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**OFFSHORING COMPONENTS AND THEIR EFFECT ON
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OFFSHORING COMPONENTS AND THEIR EFFECT ON
EMPLOYMENT: FIRMS DECIDING ABOUT HOW AND
WHERE

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ABSTRACT

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Firms must take two fundamental decisions: how and where to produce. Traditional measures of offshoring include information on both decisions but cannot distinguish between them. In this paper we attempt to distinguish the evolution of the requirement of inputs per unit of output (how to produce) from the delocalisation of production to others countries (where to produce). We call global technical change to the first element and net offshoring to the second. We further decompose net offshoring into net inter-industry substitution and intra-industrial offshoring (replacement of domestic inputs for imported ones from the same sector). This last measure quantifies better the concept of delocalisation of production to other countries looking for lower costs, the original idea behind offshoring. This decomposition allows us to further investigate on whether it is technical change or net offshoring the main factor in recent Spanish industrial employment changes.

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KEYWORDS: Offshoring; Outsourcing; Fragmentation; Labour demand; Dynamic panel data

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1. INTRODUCTION

The rising economic integration has increased not only trade in final goods but also the flows of intermediate goods, as a result of the fragmentation of production and/or the search for new and cheaper providers. As a consequence, the productive structure of the involved countries is changing with effects on production and employment for all sectors, within a general tendency to sectoral or even task specialization. While some see this phenomenon as a threat to domestic employment, it also represents a chance to reduce costs, increase flexibility and open new markets, all of which can improve competitiveness with a positive effect on sales and employment.

There are two main streams of analysis in relation to the phenomenon of offshoring. On the one hand, some papers analyse offshoring determinants theoretically and empirically (Grossman and Helpman, 2002 and 2005, are the original theoretical references). On the other hand, others study the offshoring impact on several economic aspects, mainly, distributional effects, in terms of wage gap, levels of qualification or employment (Feenstra & Hanson, 1996 and 1999; Görg & Hanley, 2005; Falk and Wolfmayr, 2008; and Cadarso *et al.*, 2008 among other) or the impact of offshoring on productivity or profitability (Marjit and Mukherjee, 2008).

The main contribution of this paper is related to the first group of the offshoring effects, since we investigate the labour market impact of offshoring, more specifically its effect on the level of industrial employment in Spain, and we do so introducing a new element. Our previous analysis of the effect of offshoring on Spanish employment shows that its sign and magnitude changes with sector and country of origin of the offshored goods, so that it seems to be related to the sector

1
2 technological component and to the country of origin task specialisation (Cadarso *et*
3 *al.*, 2008). In the present paper, we deepen into the analysis from a different
4 perspective, as we decompose the measure of offshoring traditionally used in the
5 literature into three better delimited measures.
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11 The main aim is to isolate changes in two managerial decisions: first, the
12 location of the production process (where to produce) and second, the production
13 technique (how to produce). The first type of changes refers to the location of
14 production tasks, or, in other words, to the origin of the produced inputs, domestic or
15 imported, and how they can substitute each other. We also consider two elements
16 related to location decisions, since we distinguish whether imported intermediate
17 inputs come from the same or from a different sector. The second type of changes
18 refers to the production technique, and affects the total amount of inputs, both
19 domestic and imported, required per unit of production at each point in time.
20 Technical related changes can be due to: *a*) a change in the composition of
21 production of that sector, that implies a greater use of imported inputs (for example,
22 vehicles produced in Spain now incorporate a greater amount of electronic
23 components – GPS, DVD, etc. –); or *b*) a change in the organization of production
24 that originates a substitution of direct employment for imported inputs in that
25 industry. Both elements, that comprise technological and organizational changes, are
26 expected to have an impact on industrial employment. The importance of these
27 elements have been recognized by previous literature that has tackled the problem by
28 including an independent technical change measure in the analysis (see Feenstra and
29 Hanson (1999); Hijzen *et al.* (2005); or Morrison-Paul and Siegel (2001)) however
30 we consider that, since technical decisions and localization ones are essentially
31 linked, an independent technological measure can lead to double accounting
32 problems and its derived multicollineality problems in econometric estimations. In
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2 contrast, we propose to explicitly consider the technical change element linked to the
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4 offshoring strategy.
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7 The original contribution of this empirical analysis is the decomposition of
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9 offshoring into global technical change and net offshoring, and distinguish two more
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11 elements within the net offshoring measure, the intra and the inter-sectoral element.
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13 Other defining elements are: 1) our data comes directly from the import and domestic
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15 use matrices of input-output tables, rather than being indirectly estimated through
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17 weighted trade data; 2) we estimate a labour demand function at sector level, instead
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19 of focusing on skills or wages as most of the literature¹; 3) we consider a dynamic
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21 specification for our model and use dynamic panel data econometric techniques
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23 (GMM). Our results indicate that, when offshoring is decomposed, there is a negative
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25 effect of global technical change on Spanish employment and a negative, but no
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27 significant effect of intra-industrial offshoring, giving a further insight into the
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29 previous literature with a single offshoring measure, that considers that
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31 delocalisation, and not its related technical change, is the main factor behind labour
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33 changes, however when the original measure has been properly broken down, it is
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35 shown that technical change element has a stronger effect.
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43 The remainder of this paper is as follows. In section 2 we review the main
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45 literature about the topic. In section 3 we outline the basic model used and the
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47 calculation of offshoring measures. Section 4 comments on the data and a number of
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49 important econometric issues. Section 5 contains the main empirical results and
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51 section 6 concludes.
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¹ We are only aware of one study by Görg and Hanley (2005) that studies the effect of offshoring on employment but at firm-level and using survey rather than input-output data.

