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## Inside and outside the factory: Just-in-time manufacturing systems, subcontracting and geographic proximity

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► **To cite this version:**

Adelheid Holl, Rafael Pardo, Ruth Rama. Inside and outside the factory: Just-in-time manufacturing systems, subcontracting and geographic proximity. *Regional Studies*, 2010, 44 (05), pp.519-533. 10.1080/00343400902821626 . hal-00596606

**HAL Id: hal-00596606**

**<https://hal.science/hal-00596606>**

Submitted on 28 May 2011

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**Inside and outside the factory: Just-in-time manufacturing systems, subcontracting and geographic proximity**

Journal:	<i>Regional Studies</i>
Manuscript ID:	CRES-2007-0393.R1
Manuscript Type:	Main Section
JEL codes:	L14 - Transactional Relationships Contracts and Reputation Networks < L1 - Market Structure, Firm Strategy, and Market Performance < L - Industrial Organization, L62 - Automobiles Other Transportation Equipment < L6 - Industry Studies: Manufacturing < L - Industrial Organization, L63 - Microelectronics Computers Communications Equipment < L6 - Industry Studies: Manufacturing < L - Industrial Organization, R39 - Other < R3 - Production Analysis and Firm Location < R - Urban, Rural, and Regional Economics
Keywords:	Just-in-Time, New manufacturing technology, Subcontracting, Geographic proximity, Agglomeration



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3 Just-in-Time manufacturing systems, subcontracting  
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6 and geographic proximity  
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Received December 2007, in revised form June 2008, accepted July 2008

Abstract: This article studies the spatial extent of subcontracting linkages for a sample of medium-sized and large Spanish manufacturing firms operating in the automotive and electronics industries. In particular, we analyse how Just-in-Time (JIT) organisation of production is related to the spatial pattern of these sourcing relationships when contractors' structural and organisational characteristics, as well as contract characteristics, are taken into account. We find that firms which implement new technologies and manufacturing systems at the plant level tend to prefer regional to extra-regional outsourcing. This is consistent with JIT's reliance on flexibility in ordering and quick and frequent deliveries, as well as reliable arrival times, to guarantee the disruption-free production which proximity can facilitate. Our results support the view that JIT, in the context of production subcontracting, increases the importance of proximity.

Keywords: Just-in-Time, new manufacturing technology, outsourcing, proximity, agglomeration

Adelheid Holl, Rafael Pardo and Ruth Rama 应时的制造业系统, 分包以及地域毗邻, 区域研究。本文研究了西班牙大中型汽车以及电讯业制造业公司样本中分包联系的空间拓展。我们特别分析了在将协议者的结构化特征、组织特征以及合同特征都纳入考虑范畴的情况下, 生产应时性组织 (Just-in-Time JIT) 是如何与这些源头 (分包) 联系的空间模式相对应的。我们发现, 实施了新技术与生产系统的公司倾向于选择区域分包而非区域外分包。这与 JIT 强调依靠订购、快速频繁派送以及送达时间上的灵活性来保障不间断的生产相一致。对于这种生产而言, 地域上的毗邻会有所帮助。我们的研究结果支持了这样的观点, 即在生产分包的背景下 JIT 提升了地域毗邻的重要性。

应时 新制造业技术 外部分包 毗邻性 聚合

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3 La production à flux tendus, la sous-traitance et la proximité géographique.  
4

5 Holl et al.  
6

7 Cet article cherche à étudier la portée géographique de la sous-traitance pour un échantillon d'entreprises  
8 moyennes et grandes espagnoles des secteurs automobile et électronique. En particulier, on analyse  
9 comment la production à flux tendus se rapporte à la distribution géographique des fournisseurs, compte  
10 tenu des caractéristiques structurelles et organisationnelles, ainsi que contractuelles. Il s'avère que les  
11 entreprises qui mettent en application les nouvelles technologies et les nouveaux procédés au niveau de  
12 l'établissement ont tendance à préférer la sous-traitance régionale à la sous-traitance externe. Cela  
13 correspond à la dépendance de la production à flux tendus de la flexibilité des commandes et des  
14 livraisons en temps utile, aussi bien que des délais de livraison sûrs, afin d'assurer la production continue  
15 que permet la flexibilité. Les résultats confirment que la production à flux tendus, dans le cadre de la  
16 production sous-traitée, augmente l'importance de la proximité.  
17

18 Production à flux tendus / Nouvelle technologie industrielle / Sous-traitance / Proximité / Agglomération  
19

## 20 21 **Just-in-Time Produktionssysteme, Auftragsweitervergabe und** 22 **geografische Nähe** 23

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25 In dieser Studie wird die Reichweite von Vernetzungen durch Auftragsweitervergabe, anhand einer  
26 Stichprobe von mittelgroßen und großen spanischen herstellenden Firmen in der Auto- und  
27 Elektronikindustrie, untersucht. Insbesondere untersuchen wir den Zusammenhang zwischen Just-in-Time  
28 (JIT) Produktionsorganisation und dem räumlich Verhalten dieser [Akquisition](#)beziehungen, wenn  
29 strukturelle und organisatorische Merkmale der Auftraggeber, sowie auch Vertragsmerkmale berücksichtigt  
30 werden. Die Ergebnisse zeigen, daß Firmen, die neue Technologien und Produktionssysteme auf  
31 Betriebsebene implementieren, eher zu regionalem als zu außer-regionalem Outsourcing neigen. Dies  
32 steht in Einklang mit JITs Notwendigkeit für Flexibilität bei Bestellungen, rascher und häufiger  
33 Lieferungen, wie auch zuverlässiger Ankunftszeiten, um eine von Unterbrechungen freie Produktion zu  
34 garantieren. Unsere Ergebnisse stützen die Ansicht, daß JIT im Zusammenhang der  
35 Auftragsweitervergabe die Bedeutung von Proximität steigert.  
36

37 Just-in-Time, neue Produktionstechnologien, Auftragsweitervergabe, Nähe,  
38 Agglomeration  
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40  
41 Sistemas de producción "just-in-time", subcontratación y proximidad geográfica  
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43 Este artículo estudia la dimensión espacial de las relaciones de subcontratación en una muestra de  
44 empresas industriales de tamaño mediano y grande que operan en las industrias españolas del automóvil y  
45 la electrónica. En particular, analizamos cómo la organización "just-in-time" (JIT) de la producción se  
46 relaciona con el patrón espacial de dichas relaciones de subcontratación cuando se tienen en cuenta las  
47 características estructurales y organizativas de los clientes (subcontratantes). Encontramos que las  
48 empresas que han adoptado nuevas tecnologías y sistemas de producción al nivel del establecimiento  
49 industrial tienden a preferir subcontratar regionalmente, más bien que extra-regionalmente. Este hallazgo  
50 es coherente con las necesidades de los sistemas "just-in-time" en términos de flexibilidades en los  
51 pedidos, rápidas y frecuentes entregas, así como fechas de llegada confiables que permitan garantizar un  
52 sistema de producción libre de interrupciones facilitado por la proximidad. Nuestros resultados apoyan el  
53 punto de vista de que, en el contexto de la subcontratación productiva, JIT incrementa la importancia de  
54 la proximidad.  
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57 Just-in-Time, nueva tecnología de fabricación, subcontratación,  
58 proximidad, aglomeración.  
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JEL Classification: L14, L62, L63, R3

## 1. INTRODUCTION

The last twenty years have produced important changes in the organisation of production, namely a move towards interconnected production based on Just-in-Time (JIT) techniques and the outsourcing of non-core activities.<sup>1</sup> These are two key strategies for achieving flexible and lean production, essential for company competitiveness in a rapidly changing and increasingly global economy.

