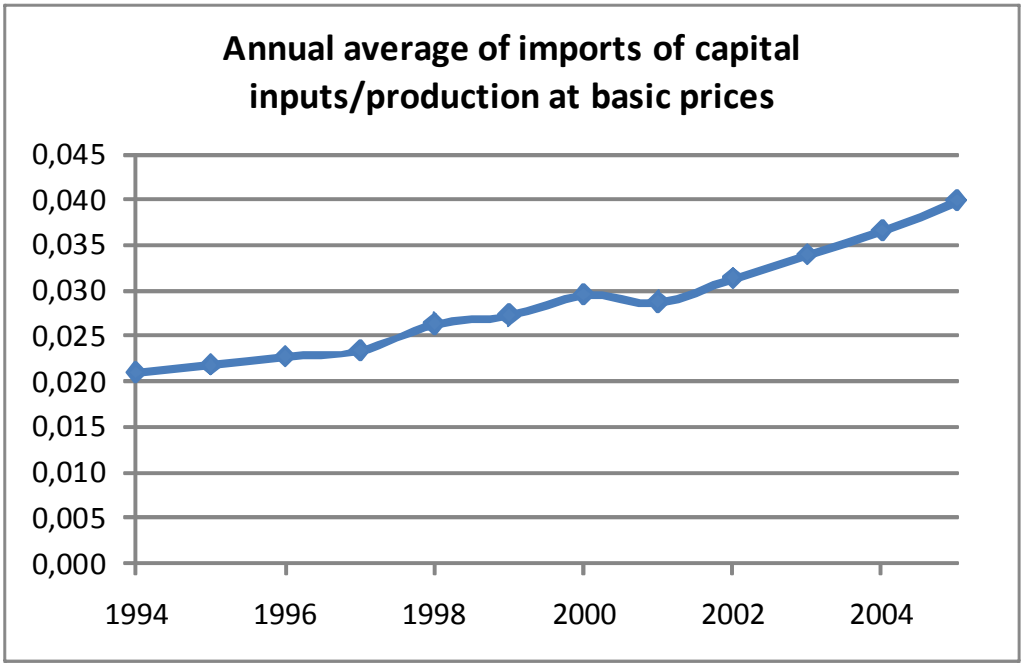
Figure 1



Evolution of total and imported inputs by industry (1999-2005)

Note: CIM/CT is imported over total inputs, CT/Q is total input requirements over net sales. Own elaboration from Industrial Survey data.

Figure 2



Evolution of imported capital inputs per unit of production

Source: Own elaboration from IOT data.