2. OFFSHORING, TECHNICAL CHANGE AND EMPLOYMENT IN PREVIOUS LITERATURE

Fragmented production is nowadays considered as a key element in the design of production organisation and it has been extensively analysed by literature. The analysis of the impact of offshoring² on the labour market originates mainly in the leading papers by Feenstra and Hanson (1996, 1999), that focused on its effects on sector wage inequality by skills. Later empirical developments on the topic substitute relative wage with relative labour demand in terms of skill, especially for European data. The original framework has evolved through time by including technological variables, distinguishing different offshoring measures or introducing geographical aspects.

Feenstra & Hanson (1996) analyse the way trade affects the relative demand for skilled labour by estimating a relative labour cost equation (see Berman *et al.* 1994) augmented by an offshoring measure built by combining import data from U.S. manufacturing industries with input purchases. Here offshoring is considered as “an index of the extent to which U.S. firms contract non-skill-intensive production activities to foreigners.”³ They work with data for 435 industrial sectors and find that during the period 1979-1990 offshoring has contributed substantially to the increase in relative non-production wage share, as a proxy for high-skilled wages share. However, results for the period 1972-1979 are non-significant.

In a later paper, Feenstra & Hanson (1999), the authors develop a similar model enhanced by including an independent technological variable, since these two

² The original term employed by Feenstra and Hanson was outsourcing, however, recent literature about the topic has moved to the analysis of offshoring, a concept which comprises a firm imported purchases, independently of whether the provider is financially linked or not of the purchaser, while outsourcing refers to firm purchases to other independent firms, which could be domestic or foreign (for further analysis see Díaz-Mora, 2008).

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

1 factors, trade and technical change, are expected to alter wage inequality. We also
2 consider that technical change is a key element to understand labour evolution;
3 however we do not consider it to be independent of changes on trade, but
4 intrinsically linked to them. Another novelty of the 1999 Feenstra and Hanson paper
5 is the differentiation between three types of offshoring, depending on whether the
6 purchases come from the same sectors, narrow offshoring, from other sectors,
7 difference offshoring; or it is the sum of both, broad offshoring. This distinction
8 allows the authors to show that the effects of intermediate inputs purchases are
9 different depending on their origin: Narrow offshoring has a greater effect than
10 difference offshoring. We also consider this distinction in our analysis.
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26 Focusing now on the offshoring element, a number of authors have followed
27 Feenstra & Hanson's work and, in most cases, have found a positive effect on skilled
28 labour, pointing to firms contracting out production phases that are intensive in low-
29 skilled labour, even though the more recent studies on this topic tend to point to the
30 existence of differences on the results that depend on other elements, as we discuss
31 below. We pay special attention to works that have included a technological
32 measure, since we consider that both elements, offshoring and technological change,
33 affect jointly labour, and when one of them is missing the effect of the other one is
34 miss-estimated.
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48 Minondo and Rubert (2006) follow Feenstra and Hanson's framework
49 developing a model that includes, as a novel element, a differentiated analysis of
50 offshoring depending on the origin, distinguishing between inputs coming from
51 developed and developing countries. The model is applied to Spanish manufacturing
52 data and they find that there is a positive effect on Spanish skilled labour demand,
53 not just when offshoring comes from developing countries and, not so expected, also
54 when it comes from developed ones. Falk and Wolfmayr (2008) also carry out a
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2 differentiated analysis for offshoring coming from low-wages on non-low wages
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4 countries and also include, as a distinctive element, the analysis of the effects of
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6 services and materials offshoring. The empirical application is done for five EU
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8 countries for which the authors analyse whether purchased services and materials
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10 from abroad are a complement or substitute for domestic employment. They find that
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12 the effect of offshoring on employment depends on the characteristics of the
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14 purchasing sector, whether the purchases are of goods or of services and the country
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16 of origin of goods. Fajnzylber and Fernandes (2009) also find different results when
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18 they analyse the effect of offshoring, exports and FDI (foreign direct investment) on
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20 labour market variables, such skilled and unskilled labour demand, and relative
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22 wages. They present an original research, since they analyse these relationships for
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24 two countries that receive offshoring, such as China and Brazil, working with cost
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26 functions instead of labour demand ones, that are common in European studies. The
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28 authors find that, even though the effects of the three globalization variables is
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30 positive for the skilled relative wage, the effect on skilled labour demand does not
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32 always behave in the same way for developing countries, since it is positive for
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34 Brazil but negative for China.
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43 We consider that these differentiating elements existing in developing and
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45 developed countries, and also found in Cadarso et al. (2008) for the Spanish
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47 economy, may be due to the technical characteristics of both the purchased inputs
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49 and the purchasing sector, and analyse it from a different perspective, by
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51 decomposing the technical element within the offshoring measure. From the Carter
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53 (1970) seminal work, the analysis of structural decomposition has been widely used
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55 in input-output tables literature in order to itemise the evolution of a variable through
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57 time according to the change of its components (Wolff, 1985 and Skolka, 1989, are
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2 fundamental papers in this area, while Dietzenbacher and Los (1998) analyse the
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4 problems derived from the no-uniqueness of decomposition).
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8 Following with offshoring literature, Hijzen *et al.* (2005) extend Feenstra &
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10 Hanson's framework by estimating a system of four variable factor demand
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12 functions, including relative demand for skilled workers, for 50 U.K. industrial
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14 sectors for the period 1982-1996. The relative demand function is augmented by an
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16 inter-industrial offshoring measure and R&D expenditure, intended to pick up
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18 technological change in working practices due to the adoption of more sophisticated
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20 technologies. Results show that both measures have a negative effect on the demand
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22 for unskilled labour and a positive effect on skilled labour.
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27 Görg & Hanley (2005) propose a microeconomic focus and analyse the
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29 absolute effect of offshoring on total labour. They estimate a dynamic labour demand
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31 function for 652 plant level data for the Irish electronic sector during the period
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33 1990-1995, and find that, in the short run, offshoring is linked to a reduction in
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35 labour demand. Nonetheless different kinds of offshoring affect employment in
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37 different ways, so greater negative effects appear from the offshoring of materials
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39 than from the offshoring of services.
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44 Together with the already mentioned Feenstra and Hanson (1999) and Hijzen
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46 *et al.* (2005), other empirical literature has paid attention to the importance of
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48 technical change by showing that changes in labour demand are the result of the
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50 action of both forces, technical change and offshoring, and also that these two
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52 elements are closely related. Morrison-Paul and Siegel (2001) incorporate trade and
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54 technology related measures that can shift relative labour demand in a system of
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56 factor demand equations for the US. Their result suggests that both elements,
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58 international offshoring and trade and technological change, significantly lowered
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60 relative demand for low-skilled labour. The authors work with US data by estimating