An important question is how such increased flexibility in production relates to the spatial organisation of inter-firm relations. Some authors argue that JIT and subcontracting strategies produce fundamental changes in the relationship between production organisation and space, often linked to the increased importance of proximity. While subcontracting may be facilitated by geographical proximity, the literature on international outsourcing also shows that subcontracting relations can be maintained over long distances. JIT may, however, reinforce the need for proximity, as it relies on quick and frequent deliveries and closer relationships and communication among firms. For JIT to be effective, flexibility in ordering and reliability of arrival times are crucial (Allen et al., 1994), and these may heighten the importance of geographical proximity. Thus, JIT might constitute an additional agglomerative force (Gale, 1999; Harrigan and Venables, 2006).

Empirical evidence regarding the spatial implications of JIT is, however, limited and inconclusive. Various authors hold that JIT has indeed encouraged the shortening of input linkages and placed greater emphasis upon geographical proximity (Reid, 1994; McCann and Fingleton, 1996).<sup>2</sup> Plant location studies

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3 also provide evidence for the importance of highway access in ensuring  
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6 punctual delivery on a just-in-time basis (Smith and Florida, 1994). Klier (1999;  
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9 2000), drawing on the U.S. auto supplier industry, argues that agglomeration  
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11 takes place principally at the regional level, and that access to transportation  
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13 which allows deliveries “within a day's drive” is more important than close  
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15 proximity between suppliers and assembly plants. Sadler (1994) and Echeverri-  
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17 Carroll (1996) argue, with regard to the European automotive industry, that JIT  
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19 does not necessarily lead to agglomeration.  
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23 With decreasing transport costs, advanced communication and the increasing  
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25 importance of non-material flows, analysts have cast doubt on the importance of  
26  
27 physical distance as a barrier to inter-company relations. However, even if  
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29 pecuniary costs for goods transport are assumed to be low, the increasing  
30  
31 importance of the cost of time, of flexibility in the ordering of inputs and of the  
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33 reliability of scheduled transport flows (Hummels, 2001; Harrigan and Venables,  
34  
35 2006) must nevertheless be taken into account.  
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39 The literature regarding the relationship between geographical proximity and JIT  
40  
41 is principally based on case studies in the automotive industry, in which many  
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43 first-tier suppliers and subcontractors undertake JIT deliveries (Sadler, 1994;  
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45 Frigant and Lung, 2002; Larsson, 2002). Today, JIT is also being increasingly  
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47 adopted in other sectors (Gale, 1999) e.g. the electronics industry (MC Cann  
48  
49 and Fingleton 1996, Gallander & Larsson, 2000). A different strand of literature  
50  
51 has examined the spatial pattern of inter-firm relations in a more general context  
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53 (Clarke, 1994; Hendry, 2000; Britton, 2003; Holl and Rama, 2009), but has not  
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55 considered the specific role of JIT.  
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3 This article contributes to research into the spatial dimension of inter-firm  
4 linkages by focusing specifically on the effect of Just-in-Time manufacturing  
5 systems (hereafter, JIT manufacturing) upon the spatial pattern of  
6 subcontracting relations. JIT manufacturing is a flexible system of production  
7 aimed at reducing lead time and excessive work in progress inventories at the  
8 plant level, while helping to improve productivity and product quality. It often  
9 involves the use of new technology, such as computer integrated  
10 manufacturing, cellular layouts and advanced information systems. This new  
11 technology is also frequently associated with the implementation of innovative  
12 management practices, such as JIT sourcing.  
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27 The present article analyses detailed survey data for a sample of Spanish  
28 electronics and automotive producers, in order to determine whether  
29 contractors using new technology and organisation display the same  
30 geographical patterns as contractors who employ a more traditional approach to  
31 manufacturing. We argue that the implementation of a new organisation of  
32 production within factories encourages firms to develop geographically closer  
33 external relationships.  
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44 Focusing specifically on JIT manufacturing and subcontracting permits the  
45 identification of those characteristics of manufacturing technology which may  
46 make partner proximity more important. This approach helps to explain why the  
47 agglomeration of industry, and in particular of high technology sectors, is a  
48 continuing phenomenon, despite important reductions in transport and  
49 communication costs.  
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59 Below, Section 2 discusses the role of proximity in the organisation of  
60 production. Section 3 describes our data. Section 4 presents the model and



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3 discusses the determinants of the geographical extent of subcontracting  
4 linkages. Section 5 offers our empirical results and a discussion and Section 6  
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6 is dedicated to our conclusions.  
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## 10 11 12 13 14 2. SPACE IN THE ORGANISATION OF PRODUCTION. THE ROLE OF 15 16 PROXIMITY 17

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19 There exists no general theory of the spatial dimension of inter-firm linkages  
20 (and of subcontracting relations in particular). However, spatial economic  
21 analysis, focusing on the determinants of the location of economic activity  
22 across space, is a long-standing research field. Costs and interdependence  
23 between firms have been accepted as the principal factors explaining the role of  
24 proximity in company location. A further branch of the literature has analysed  
25 why companies engage in inter-firm relations instead of vertically integrated  
26 production. Transaction Cost Theory (TCT) concentrates on the trade-off of the  
27 costs and benefits associated with different forms of governance: markets,  
28 hierarchies (firms) and hybrids (e.g. subcontracting networks) (Williamson,  
29 1991). Inter-firm relations involve costs of establishing and maintaining an  
30 external relationship (Williamson 1985). This involves search and information  
31 costs, bargaining and decision costs, and monitoring and enforcement costs  
32 (Grossman and Hart 1986). Williamson (1985) also refers to the costs involved  
33 in product flows, such as transport costs and those of product losses and  
34 damages. Transaction costs increase when these transactions are frequent  
35 (David and Han, 2004), as in the case of JIT systems. Though distance and  
36 location are constants in earlier TCT abstract models (Williamson, 1991), recent  
37 work by Harrigan and Venables (2006) and Feenstra and Spence (2006),  
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3 among others, shows that these costs are presumably more of a deterrent in  
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5 long-distance relations.  
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9 Today, although transport costs may represent a relatively small percentage of  
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11 total costs for most firms, other logistic costs may still be substantial (McCann,  
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13 2001). In the inventory model proposed by McCann (1993), optimum firm  
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15 location depends on the balancing of inventory holding costs, procurement  
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17 costs and transport costs. JIT implies more frequent deliveries. At the optimized  
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19 Economic Order Quantities (EOQ), this increases transport costs and  
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21 encourages localization (McCann 1993, 1998).  
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26 Focusing specifically on the implications of JIT for agglomerations, Harrigan and  
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28 Venables (2006) show, in a theoretical model, how the need for timeliness in  
29  
30 delivery encourages clustering. Proximity between supplier and customer is  
31  
32 important to provide flexibility and to reduce demand uncertainty. Harrigan and  
33  
34 Venables study two types of uncertainty. Firstly, there is greater uncertainty  
35  
36 regarding delivery times for components from remote suppliers. This implies a  
37  
38 greater risk of costly production delays caused by late arrival, while localised  
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40 sourcing benefits from timeliness. Secondly, decisions regarding inputs from  
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42 remote sources have to be taken earlier and thus involve greater uncertainty  
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44 regarding the level of demand or cost. By contrast, decisions concerning locally  
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46 produced inputs can be taken at later stages, once a greater degree of  
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48 uncertainty has been resolved. In both cases, uncertainty encourages the  
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50 clustering of component producers. Producers in the clusters benefit from  
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52 flexibility in ordering, which leads to higher productivity compared to producers  
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54 in other locations, who do not enjoy the benefits of timeliness in delivery from  
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56 local sourcing. Harrigan and Venables (2006) argue that proximity is a  
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3 quantitative dimension of the cost of exchange and interaction, but is also an  
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5 important qualitative aspect of reducing uncertainty.<sup>3</sup>  
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9 Proximity not only reduces distance costs and permits greater flexibility, since  
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11 inputs can be more easily obtained in smaller quantities or on an as-needed  
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13 basis, but also facilitates close contacts between clients (contractors) and  
14  
15 suppliers (subcontractors) in collaborative arrangements which require frequent  
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17 face-to-face contact.  
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20 A further theory may help to explain geographic distance through the  
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22 interdependence of firms. In management literature, network theory stresses  
23  
24 that inter-firm relations will be affected by cost-minimising concerns as well as  
25  
26 by power (see, for example, Sacchetti and Sudgen, 2003). This approach  
27  
28 focuses on the uneven distribution of resources, information and control within  
29  
30 inter-firm relations and the consequent unequal abilities of actors within  
31  
32 networks to dominate the behaviour of others. Firms with more exchange  
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34 alternatives and greater resources enjoy a better negotiating position (Lee,  
35  
36 2002). Powerful firms are better equipped to impose their own distributive rules  
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38 not only within the network, but probably upon even extra-regional partners.  
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40 However, the distribution of power within networks may change, depending on  
41  
42 the duration of relations. Grandori and Neri (1999) and Sacchetti and Sudgen  
43  
44 (2003) believe repeated and long-lasting relations are a necessary condition for  
45  
46 the adoption of "fairness rules" and the basis of mutual relationships in which  
47  
48 power becomes evenly distributed amongst network partners; they argue that  
49  
50 such mutual relationships create "proximity".<sup>4</sup>  
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59 Despite these theoretical developments, few empirical studies have specifically  
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analysed the spatial extent of inter-firm relations. Hendry et al. (2000), Britton

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3 (2003) and Rosenthal and Strange (2001) suggest that material linkage patterns  
4 are not necessarily local, but rather span over wider geographical areas. Clarke  
5 (1994) and more recently, Holl and Rama (2009) show that there is a clear  
6 geographical dimension to different inter-firm linkages and, more specifically, to  
7 different forms of governance. Network linkages are in general shorter than  
8 arm's-length<sup>5</sup> input-output transactions, suggesting that proximity is more  
9 important for networking than for arm's-length relations that primarily involve  
10 standardised products and formal relations. This is consistent with the fact that  
11 network agreements imply deeper, steadier, and more informal relationships.  
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13 Holl and Rama (2009) also show that, from among the different types of  
14 network relations, subcontracting relations are the most localised type of  
15 cooperation.

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The growing complexity of industrial organisation is likely to make the role of proximity more complicated; improved knowledge of the particular circumstances in which proximity matters is therefore of increasing importance.

### 3. DATA

The data employed in the following analysis were obtained from a company-level survey targeting firms in the electronics and automotive industries and conducted in 2003<sup>6</sup>. All the companies had 50 or more employees. Their main activities were the manufacturing of: 1) electronics, TV and radio equipment, 2) electronics components, 3) office machines and informatics equipment, 4) motor vehicles and carriage building, and 5) other transport equipment, such as motorcycles.

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3 In order to establish the dimension of the population of plants in terms of sector,  
4 region and size, we used the information provided by the Directorio Central de  
5 Empresas (*Central Directory of Companies* - DIRCE) from the National Institute  
6 of Statistics. To select the sample, the regional and sectoral distribution of  
7 plants indicated by DIRCE was taken into account. Here, regions are the 17  
8 Spanish Autonomous Communities. Sectors were defined according to the  
9 CENAE classification (National Classification of Economic Activities). We  
10 selected companies for analysis from the Dun & Bradstreet Spain list. The  
11 response rate was 71.2%. Given their size, sector and geographic location, the  
12 sampled firms are statistically representative of firms with over 50 employees in  
13 the above mentioned Spanish industries. For a confidence level of 95.5%, the  
14 sampling error is  $\pm 6.9\%$ .

15  
16 A pre-test of the questionnaire was conducted and all the principal problems  
17 encountered (e.g. poor understanding of some questions) were addressed  
18 before the fieldwork was commenced. At the company level, in most cases we  
19 interviewed Directors of Production, each personal interview lasting  
20 approximately one hour. The survey does not suffer from significant item non-  
21 response. Some of the questions follow an ordinal 1-5 Likert scale, indicating  
22 the interviewee's assessment (Appendix 2). In contrast to variables which  
23 capture objective and quantitative information, it is well known that subjective  
24 evaluations may contain a greater degree of error. On the other hand, such  
25 variables are sufficiently robust and allow valuable dimensions of a factor, which  
26 would otherwise remain concealed, to be captured. Moreover, assessments and  
27 evaluations are a basic facet of organisational life.

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3 The total sample includes 162 companies, of which 24.7% operate in the  
4 electronics industry, 65.4% in the automotive field and 3.7% in the "other  
5 transport equipment" sector. The sample also includes 10 firms (6.2%) which  
6 supply part of their output to these industries but are classified under other  
7 headings (e.g. rubber and plastics or machinery and mechanical equipment).  
8 Firms in the automotive and electronics industries and in auxiliary industries  
9 were asked to rate, using a 1-5 Likert scale, the importance of 32 different  
10 economic activities (e.g. the manufacture of electronics components). We  
11 identified a group of firms involved in the manufacture of automotive and  
12 electronics products, even if this was not their principal activity. A company  
13 which indicates "machinery and mechanical equipment" as its main activity, for  
14 instance, may also produce parts and components used in motorcycle  
15 manufacture. In other words, part of its production may consist of "other  
16 transport equipment". Our sample includes affiliates of companies such as  
17 Siemens and Samsung in the electronics industry and Volkswagen, Renault  
18 and Daimler-Chrysler in the automotive industry.  
19  
20 The sample includes vertically integrated firms and firms participating in  
21 outsourcing networks as contractors (clients), subcontractors (suppliers) or  
22 both. We use this sample of 162 companies to determine the diffusion of JIT  
23 and subcontracting in the industries selected and the general relationship  
24 between the two. As stated in the Introduction, however, our more specific  
25 intention is to establish whether contractors using new technology and  
26 organisation display the same geographic patterns as contractors who employ a  
27 more traditional approach to manufacturing. Thus, in section 5 we focus on the  
28 sub-sample of firms which subcontract part of their production activities.  
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### Sectors analysed

After Germany and France, Spain is the third largest European producer of automobiles<sup>7</sup>. Approximately 82% of Spanish vehicle production is exported. The largest assemblers are well represented in most Spanish regions: for example, Peugeot and Citroën in Galicia; Nissan, Seat, etc. in Catalonia; Ford in Valencia; Daimler Chrysler in the Basque Country; and Renault and others in Andalucía. The electronics industry is also important in Spain. For instance, the Spanish ICT (Information and Communication Technology) industry (including services) amounts to around €70 billion, nearly 10% of Spanish GDP. Electronics manufacturing firms tend to cluster mainly in Madrid, Catalonia and the Basque Country (which together account for nearly 85% of total production), although other regions, such as Andalusia, Valencia and Aragon are also producer regions.