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2 a dynamization of the original labour cost function introduced by Feenstra and
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4 Hanson, while other applications use labour demand functions mainly due to the
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6 specific characteristics of the European labour market, where wage differentials are
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8 lower than in the US one.
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11 Our approach combines characteristics already considered in previous
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13 literature and adds a new perspective. We work with a labour demand equation such
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15 as studies in the European context do, augmented to account for the effect of
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17 offshoring and a measure of technical change, however both measures are developed
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19 from the decomposition of the traditional offshoring measure, reflecting that both
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21 types of changes are dependent on each other. This decomposition is a novelty of this
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23 analysis, since previous literature included an independent technological measure,
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25 however we consider that the usual procedure can lead to problems since, in most
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27 cases, changes related to offshoring cannot be implemented without technological
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29 changes, so studies that include technical change as an independent measure are
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31 including, in fact, two measures of offshoring, a direct one through the technological
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33 measure, and an indirect one contained in the offshoring one. We consider the
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35 equation to be dynamic and work with total labour as in Görg and Hanley. Our
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37 measures of offshoring and technical change are calculated from original input-
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39 output data (as in Hijzen *et al.*) instead of being approximated by weighted trade
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41 data.
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56 **3. DECOMPOSITION OF OFFSHORING: NET OFFSHORING VERSUS** 57 58 **TECHNICAL CHANGE** 59 60

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2 We prefer the term “offshoring” (to the previous literature “outsourcing”)
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4 because it properly reflects the substitution of domestic intermediate inputs for
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6 imported inputs since it «implies that tasks formerly undertaken in one country are
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8 now being performed abroad» (Grossman & Rossi-Hansberg, 2006) and these
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10 changes are more likely to affect employment at home. Moreover, along with the
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12 discussion about terms to refer to this phenomenon there is another debate about
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14 which measure is closer to it. Splitting up the traditionally considered measure
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16 (imported intermediate inputs) we try to contribute to this issue.
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21 It is not straightforward to disentangle the effects of trade and technological
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23 change, since international fragmentation involves both. Changes in production
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25 intermediate inputs requirements entail two main reasons for variations in the
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27 imported technical coefficients between two periods, t and the base year 0: a) input
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29 substitution is taking place; b) a different amount of inputs is required per unit of
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31 output. Our aim is to isolate both elements so that it possible to distinguish, in the
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33 coefficients of imported intermediate inputs at period t (\mathbf{A}^m_t), two components: a)
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35 Pure or net offshoring (\mathbf{A}^{off}), that requires to build a matrix able to account for the
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37 value of imported technical coefficients at year t by keeping constant the total
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39 intermediate consumption per unit of output between t and 0; b) global technical
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41 change (\mathbf{A}^{tc}), that requires to build a matrix where the distribution of technical
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43 coefficients is held constant and each coefficient varies in the same proportion as the
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45 sum by columns of the total (domestic + imported) coefficients⁴. This latter matrix
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47 controls for the change in total intermediate consumption for each sector during the
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49 period. Certainly, whenever both matrices are added the result will equal the total of
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51 imported intermediate consumption at year t :
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$$\mathbf{A}^m_t = \mathbf{A}^{\text{off}} + \mathbf{A}^{\text{tc}} \quad (1)$$

⁴ This technical change assumes that each imported coefficient increases at the same rate than the average of total intermediate inputs.

\mathbf{A}^m is the usually accepted offshoring measure, however previous literature does not consider the technological element within. The previous decomposition allows us to differentiate two elements in firms' decisions: a) the localisation of production and b) the most efficient technique (least inputs requirement per unit of output). Within this framework it is possible to distinguish the offshoring linked to reduction in costs suggested by Feenstra and Hanson (1996), collected in \mathbf{A}^{off} , since it comprises the stages of production that are located in a low-wage countries (based on the hypothesis of no changes in the production technique). In this scheme, once the technique for a good has been decided at year $\mathbf{0}$, production stages intensive in non-qualified labour can be taken away to those countries where it is an abundant factor.