### Subcontracting and JIT

#### Definition of JIT

The JIT system involves developing both JIT manufacturing and JIT delivery capabilities (Echeverri-Carroll, 1996). In our empirical analysis we specifically concentrate on JIT manufacturing, as our objective is to study the potential association between the use of new organisational forms for manufacturing and the production of technologies and the importance of geographic inter-establishment proximity in subcontracting relations.<sup>8</sup> The JIT *delivery* system means that small and precise deliveries must be made by suppliers exactly when needed by the assembler plant. The JIT *manufacturing* system “originally referred to the production of goods to meet the customer demand exactly, in

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3 time, quality and quantity” and now means producing with minimum waste of  
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5 time and resources.<sup>9</sup> Inside the factory, the implementation of JIT  
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7 manufacturing includes new practices such as improved quality control,  
8  
9 preventive maintenance, the avoidance of mistakes, eliminating waiting time  
10  
11 wastage due to product defects, greater cleanliness and more efficient  
12  
13 organisation, a multi-skilled workforce, ensuring a smooth flow of products  
14  
15 through the factory, etc.. For instance, timewasting may consist of workers  
16  
17 remaining idle, which is not uncommon in a sequential line production process.  
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19 To solve this problem, factories which implement JIT manufacturing can, among  
20  
21 other solutions: smooth the flow of products through the plant; reduce set-up  
22  
23 time; train their employees to use alternative machines, etc...  
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### 33 Subcontracting and JIT in our sample

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35 Table A1 provides information for both the total sample of 162 companies and  
36  
37 the sub-sample of 130 companies that subcontract. Subcontracting and JIT  
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39 manufacturing are common strategies among the sample firms. From among all  
40  
41 the sampled firms, approximately 80% subcontract and 58% report that they  
42  
43 use JIT manufacturing. 61.8% of the plants in the total sample also report JIT  
44  
45 sourcing and approximately 75% report the use of JIT for at least half of  
46  
47 deliveries to their customers. Although few firms use JIT in all their sourcing and  
48  
49 deliveries, the companies studied are linked quite closely by JIT relationships.  
50  
51 In fact, only 16 firms (9.9%) in our total sample make no use whatsoever of  
52  
53 JIT.<sup>10</sup> While electronics firms are more likely to subcontract, JIT manufacturing  
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55 is more common in the automotive industry. Nevertheless, almost half of the  
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57 electronics companies are also JIT manufacturers.  
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3 In their analysis of the Los Angeles Basin, Suarez-Villa and Walrod (1997) find  
4 that 54% of the electronics producers utilised JIT production methods as early  
5 as the mid-1990s. Comparison with our results suggests that Spanish  
6 electronics producers adopted such methods relatively late. By contrast,  
7 outsourcing of production is far more common in our sample of electronics firms  
8 than in that of Suarez-Villa and Walrod (58%). Since the implementation of JIT  
9 usually entails both risks and substantial investment, many Spanish electronics  
10 producers may have preferred to fully exploit a cooperation strategy to achieve  
11 flexibility, benefiting from an enduring “network culture” in their sector (Estevan,  
12 1988; Suarez-Villa and Rama, 1996). We shall return to companies’ search for  
13 flexibility below.  
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#### 32 4. SELECTION OF THE MODEL AND VARIABLES

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34 We analyse whether companies that subcontract regionally display specific  
35 characteristics, notably the adoption of JIT manufacturing. We estimate the  
36 probability that a firm’s main subcontractors are exclusively located within its  
37 same region. The regional dimension of subcontracting patterns is important for  
38 policymakers. Regions in Spain enjoy a high degree of self-determination and  
39 fiscal autonomy and develop their own territorial programmes (Suarez-Villa and  
40 Cuadrado Roura, 1993).  
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50 We represent intra-regional subcontracting  $y_i$  by firm  $i = 1, 2$ , etc. by a binary  
51 choice model:  
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$$55 y_i = \begin{cases} 1 & \text{if } y_i^* \geq 0 \\ 0 & \text{otherwise} \end{cases} \quad (1)$$

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3 where the latent variable  $y_i^*$ , which represents firm  $i$ 's underlying propensity to  
4 subcontract within the region in which it is located is a linear function of  
5  
6 observable firm-specific characteristics  $c_i$ , characteristics of the production  
7  
8 process  $p_i$ , and characteristics of the specific subcontracting relation  $r_i$ .  
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$$y_i^* = c_i\beta_1 + p_i\beta_2 + r_i\beta_3 + v_i \quad (2)$$

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20 The term  $v_i$  captures the effects of unobserved factors and is assumed to be  
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22 i.i.d. normal. Since we focus on the spatial extent of subcontracting, estimations  
23  
24 are based on a sub-sample of 128 firms which subcontract out part of their  
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26 production and provide information regarding the location of their main  
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28 subcontractors.<sup>11</sup>  
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### 35 Independent variables

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38 We include in our model variables which the existing empirical and theoretical  
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40 literature has related to the spatial extent of outsourcing linkages. These can be  
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42 grouped into three sets of independent variables (see Appendix A2 for a  
43  
44 description). The variables concern, respectively: company characteristics, the  
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46 characteristics of its organisation of production and relation-specific  
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48 characteristics.  
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53 Firstly, the literature shows that specific company characteristics may affect  
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55 firms' spatial behaviour. On the one hand, the costs involved in setting up  
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57 distant network relations will be less onerous for certain firms and, on the other,  
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59 access to specific resources can lower transaction costs and increase firms'  
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3 ability to enforce contracts, particularly in the case of extra-regional relations.  
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5 Such resources include financial and human capital, information, knowledge  
6  
7 and other intangibles.  
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11 Size: Costs related to establishing, monitoring, and enforcing network  
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13 relationships over longer distances should be less of an impediment for larger  
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15 firms. Larger firms are likely to have the necessary human and physical capital  
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17 and market power necessary to gain information and enforce contracts over  
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19 distance. Conversely, some empirical studies show that smaller companies  
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21 have more limited geographical range, and thus are more deeply embedded in  
22  
23 the regional economy, than large companies (Gray et al. 1996; Suarez-Villa and  
24  
25 Rama, 1996). Here, we test whether smaller firms are more prone to outsource  
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27 production regionally.  
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33 Foreign ownership and single plant status: Arita and McCann (2002) argue that  
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35 organisational structure influences the spatial behaviour of firms. The spatial  
36  
37 linkage pattern of businesses which form part of multi-plant companies may be  
38  
39 dictated by corporate structure. Such establishments are more likely to be  
40  
41 integrated in a wider network, and are correspondingly more likely to engage in  
42  
43 spatially broader inter-firm relations than single-plant companies (Holl and  
44  
45 Rama, 2009). Similarly, foreign ownership may influence company  
46  
47 management style and consequently affect spatial linkage patterns. Here, we  
48  
49 test whether the likelihood of outsourcing intra-regionally is associated with  
50  
51 specific types of company organisation.  
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57 Product innovation: The literature demonstrates that when high-tech sector  
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59 firms search for new technology, they may cooperate with both co-located  
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companies and with extra-regional firms, On the one hand, the search for

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3 knowledge externalities may stimulate firms to co-locate. Empirical studies have  
4  
5 shown that, in R&D-intensive industries where knowledge spillovers are  
6  
7 substantial, the location of production tends to be geographically concentrated  
8  
9 (Audretsch and Feldman, 1996). An analysis of the Spanish industry finds that  
10  
11 electronics plants, for instance, tend to locate near their customers and  
12  
13 suppliers (Alonso-Villar et al., 2004). This supports the idea that contractors  
14  
15 outsource manufacturing locally in order to benefit from spillovers generated at  
16  
17 the local level. On the other hand, companies in high-tech sectors require an  
18  
19 increasingly wide range of technologies to manufacture their products, which  
20  
21 may force them to use extra-regional suppliers to satisfy at least part of their  
22  
23 innovation requirements (Dyer and Singh 1998, Brusoni et al. 2001). A different  
24  
25 issue is whether, within a high-tech sector, the most R&D-intensive companies  
26  
27 are actually willing to network with co-located firms. Innovative companies may  
28  
29 prefer a degree of physical isolation from other clustered companies, so as to  
30  
31 avoid the unintended spillover of new knowledge (Kearns and Görg, 2002;  
32  
33 Nachum and Wymbs, 2002; Suarez-Villa, 2002). Ahuja (2000) also  
34  
35 demonstrates that innovators may even be reluctant to network with other firms,  
36  
37 although he does not explore the spatial dimension of company behaviour.  
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39 Here, we test whether companies which generate internal or external product  
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41 innovations are more likely to outsource intra-regionally (for definitions, see  
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43 Appendix A2).  
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53 Second, the literature emphasises that in addition to companies' structural  
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55 characteristics, the way they organise their production may also be linked to the  
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57 spatial extent of inter-firm relations. We specifically focus on how JIT  
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3 manufacturing affects the spatial pattern of subcontracting relations, but also  
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5 control for a number of other production-specific characteristics.  
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9 JIT: JIT manufacturing potentially favours local outsourcing, due to the need for  
10 flexibility and for fast, frequent and reliable deliveries and communication, in  
11 order to keep component delivery scheduling tight (Allen et al. 1994). As  
12  
13 Harrigan and Venables (2006) show, proximity is important to facilitate flexibility  
14 and reduce uncertainty in input ordering in timeliness production e.g. JIT. There  
15 are further reasons why JIT encourages, at least in theory, proximity between  
16 clients and suppliers. Car assemblers using JIT may prefer proximity if they feel  
17 that it simplifies social relations and facilitates control, and because willingness  
18 to locate in the vicinity of the assembly plant represents a sign of commitment  
19 on the part of the supplier (Larsson, 2002); the location of several suppliers  
20 near the assembly plant might increase the contractor's bargaining power with  
21 respect to the rest of the network (Aláez-Aller and Erro-Garcés, 2006).  
22 Furthermore, as argued by Echeverri-Carroll (1996), JIT is not merely a delivery  
23 programme. The ability to produce components which conform to the  
24 specifications requested by the client requires the close coordination of  
25 manufacturing processes, implying the continuous sharing of information  
26 between client and supplier.  
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49 Although the literature on this issue is almost non-existent, there exists some  
50 evidence to suggest that the implementation of JIT may heighten the  
51 importance of proximity in subcontracting relations. Clarke and Mia (1993) find  
52 that, in some Australian industries, geographic proximity of customers and  
53 suppliers and a low level of vertical integration of the company, which denote a  
54 prevalence of outsourcing, are good predictors of the successful implementation  
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3 of JIT manufacturing at the plant level. Analysing two large companies  
4 operating, respectively, in the Swedish automobile and electronics industries,  
5 Gallander and Larsson (2000) argue that “outsourcing may and may not have  
6 location implications“ (p.2). Focusing on JIT deliveries (rather than on JIT  
7 manufacturing, as in this article), they conclude that sequential JIT with short  
8 lead times is the most important location factor explaining local outsourcing.  
9 Here, we test whether firms which implement new technologies and  
10 manufacturing systems, such as JIT, are more likely to outsource intra-  
11 regionally than those using more traditional manufacturing systems.  
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25 Small batch production: JIT is a key characteristic of flexible production  
26 strategies. Flexible production organisation is also often associated with low-  
27 volume and customised production (D'Costa, 2004). Small batch size involves  
28 the shortening of production cycles, the reduction of finished goods inventories  
29 (Milgrom and Roberts, 1990), the production of smaller quantities and more  
30 customer-specific manufacture. As with JIT, small batch production tends to  
31 entail greater buyer-supplier cooperation and, according to some empirical  
32 evidence, the increased importance of suppliers' geographic proximity (D'Costa,  
33 2004). Here, we test whether companies which define their type of production  
34 as small batch production are more likely to outsource intra-regionally.  
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49 CAD/CAM: JIT manufacturing can be implemented using either computer-aided  
50 design/computer-aided manufacturing (CAD/CAM) or traditional machinery.  
51 Here, we test whether the employment of CAD/CAM may increase the  
52 importance of proximity between the implementing plant and its suppliers.  
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59 Third, the particular characteristics of the subcontracting relation may also be  
60 linked to its spatial pattern.

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3 Subcontracting stage: The precise nature of the activity involved in the  
4 subcontracting relation may determine the relative importance of proximity.  
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6 Depending on the production stage at which subcontracting takes place, the  
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8 relation may involve either more face-to-face contact or an increased exchange  
9  
10 of parts and components. If the need for face-to-face contact is great, proximity  
11  
12 may become more important, but the exchange of bulky and submodular parts  
13  
14 that involve high transport costs may also favour the proximity of supplier and  
15  
16 client (Lee, 2002). Moreover, suppliers probably locate closer to their clients  
17  
18 when they provide parts and components rather than finished products, as the  
19  
20 former generally require more frequent delivery.<sup>12</sup> It is common for system  
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22 suppliers delivering finished products to form part of large domestic groups or  
23  
24 multinational enterprises which supply car assemblers in a number of locations.  
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26 Here, we test the relationships between the likelihood of outsourcing intra-  
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28 regionally and four different stages of the production process at which  
29  
30 subcontracting takes place (see Appendix A2). These stages also reflect the  
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32 type of goods or services outsourced.  
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41 Stable subcontracting relations: Johanson and Mattson (1992) argue that the  
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43 stability and duration of exchange relationships is especially important where  
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45 the actors must adapt their heterogeneous resources to each other and the  
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47 relationship becomes highly specialised. Stability generates trust (Sturgeon,  
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49 2003), and in turn trust reduces the risk of opportunism and thereby lowers  
50  
51 transaction costs (Ring, 1999). The literature on the automotive industry in the  
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53 US, Japan and some European countries shows that most of the contracts  
54  
55 between assemblers and their suppliers are relatively long lasting (Aláez-Aller  
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57 and Erro-Garcés, 2006; Baudry, 1993; Torreguitart-Mirada and Martínez-Parra,  
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3 2000); according to Chanaron (1998), the new post-Fordist system of  
4 production means that assemblers select suppliers on the basis of their past  
5 relationship and proven performance record (rather than on the basis of  
6 tenders). Hoare (1985) argues that if inter-firm relations are stable, they can be  
7 planned more easily, and thus proximity is less important. However, in *ad hoc*  
8 relationships and, more generally, in relations that must be renegotiated  
9 periodically, the subcontracting partners may have a greater need for proximity.  
10 In particular, short-term contracts involve frequent renegotiations of price and  
11 new rounds of competition among suppliers (Baudry, 1993), which may  
12 encourage them to cluster around the assemblers in order to obtain updated  
13 information. We test whether companies are more likely to outsource intra-  
14 regionally when the duration of contracts is relatively short.