The imported intermediate inputs matrix \mathbf{A}^{off} is defined so that it contains the same amount of total intermediate inputs used on the base year $\mathbf{0}$ together with the imported technical coefficient distribution on year t . It is calculated by dividing each element of the imported intermediate coefficient matrix (\mathbf{A}^m_t) by the total of technical coefficients at year t (\mathbf{uA}_t) and multiplying by the total at year $\mathbf{0}$ (\mathbf{uA}_0). This process allows us to obtain a *net offshoring* measure, once technical change has been taken off (since intermediate consumption per unit of output is forced to be constant). Our measure can, therefore, isolate the change in imported intermediate inputs due to technical change. For the Spanish context, where more inputs are required on average for production, net offshoring is expected to grow slower than the usual offshoring measure. We can calculate (\mathbf{A}^{off}) in a matrix form and for a unique element:

$$\mathbf{A}^{off} = \mathbf{A}^m_t \langle \mathbf{uA}_0 \rangle \langle \mathbf{uA}_t \rangle^{-1} \quad a_{ij}^{off} = \frac{a_{ijt}^m}{\sum_{i=1}^n a_{ijt}} \sum_{i=1}^n a_{ij0} \quad (2)$$

where \mathbf{u} is a unitary vector ($1 \times n$), “ $\langle \cdot \rangle$ ” denotes that a diagonalized vector, \mathbf{A}^m_t is the imported technical coefficient matrix for year t , and \mathbf{A}_0 and \mathbf{A}_t are the total (imported + domestic) coefficient matrix for year 0 and t . The element a^m_{ijt} is the imported technical coefficient for year t and $\sum_{i=1}^n a_{ijt}$ the total technical coefficient (domestic and imported) for sector j on year t . \mathbf{A}^{tc} is calculated as:

$$\mathbf{A}^{tc} = \mathbf{A}^m_t \langle \mathbf{uA}_t \rangle^{-1} (\langle \mathbf{uA}_t \rangle - \langle \mathbf{uA}_0 \rangle) \quad a^{tc}_{ij} = \frac{a^m_{ijt}}{\sum_{i=1}^n a_{ijt}} \left[\sum_{i=1}^n a_{ijt} - \sum_{i=1}^n a_{ij0} \right] \quad (3)$$

By adding net offshoring and net technological change we obtain the imported technical coefficient for sector j at year t (the usual offshoring measure in literature):

$$a^m_{ij} = a^{off}_{ij} + a^{tc}_{ij} = \frac{a^m_{ijt}}{\sum_{i=1}^n a_{ijt}} \sum_{i=1}^n a_{ij0} + \frac{a^m_{ijt}}{\sum_{i=1}^n a_{ijt}} \left[\sum_{i=1}^n a_{ijt} - \sum_{i=1}^n a_{ij0} \right] \quad (4)$$

It would also be possible to decompose the total technical coefficients matrix that accounts for imported and domestic inputs required for production. Domestic coefficients are found in a similar fashion to imported ones.

Decomposition of net offshoring: Net intra-industrial offshoring and inter-industrial substitution

We further decompose net offshoring into two components: net intra-industrial offshoring and inter-industrial substitution (or net inter-industrial offshoring). Net intra-industrial offshoring quantifies the evolution of offshoring when there is substitution of domestic inputs by imported inputs inside the sector, keeping constant the substitution between inputs of different sectors and the global

technical change. Inter-industrial substitution shows that the increase in imported inputs reduce the purchases of inputs from other sectors. This decomposition can be expressed as follows:

$$a_{ij}^{off} = (a_{ij}^{offIntra} + sustInter_{ij}) \quad (5)$$

We can express the net intra-industrial offshoring coefficient as:

$$a_{ij}^{offIntra} = \frac{a_{ijt}^m}{(a_{ijt}^m + a_{ijt}^d)} (a_{ij0}^m + a_{ij0}^d) \quad a_{ij0} = (a_{ij0}^m + a_{ij0}^d) \quad (6)$$

The inter-industrial substitution can be expressed as:

$$sustInter_{ij} = a_{ijt}^m \left[\frac{\sum_{i=1}^n a_{ijo}}{\sum_{i=1}^n a_{ijt}} - \frac{a_{ijo}}{a_{ijt}} \right] \quad (7)$$

The results presented in this paper are referred to narrow offshoring, that is, to the coefficients in the diagonal. This is the measure that has traditionally received most attention, as studies try to estimate its impact on employment. Changes in off-diagonal coefficients (difference offshoring) are expected to affect employment in the inputs producing sectors and not in the one that is using them.

In this line, we can say that Feenstra and Hanson offshoring, where firms respond to import competition from low-wages countries, “by moving non-skill-intensive activities abroad” (Feenstra and Hanson, 1996, p. 24) is better measured by (narrow) net intra-industrial offshoring ($a^{offintra}_{ij}$). This coefficient quantifies the purchase of goods within a sector that is no longer bought domestically but brought from abroad because of cost reductions, and coefficient variations due to technical change have been properly disentangled.