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32 Responsibility: Where the subcontracting client and supplier have adopted a  
33 policy of close involvement, including, for example, information sharing, quality  
34 control or design participation, the relationship is more likely to require higher  
35 levels of interaction through substantial face-to-face contact, making proximity  
36 more important. Conversely, subcontracting suppliers with full responsibility for  
37 the production of parts or modular parts tend to require less supervision, and  
38 thus proximity may become less important. We test whether the likelihood of  
39 outsourcing regionally is greater when the company's subcontracting suppliers  
40 assume full responsibility for the manufacture of the entire final product (as  
41 opposed to parts or components).

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56 Flexibility motive: This variable considers the client (contractor) motivation to  
57 outsource production. Certain characteristics of clients' organisation of  
58 production (e.g. flexible production) are taken by the literature to constitute a  
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3 new form of manufacturing which is replacing Fordist factories (Milgrom and  
4  
5 Roberts, 1990). This search for flexibility is a general strategy, aimed principally  
6  
7 at speeding up company operations (Milgrom and Roberts, 1990). Thus, while  
8  
9 firms' principal motive for subcontracting is the need for greater flexibility,  
10  
11 proximity may also become increasingly desirable. Therefore, we test whether  
12  
13 the likelihood of outsourcing intra-regionally is greater when the company is  
14  
15 highly motivated by the search for flexibility.  
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19 Finally, the model also includes dummy variables to check for differences  
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21 between sectors.  
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## 28 5. EMPIRICAL RESULTS

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30 As Table 1 shows, there is an important regional dimension to subcontracting  
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32 linkages. The pattern is very similar to that reported in López (2001), Rama et  
33  
34 al. (2003) and Holl and Rama (2009) for subcontracting among electronic firms  
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36 in Spain, and confirms that important intra-regional linkages exist. Table 2  
37  
38 shows a strong relation between local subcontracting and JIT manufacturing.  
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43 Table 3 presents the results of the multivariate probit analysis, and a number of  
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45 interesting findings emerge. Firstly, JIT manufacturing has a significant positive  
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47 influence on the probability of subcontracting locally. Secondly, with regard to  
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49 company characteristics other than JIT manufacturing, the coefficients are  
50  
51 weak, in line with McCann and Fingleton (1996). In a study of the Scottish  
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53 electronics industry, these authors found JIT sourcing to be the single most  
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55 important factor influencing firms' propensity towards local expenditure. In our  
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57 analysis, only the dummy variable for companies which introduced product  
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3 innovation in collaboration with external innovators (firms or institutions) is  
4 significant in Column 1, indicating that such firms are more likely to subcontract  
5 to suppliers outside their own region. A possible explanation is as follows:  
6 technological networking with extra-regional partners, often a necessity for firms  
7 in high-tech industries (Dyer and Singh 1998, Brusoni et al. 2001), may provide  
8 such companies with useful information on the “market” for possible outsourcing  
9 partners in distant localities.<sup>13</sup> This may increase the willingness and ability of  
10 companies to outsource production extra-regionally. In our sample, the  
11 coefficient for innovators who produce and develop their new products in-house  
12 is also negative, although not statistically significant. The relatively low pseudo-  
13  $R^2$  indicates that other factors are also likely to be influential.

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30 In Columns 2 and 3 we include two further characteristics of plants’ production  
31 processes: small batch production and CAD/CAM. While the former is not  
32 significant, CAD/CAM is significantly associated with local subcontracting. In  
33 line with David and Han (2004), a possible explanation is that the utilisation of  
34 these new technologies may increase contractors’ transaction costs; contractors  
35 who have adopted them may attempt to reduce these costs by outsourcing  
36 exclusively within their own region. This hypothesis, however, deserves a more  
37 detailed analysis than that offered by the present article; the data available does  
38 not permit the TC costs of contractors who use CAD/CAM to be compared to  
39 those of contractors who use more traditional technologies.

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54 In Column 4 of Table 3 we introduce additional variables to control for the stage  
55 at which subcontracting takes place. Stage1 (subcontracting of parts and  
56 modular components) increases the probability of local subcontracting, while  
57 Stage3 (subcontracting of final production) reduces this probability, compared to  
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3 the control stage of subcontracting services to be integrated in the final product.  
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5 This confirms that the subcontracting of parts and components manufacture has  
6  
7 a greater local dimension. By contrast, if the subcontracted activity is located at  
8  
9 the end of the production process, the subcontractor could be located closer to  
10  
11 the final customer (to whom the product must be delivered) than to the  
12  
13 subcontracting client i.e. proximity to the principal client is less important. Since  
14  
15 these variables indirectly control for the characteristics of different types of  
16  
17 suppliers, it is also possible that the suppliers of high-tech, non- standardised  
18  
19 goods (e.g. final products) of our sample are limited in number and manufacture  
20  
21 their products in only a few locations, as the suppliers analysed by Arita and  
22  
23 McCann (2004). These qualitative aspects of local sourcing were also detected  
24  
25 in the study of the Brazilian automotive industry performed by Frigant and Lung  
26  
27 (2002). Column 5 includes a dummy variable for subcontracting relations lasting  
28  
29 over two years. As expected, we find that when relations are stable they can be  
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31 more easily organised, even over longer distances. Column 6 includes as an  
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33 additional control variable a dummy that indicates whether the subcontractor  
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35 assumes complete responsibility for the subcontracted activity. Full  
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37 responsibility is also significantly associated, in our sample, with a lower  
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39 probability of local subcontracting. Suppliers who accept entire responsibility  
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41 need less supervision, and are probably less involved in local subcontracting  
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43 relations, thereby making proximity less important. As in the case of the stages  
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45 of subcontracting, the introduction of this new variable in the model may also  
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47 suggest that local suppliers have lower skill levels and produce items of lower  
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49 added value.  
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3 Finally, Column 7 includes information on the role of flexibility as a motive for  
4 production subcontracting. The results indicate that the greater the importance  
5 of flexibility, the greater is the probability of local outsourcing. Since flexibility is  
6 also a key characteristic of JIT manufacturing, our results support the view that  
7 co-location of supplier and client facilitates flexibility in modern production  
8 organisation (Harrigan and Venables, 2006).  
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11 To test the predictive accuracy of the model, we calculate a classification  
12 matrix, which contains both the real and predicted classifications of the sampled  
13 firms. In the progression from model 1 to model 7, the percentage of correctly  
14 classified cases increases from 76% of the total to 86%. The goodness of fit of  
15 model 7 suggests that the microeconomic aspects selected for analysis here  
16 are instrumental to understanding why firms outsource production at the intra-  
17 regional level.  
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20 We find stronger evidence that proximity is more the result of production-  
21 specific characteristics than of companies' structural characteristics.<sup>14</sup> Firstly,  
22 most of variables specifically related to production technology and relations  
23 display a consistent effect across different model specifications. Secondly, the  
24 inclusion of these variables produces a greatly improved pseudo-R<sup>2</sup>.  
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26  
27 By contrast, in our sample, companies' structural characteristics show much  
28 weaker and less robust effects. In Specification 7, only company size displays a  
29 statistically significant coefficient, indicating that larger firms are less restricted  
30 in their spatial extent of subcontracting, even when flexibility is a prime concern.  
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32 As suggested by network theory, resources which represent elements of power  
33 can make it easier for companies to manage inter-firm relations over greater  
34 distances. Overall, however, our results provide only limited support for network  
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3 theory, although a possible explanation may be the difficulty of  
4 operationalisation. Company power may produce, in our view, divergent  
5 outcomes regarding geographic proximity. As stated earlier, powerful  
6 contractors can not only enforce contracts over distance, but also pressurise  
7 their suppliers to co-locate (Aláez-Aller et al. 1999; D'Costa, 2002; Lee, 2002).  
8 If the size of a company and its possession of intangibles are also indicators of  
9 its power within a network, as the above theory suggests (Easton, 1992), then  
10 we find no evidence, in our sample, that companies are exploiting such power  
11 to oblige their suppliers to cluster around them.  
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25 Regarding sectoral differences, Specification 7 shows that the dummy variables  
26 for both electronics establishments and for other transport equipment display a  
27 significant negative effect. Compared to the automotive establishments in our  
28 sample, these plants are less likely to subcontract locally.  
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35 A final note of caution is necessary; it is important to emphasise that the results  
36 should not be understood as evidence that causal relations exist. Firms make  
37 simultaneous decisions regarding their production organisation and the spatial  
38 extent of their subcontracting relations. Moreover, unobserved company  
39 characteristics (e.g. managerial governance skills) may also influence such  
40 choices. Survey data of the type available in this study do not permit us to  
41 control for all these factors, or for the simultaneous nature of these decisions.  
42 Nevertheless, our analysis provides new exploratory empirical evidence  
43 regarding the particular circumstances in which proximity matters.  
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## 6. CONCLUSIONS

Our results show how modern logistic and production strategies relate to the spatial organisation of production. Even among firms with a similar form of governance, we find that the search for flexibility in modern production organisation (e.g. the implementation of JIT production) produces a specific situation, in which proximity matters. A possible explanation is that some new modes of production organisation, which rely on flexibility and time-savings, also entail relatively high uncertainty and logistic transaction costs that increase in line with the physical distance between inter-connected companies. These costs are probably offset by other benefits (e.g. lower production costs) or mitigated when companies, such as those studied here, network (Ring, 1999). This interpretation is suggested by our finding that stable subcontracting relationships permit more extensive geographic networks. However, these “new” transaction costs may be sufficiently high to persuade networked firms to outsource locally. This question, however, deserves more investigation than attempted here.

The results provide support for the role of JIT as a mechanism for agglomeration; this is consistent with the theoretical models proposed by McCann (1993, 1998) and Harrigan and Venables (2006). JIT effects work through the product market. While, in general, product market effects are likely to work over longer distances, those based on JIT in the context of subcontracting relations are of much shorter range. When JIT manufacturers also use modern manufacturing technology, such as CAD/CAM, then together with their general search for flexible production, the positive influence of JIT on local outsourcing and, consequently, its effects on regional development will be

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3 strengthened even further. According to our findings, however, firms are likely to  
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5 outsource at the local level principally goods of low added value. High value-  
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7 added, complex goods, by contrast, appear instead to be outsourced in extra-  
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9 regional locations. Secondly, firms which engage successfully in technology  
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11 networking are likely to outsource extra-regionally. These two factors, taken  
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13 together, suggest that most proximity localizations may involve low-tech  
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15 activities and, probably, relatively limited job creation. These circumstances  
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17 may reduce the potential of JIT, in the context of subcontracting relationships, to  
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19 the stimulation of new growth poles.  
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25 Our findings are important, because both outsourcing and JIT production  
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27 organisation have become two key features of modern economies. In general,  
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29 our results indicate that the spatial organisation of firms is closely related to  
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31 modes of production organisation and probably, comparing our results to those  
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33 of previous studies (Britton, 2003; Holl and Rama, 2009), also to the style of  
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35 company governance.  
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39 This has important theoretical implications. Existing theories are only partial,  
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41 insofar as they explain the spatial dimension of subcontracting. Our empirical  
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43 analysis shows that different types of production organisation are associated  
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45 with different spatial patterns of subcontracting, even among firms with similar  
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47 governance styles. This question has not been sufficiently analysed in existing  
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49 theoretical approaches. Moreover, the increasing significance of timeliness in  
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51 modern production organisation, as reflected in JIT, requires more in-depth  
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53 review. Analyses of those outsourcing characteristics which increase or restrict  
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55 the impact of JIT on regions are needed.  
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3 The present study focuses on the characteristics of the client company, its type  
4 of production organisation and the subcontracting relation. Other factors may,  
5 nevertheless, also influence the spatial dimension of subcontracting. Future  
6 research may benefit from a more direct analysis of the characteristics of local  
7 suppliers, the role of local policies in shaping subcontracting patterns and the  
8 quality of logistics (e.g. technological parks) in the environment.  
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11 From a policy point of view, understanding the spatial extent of subcontracting  
12 linkages is important, since this indicates the degree to which regions are  
13 integrated into the national and international economy and to which companies  
14 are regionally embedded. Such information should be of particular interest to  
15 policymakers and planners who aim to promote regionally-based industrial  
16 development. Our results provide some support for the view that modern time-  
17 based production strategies may lead to greater local linkages and the  
18 agglomeration of related activities. For any regional development effects taking  
19 place, it will require not only provisions in land use, such as increased local  
20 availability of industrial sites or technology centres, as well as skilled  
21 workforces, but also the existence of an industrial base that is already  
22 sufficiently large to attract new producers and suppliers.  
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Acknowledgements:

The authors are grateful to the BBVA Foundation (Spain) for financial support  
(Project: "Innovation in Spanish industry", CSIC-BBVA Foundation).

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## Appendix A1. Subcontracting and JIT by sector:

	<u>Full sample</u>		<u>Sub-sample of firms that subcontract</u>	
	% which subcontract	% using JIT production	% which only subcontract locally	% using JIT production
Automotive industry	77.4 (82/106)	64.2 (68/106)	78.05 (64/82)	63.4 (52/82)
Other transport equipment	83.4 (5/6)	66.7 (4/6)	40.0 (2/5)	60.0 (3/5)
Electronics industry	90.0 (36/40)	47.5 (19/40)	66.7 (24/36)	50.0 (18/36)
Others	70.0 (7/10)	30.0 (3/10)	85.7 (6/7)	28.6 (2/7)
All	80.3 (130/162)	58.0 (94/162)	58.0 (94/130)	57.7 (75/130)

*Note: absolute numbers in parentheses*

Source: Authors' calculations based on survey

## Appendix A2. Variable Description

Name	Question	Measurement	Mean (1)
Local subcontracting	Where do your principal subcontracting suppliers locate?	1 = Only in the same region 0 = Otherwise	0.74
Size	No. of employees working in the establishment.	No. of employees	286.8
Foreign ownership	What is the origin of capital?	1 = 100% Spanish 0 = Otherwise	0.50
Single plant establishment	Is your firm a single plant?	1 = Yes 0 = Otherwise	0.45
Internal product innovation	New products have been developed internally.	1 = Yes 0 = Otherwise (no product innovation or in collaboration)	0.53
External product innovation	New products have been developed in collaboration with external innovators.	1 = Yes 0 = Otherwise (no product innovation or internal)	0.13
JIT manufacturing	Do you use JIT manufacturing technology?	1 = Yes 0 = No	0.57
Small batch production (2)	Type of production	1 = small batch production 0 = otherwise	0.46
CAD/CAM	Do you use CAD/CAM production?	1 = yes 0 = no	0.51
<u>Stage of subcontracting: Respondents followed a Likert 1-5 scale, where 1 is "Never" and 5 is "Always"</u>			
Stage 1 subcontracting	Do you outsource the manufacturing of parts and components to be integrated in the final product?	1 = rated as 4 and 5 0 = rated as lower	0.65
Stage 2 subcontracting	Do you outsource specific phases of production to be integrated in the final product?	1 = rated as 4 and 5 0 = rated as lower	0.42
Stage 3 subcontracting	Do you outsource the manufacturing of the complete final product?	1 = rated as 4 and 5 0 = rated as lower	0.06
Stage 4 subcontracting	Do you outsource services to be integrated in the final product?	1 = rated as 4 and 5 0 = rated as lower	0.21
Stable subcontracting relations	What is the average duration of contracts with your subcontracting suppliers?	1 = over 2 years 0 = two or less years	0.57
Responsibility	Does your subcontracting supplier assume full responsibility?	1 = Yes 0 = No	0.74
Flexibility motive	Do you subcontract primarily to achieve greater flexibility?	Respondents followed a Likert 1-5 scale, where 1 is "Never" and 5 is "Always"	3.23
Notes: (1) For dummy variables, the percentages indicates the share of "Yes" answers among responding firms; (2) also includes manufacturing of single products by project.			