Evolution of Narrow offshoring in Spanish industry

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2 This subsection focuses on the evolution of the “disentangled” measures for
3 the Spanish economy through the period 1993-2002. We can observe an important
4 growth in offshoring for the average of industrial sectors in Spain between 1993 and
5 2002 (Figure 1). Breaking down this evolution, the data show that the substitution of
6 domestic inputs for imported inputs (net offshoring) is the main explaining factor.
7 Global technical change is low but increases over the period, implying an increase in
8 the requirements of imported intermediate inputs by unit of production.
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25 The breaking down of net offshoring, into net intra-industrial offshoring and
26 inter-industrial substitution, points out a dual behaviour across the time. Net intra-
27 industrial offshoring measures how offshoring would evolve if there were
28 substitution of domestic for imported inputs from the same sector (this would be the
29 case, for example, if the sector Fabricated metal products buy the metal lids of food
30 containers to foreign suppliers instead of the regular domestic ones), keeping
31 constant the substitution between inputs from different sectors (i.e., the possibility
32 that Fabricated metal products use now plastic for making food containers and that
33 input must be imported so they stop buying metal inputs from domestic suppliers)
34 and global technical change. Between 1993 and 1998, the increase in intra-industrial
35 imported inputs implies the reduction of intermediate consumption from the same
36 sector. Nevertheless, since 1998, the intra-industrial substitution between domestic
37 and imported inputs remains nearly constant while purchases from other sectors,
38 inter-industrial inputs, grow.
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58 In general, when those sectors where global technical and organizational
59 change require increases in intermediate inputs purchases are analysed, we find that
60 most of them are high and medium high technology sectors.

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<Figure 2 here>

Among them, the increase in the offshoring measure in Electronic Components is remarkable, it goes from 0,1 to more than 0,5 (only shown for the last year of the sample) and Figure 2 shows that this increment is explained mainly by the change in inter-industrial substitution and global technical change and not by net intra-industrial offshoring. The behaviour of Office machinery and computers is similar.

<Figure 3 here>

On the contrary, there is a group of industries, mainly traditional, for which global technical change implies saving in intermediate consumption from the same sector per unit of output. But, this has not been enough to offset the increase in foreign same sector consumption of imported inputs that are replacing inputs produced inside the country (net intra-industrial offshoring).

A deeper discussion about the specificities of the Spanish industrial sectors and the relative weight of each element within the offshoring measure on different characteristics sectors is developed in Cadarso *et al.* (2009).

4. LABOUR DEMAND EQUATION, DATA AND ESTIMATION ISSUES

In order to analyse the effects of offshoring, and its three inherent elements, on labour we developed a labour demand equation from a CES production function, from this function we follow the usual steps⁵ (see Van Reenen 1997, Barrell and Pain 1997 or Piva and Vivarelli, 2004) to find an augmented labour demand function fitted to panel data:

⁵ From the assumption of firms maximising profits in a perfect competition environment, it is possible to obtain the demand function for the labour factor from the first order condition, which states that each factor's marginal product has to equal its real price.

$$n_{it} = \alpha_1 y_{it} + \alpha_2 w_{it} + \beta_{n=1}^3 \text{offshoring}_{it} + (\varepsilon_i + u_{it}) \quad (8)$$

for $i = 1, \dots, N$ sectors or firms and $t = 1, \dots, T$ years or periods, while y is log output, n is log employment, w is log real wage, and offshoring is calculated as explained below; ε are firm – specific (time – invariant) effects and u is the usual error term.

We extend this framework in two features: first we decompose the measure of offshoring as explained in the previous section; second, we consider that changes in labour demand as a result in any of the variables considered in equation (9) is not automatic, labour requires time to adapt so that a dynamic relation shall be considered instead.

The new equation considering a dynamic relationship and including offshoring measures and innovation activities is:

$$n_{it} = \alpha_0 n_{it-1} + \alpha_1 y_{it} + \alpha_2 w_{it} + \beta_1 \text{offsh} - \text{intra}_{it} + \beta_2 \text{sust} - \text{inter}_{it} + \beta_3 \text{TC}_{it} + (\varepsilon_i + u_{it}) \quad (9)$$

In order to analyse the relationship between offshoring and employment, we use data for 28 Spanish manufacturing sectors for the period 1993-2002⁶. Variables are standard: **Employment** is measured by thousands of worked hours yearly for each sector; **Production** is added value (net sales minus intermediate goods) in € thousands; **Labour cost** is measured by labour related expenditure per worked hour in €. These data are provided by the *Encuesta Industrial* (INE) and they are deflated for each sector by its industrial price index. Our offshoring related measures are defined from the Spanish Input-Output Tables.

⁶ To calculate different offshoring measures we employ the use matrices of the Spanish input-output tables, instead of the inter-industry symmetrical (commodity by commodity) matrices. Our decision is justified by data availability for the period 1993-2002, as we have at our disposal six use tables (1995-2000)⁶ for one symmetrical table, which allow us to take into account changes in the table coefficients. Also, we measure offshoring directly from the use matrices. It is possible to observe a very important change in the coefficients from 1995 to 2000. This is why to fill the gaps we estimate the data for 1993 and 1994 by extrapolating the growth rates of 1995-1998, and for 2001 and 2002 we apply the growth rates of 1998-2000.

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2 We now analyse which is the most appropriate estimation method. Our panel
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4 is short in terms of observations (28 sectors and 10 years) and it also has an
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6 important dynamic component. The existence of a lagged dependent variable among
7
8 the regressors generates problems in standard OLS and within estimations.
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10 Furthermore our model contains endogenous and predetermined variables which
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12 point to the use of GMM (general method of moments) techniques as the most
13
14 suitable ones, more specifically GMM system technique (SYS-GMM) that also
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16 avoids problems of weak instruments due to short panel or autocorrelation in the
17
18 variables (see Blundell and Bond, 1998). SYS-GMM estimator uses all possible lags
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20 of regressors as instruments to generate orthogonality restrictions. This estimation
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22 technique combines an equation in differences that uses suitable lagged levels as
23
24 instruments, with an additional equation in levels with suitable lagged first-
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26 differences as instruments. The order and number of lags included for each variable
27
28 depends on whether they are considered endogenous, predetermined or exogenous.
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30 The validity for this estimation technique is tested through the use of the Sargan test
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32 of over-identifying restrictions and m_1 and m_2 Arellano and Bond (1991) tests. We
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34 must be cautious about results: these techniques are optimal for large samples, while
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36 in sectoral studies like this one we only have at our disposal a limited number of
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38 observations.
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50 5. EMPIRICAL ANALYSIS

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52 Table 1 summarizes the results from our empirical application. For the
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54 standard determinants of labour demand, Table 1 shows consistent coefficients for
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56 added value, wages and the lag of labour. All three coefficients keep approximately
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58 constant in all regressions, with values close to those found by previous empirical
59
60 studies and are significant in all cases.

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2 We discuss in detail results for the decomposed offshoring variables that are
3 progressively disentangled. Column (1) considers the total offshoring variable
4 (global technical change + net offshoring). From column (2) to column (5) elements
5 are included independently, (2) shows the results for a part of the previous variable,
6 global technical change, while column (3) considers the other component of
7 offshoring, net offshoring. Columns (4) and (5) include net intra- and net inter-
8 offshoring, respectively, that are both elements within net offshoring (3). Finally,
9 column (6) further investigates global technical change and net offshoring
10 (considering its both elements) jointly.
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<Table 1 around here>

29 From these preliminary results we observe that offshoring seems to have a
30 negative but not significant impact on employment (column 1). This result is
31 coherent with a previous study (Cadarso *et al.*, 2008), that considered the global
32 offshoring measure. However in this previous work the measure shows significant in
33 some cases in a by-sector and by-country of origin decomposition of the offshoring
34 measure, pointing to the effect of offshoring depending on other elements: the
35 technological composition of the importing sector, the technological composition of
36 the country of origin and the specialization of the importing country. We investigate
37 further on these results from a different perspective on this work.
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50 When we decompose this measure of offshoring into its different components, we
51 observe that all elements have a negative sign, but in one case, however it is global
52 technical change the only significant one, both in column 2 where it is included in
53 individually and in column 6, where it is accompanied by all other offshoring related
54 elements. In these years, technical change/organization change has increased the
55 requirements of inputs per unit of output in industrial sectors on average. Spanish
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2 firms substitute direct employment by intermediate inputs between 1993 and 2002,
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4 while it can generate indirect employment in other sectors and/or countries,
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6 especially in low-wage countries. This impact is common to all industries, and not
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8 just medium and high-tech sectors, as well as for all firms in each industry, as it
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10 requires a higher input consumption per unit of production. The impact of global
11
12 technical change becomes even clearer when we introduce the different variables
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14 together in the regression, as in column (6). Global technical change becomes even
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16 more negative and significant while the measures of net intra-industry offshoring and
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18 inter-industry substitution remain not significant.
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24 Since in the rest of the columns, where elements are included in isolation, one
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26 element can be capturing the effects of the missing ones, even more taking into
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28 account that the three elements are closely related, we discuss in detail results in
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30 column 6, our preferred ones. The inter-industrial substitution, in column (6), has a
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32 positive coefficient, but it is not significant, probably because it collects a number of
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34 different structural changes, not all of them related to offshoring (secondary
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36 production, energy, raw materials, etc), so its effect gets blurred, but it is pointing to
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38 a positive effect of employment of increasing specialization for a sector, and
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40 increasing the purchase of intermediate inputs not directly related to the sector
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42 principal production. It has, however, a negative sign in column 5, since it catches
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44 the effect of other elements of the offshoring measure that are not included in column
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46 5 regression, pointing to the importance on including all elements in a itemized way.
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51 It should also be noted, that the negative effect of offshoring related technical change
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53 takes place in a period when industrial employment and production are growing for
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55 Spain, so that we consider that firms are taking well oriented strategic decisions
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57 about where and how to produce, leading to a more competitive firms that survive
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59 and grow in an international context.
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2 The intra-industrial net offshoring, in column (4), with a negative coefficient,
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4 is not significant. We recall net intra-industrial offshoring is the measure we consider
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6 closer to the concept of substitution of domestic production for imported inputs. The
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8 fact that net intra-industrial offshoring does not appear to affect employment
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10 significantly might be explained by several reasons. First, there is a compensation
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12 effect within each sector between the providing domestic firms that reduce
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14 production and employment and the using firms that might increase their sales and
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16 employment due to the rise in competitiveness allowed by offshoring. This
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18 compensation effect among firms does not take place with the organizational change
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20 measure, as it assumes a net increase in inputs and not a substitution of domestic for
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22 imported inputs. Secondly, the labour market in Spain is relatively rigid. Institutions
23
24 and legal framework make dismissals difficult and encourage reassignments of
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26 employment to other tasks. Thirdly, and related to the previous point, offshoring
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28 moves industrial employment while it generates other services activities in the home
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30 country: sales, marketing, design, transport, trade, etc. Some of these tasks are
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32 included in the production of the industry where offshoring takes place. These two
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34 elements are common to both variables; net offshoring and global technical change,
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36 and therefore are not valid to justify the difference in the results.
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45 Finally, there are difficulties to compare our results to other studies results, since the
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47 offshoring measure has never been decomposed in previous literature. Those studies
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49 that have found an effect of offshoring on employment, as a negative one for total
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51 employment in Görg & Hanley (2005), may be catching the effect of other elements
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53 included in the offshoring measure, also among those studies that include a measure
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55 of technical change, a negative effect of both offshoring and technical change on
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57 unskilled labour for Hijzen *et al.* (2005) or Morrison-Paul and Siegel (2001), may be
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2 incurring in a double accounting problem, with implications on the robustness of the
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4 results.
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10 **6. CONCLUDING REMARKS**

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12 In this paper we have estimated the effects of offshoring on Spanish
13 employment for 28 manufacturing for the period 1993-2002. Most of the recent
14 literature focuses on foreign (or international) offshoring, as they consider that the
15 major reason for contracting out some activities is to benefit from lower wages in
16 other countries. In particular, some of those papers point to the substitution of low-
17 skilled labour for imported inputs from abroad, measured as offshoring. We directly
18 estimate the impact of offshoring on the level of manufacturing employment,
19 however, within the traditional offshoring measure, we distinguish the evolution of
20 the requirement of inputs per unit of output (how to produce) from the delocalisation
21 of production to others countries. We call global technical change to the first element
22 and net offshoring to the second. We further decompose net offshoring into two
23 factors: inter-industry substitution and net intra-industrial offshoring. This last factor
24 better quantifies the delocalisation of production to other countries looking for lower
25 costs, what has been considered by previous literature as the main reason behind
26 changes in the labour market
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49 When the evolution of our refined offshoring measure is considered, we
50 found that, on average, technical change implies an increase in the imported
51 intermediate inputs for the Spanish industry, and this is also the case, in a greater
52 extend, for the net offshoring measure. However, when net offshoring is included in
53 a dynamic labour demand function for Spanish manufacturing employment, we find
54 that it shows a negative but not significant impact on employment, while the effect of
55 technical change is negative and significant. When net offshoring is further splitted
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2 in its intra-industrial offshoring and inter-industrial substitution elements, none of
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4 them have significant effect on employment. So, our results show that it is technical
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6 change, instead of net offshoring, the main element behind changes in labour
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8 demand. We consider that this revealing result explains why the effect of the
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10 compressed offshoring measure, that includes net offshoring and technical change
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12 elements, remains dicey in previous empirical literature, with effects on labour
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14 market variables that seem to be dependant on other elements, as origin of goods,
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16 country specialization or sector technological contents. We consider that the missing
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18 element in this puzzle is the technological element required to implant offshoring as
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20 a firms' competitive strategy, which is separately included in our analysis.
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26 The traditional offshoring measure grows for all sectors in the analysed
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28 period for Spain, however it does so just by substitution of domestic by foreign
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30 inputs for low technology sectors, while the technical change element plays a more
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32 important role for medium and high technology sectors, probably leading to more
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34 competitive products and more efficient production processes. This is an interesting
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36 issue, since the found negative effect of the global technical change measure on
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38 employment is taking place in a period when manufacturing employment is growing
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40 in Spain, probably due to the fact that firms are gaining market shares because of
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42 their offshoring and technical change strategies, and, following Falk & Wolfmayer
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44 (2008), output performance and competitiveness in markets remain as the major
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46 determinants behind employment performance.
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For Peer Review

Table 1: Main results for different offshoring variables

Estimation	SYS-GMM					
	Dependent variable: employment L_t					
	(1)	(2)	(3)	(4)	(5)	(6)
n_{t-1}	0.8247 (11.0)***	0.8278 (11.7)***	0.8240 (10.8)***	0.8152 (9.90)***	0.8286 (12.0)***	0.8192 (12.7)***
y_t	0.1907 (2.46)**	0.1857 (2.43)**	0.1934 (2.46)**	0.2100 (2.48)**	0.1928 (2.51)**	0.1986 (2.98)***
w_t	-0.2163 (2.71)***	-0.2224 (2.84)***	-0.2130 (2.65)***	-0.2089 (-2.58)***	-0.2138 (2.92)***	-0.2170 (3.26)***
Offshoring $_t$	-0.1906 (1.31)					
Global tech. change $_t$		-0.5889 (1.80)*				-0.9708 (3.40)***
Net offshoring $_t$			-0.2459 (1.19)			
Net intra-ind offshor $_t$				-0.4611 (1.35)		-0.3070 (1.03)
Net inter-ind offshor $_t$					-0.0794 (0.321)	0.3795 (1.32)
Sargan test	0.024	0.019	0.039	0.239	0.052	0.058
$m(1)$	-3.546 (0.000)	-3.544 (0.000)	-3.549 (0.000)	-3.542 (0.000)	-3.576 (0.000)	-3.537 (0.000)
$m(2)$	-0.0598 (0.952)	0.0102 (0.992)	-0.0790 (0.937)	-0.0420 (0.967)	0.0073 (0.994)	0.0676 (0.946)

Notes:

1. Test shown are: p values for the null hypothesis of joint validity of the instruments for Sargan test of overidentified restrictions, and autocorrelation tests $m(1)$ and $m(2)$ (they are tests - with distribution $N(0,1)$ - on the serial correlation of residuals; p values in parentheses). The Sargan-test has a χ^2 distribution under the null hypothesis of validity of the instruments.

2. The GMM-SYS estimates shown are *one-step*, consistent with possible heteroscedasticity and more reliable than the *two-step* ones.

3. Asymptotic standard errors, asymptotically robust to heteroskedasticity, are reported in parentheses.

4. Data for 28 sectors and 10 years.

5. Year dummies are included in all specifications.

6. The equations are estimated using DPD for PcGive

7. The instruments used in column 1: $L_{i,t-2}$, $L_{i,t-3}$, $L_{i,t-4}$, $(Q-CI)_{i,t-2}$, $(Q-CI)_{i,t-3}$, $(Q-CI)_{i,t-4}$, $w_{i,t-1}$, $w_{i,t}$, $offshoring_{it}$, $\Delta L_{i,t-1}$ and $\Delta(Q-CI)_{i,t-1}$.

8. Instruments for column 2: same as in column 1 but $Global\ tech.\ change_{it}$ instead of $offshoring_{it}$.

9. Instruments for column 3: same as in column 1 but $Net\ offshoring_{it}$ instead of $offshoring_{it}$.

10. Instruments for column 4: same as in column 2 but $Net\ intra-ind\ offshoring_{it}$ instead of $Net\ offshoring_{it}$.

11. Instruments for column 5: same as in column 2 but $Net\ inter-ind\ offshoring_{it}$ instead of $Net\ intra-ind\ offshoring_{it}$.

12. Instruments for column 6: same as in column 2 and $Net\ intra-ind\ offshoring_{it}$ and $Net\ inter-ind\ offshoring_{it}$.

13. *** denotes the variable is significant at 1% level, ** significant at 5%, and * significant at 10%.

Variables:

- L: (log) total worked hours in each considered sector, thousands.
- VA (Q-CI): (log) net sales minus intermediate consumption (inputs) (€ thousands).
- GPH: (log) labour cost per worked hour (€).

Figures

Figure 1. Decomposition of Narrow offshoring in the industry (average).

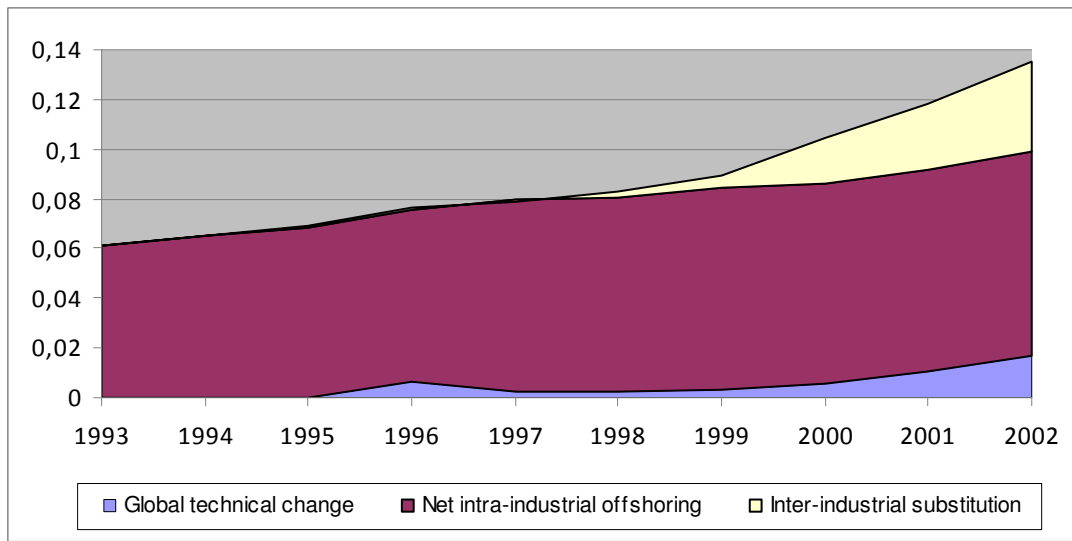


Figure 2. Decomposition of offshoring for industries with positive technical change, 2002.

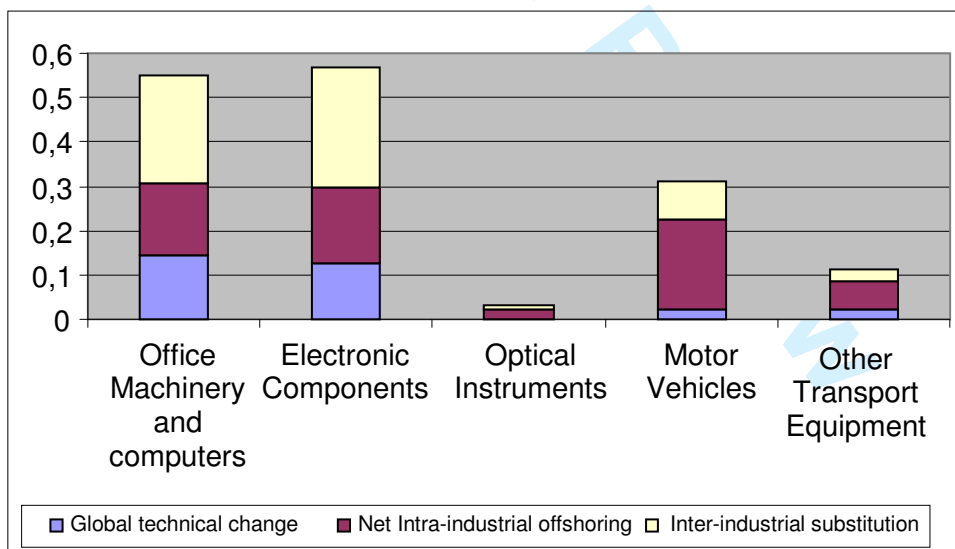


Figure 3. Decomposition of offshoring for industries with negative technical change, 2002.