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Table 1. Maximum spatial extent of subcontracting linkages based on the location of main suppliers

	Only in the same region	National	International
Number of firms	96	24	8
%	75.0	18.7	6.3

Source: Authors' calculations based on survey

Table 2. Contingency table: JIT and local subcontracting

Count Row (%) Column (%)	Local subcontracting	Extra-regional subcontracting	Row total
No JIT production	33 60.0 34.4	22 40.0 64.7	55 100 42.3
JIT production	63 84.0 65.6	12 16.0 35.3	75 100 57.7
Column total	96 73.9 100	34 26.1 100	130 100 100
Pearson chi-square: 9.463; pr=0.002			

Source: Authors' calculations based on survey.

Table 3: Probit estimations of local subcontracting

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
<b>Plant Characteristics</b>							
Number of employees	0.0002 (0.0004)	0.0001 (0.0004)	0.0000 (0.0004)	0.0000 (0.0004)	-0.0008 (0.0008)	-0.0007 (0.0008)	-0.003** (0.001)
Foreign ownership	0.097 (0.290)	0.090 (0.300)	0.226 (0.316)	0.287 (0.336)	0.490 (0.463)	0.574 (0.501)	0.788 (0.617)
Single plant establishment	0.433 (0.284)	0.258 (0.291)	0.278 (0.300)	0.416 (0.320)	0.263 (0.398)	0.414 (0.426)	0.694 (0.500)
Internal product innovation	-0.304 (0.339)	-0.280 (0.349)	-0.265 (0.359)	-0.436 (0.388)	-0.694 (0.564)	-0.708 (0.592)	-0.965 (0.716)
External product innovation	-0.693* (0.420)	-0.590 (0.438)	-0.724* (0.440)	-0.693 (0.462)	-1.436** (0.615)	-1.311** (0.634)	-1.009 (0.786)
<b>Production Characteristics</b>							
JIT production	0.842*** (0.280)	0.887*** (0.280)	0.831*** (0.307)	1.094*** (0.344)	1.067** (0.468)	1.239* (0.501)	1.757*** (0.628)
Small batch		0.248 (0.291)	0.291 (0.304)	0.326 (0.322)	0.168 (0.405)	0.249 (0.425)	-0.175 (0.495)
CAD/CAM			0.647** (0.296)	0.704** (0.325)	1.000** (0.417)	0.936** (0.431)	1.423*** (0.530)
<b>Subcontracting Relation Characteristics</b>							
Stage 1 subcontracting				0.699** (0.398)	1.481*** (0.442)	1.610*** (0.472)	2.064*** (0.608)
Stage 2 subcontracting				0.129 (0.316)	0.426 (0.428)	0.423 (0.445)	0.119 (0.483)
Stage 3 subcontracting				-1.378** (0.579)	-2.217*** (0.831)	-2.572*** (0.912)	-3.431*** (1.193)
Stable subcontracting					-0.934** (0.453)	-0.879* (0.488)	-1.798*** (0.682)
Supplier assumes full responsibility						-0.871* (0.516)	-0.952* (0.595)
Flexibility as motive							0.442** (0.200)
<b>Sector dummies</b>							
Electronics sector	-0.165 (0.301)	-0.271 (0.313)	-0.359 (0.321)	-0.319 (0.344)	-0.282 (0.436)	-0.490 (0.463)	-1.159** (0.551)
Other transport equipment	-1.022 (0.689)	-1.065 (0.678)	-1.267* (0.682)	-1.394** (0.682)	-1.990*** (0.776)	-1.874** (0.791)	-3.588*** (1.102)
Other sectors	0.356 (0.626)	0.298 (0.628)	0.225 (0.673)	0.888 (0.897)	1.681 (1.162)	1.329 (1.157)	1.826 (1.670)
No. of observations	125	119	119	119	96	96	91
Log likelihood	-63.768	-60.117	-57.617	-52.674	-36.649	-35.073	-28.010
Pseudo R <sup>2</sup>	0.116	0.119	0.156	0.228	0.334	0.363	0.467

Note: \*\*\* denotes significance at the 1% level, \*\* the 5% level, and \* the 10% level. Standard errors in parentheses. Qualitatively identical results were produced when regional dummies were included in alternative estimations.

## Notes:

<sup>1</sup> The literature frequently uses the terms "subcontracting" and "outsourcing" interchangeably. The present article uses the term "subcontracting" to refer to the outsourcing of manufacturing activities, and not the outsourcing of services, which could display a very different spatial pattern.

<sup>2</sup> In Spain, for instance, the literature on the automotive industry has studied several regional clusters of suppliers who use JIT for deliveries (Aláez-Aller & Erro-Garcés, 2006; Larsson, 2002; Pérez & Sánchez, 2000).

<sup>3</sup> Consistent with the model proposed by Harrigan and Venables (2006), in the EOQ optimization approach, greater uncertainty leads to higher buffer stocks; in order to reduce these inventory costs, it is also necessary to reduce shipment distance (McCann 1993, 1998). We would like to thank an anonymous referee for drawing attention to this point.

<sup>4</sup> Torre and Rallet (2005) emphasise that effective interaction among firms requires organised proximity, defined as the ability to make members interact and based on shared formal and informal rules, common beliefs, a common knowledge base, mutual trust and the general integrity of relations. The same authors argue that organised proximity is a powerful mechanism for long-distance coordination, as inter-firm relations among organisations with similar characteristics are likely to involve lower transaction costs.

<sup>5</sup> Arm's-length transactions are those in which the buyer and seller of a product act independently of each other and have no mutual relationship apart from trade (i.e. there are no ownership or contractual relationships).

<sup>6</sup> Previous studies highlight the importance of outsourcing in these Spanish industries (Aláez-Aller and Erro-Garcés, 2006; European-Commission, 1997a, ,

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2  
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4 1997b; Larsson, 2002; Rama and Calatrava, 2002; Torreguitart-Mirada and  
5  
6 Martínez-Parra, 2000) ; Holl and Rama 2007).

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9 <sup>7</sup> Cajamar, Boletín Económico Financiero, no.25, January 2006.

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11 <sup>8</sup> JIT is a production as well as a purchasing philosophy. Previous studies have  
12  
13 mainly focused on JIT sourcing. While JIT production and JIT sourcing tend to  
14  
15 be related, the latter, however, is only an indirect indication of a plant's  
16  
17 production system. Moreover, the concept of JIT manufacturing is more  
18  
19 precisely defined by the use of specific technologies at the plant level. By  
20  
21 contrast, the concept of JIT sourcing is more likely to depend on less objective  
22  
23 criteria.  
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27  
28 <sup>9</sup> University of Cambridge, Department of Engineering,  
29  
30 [www.ifm.cam.ac.uk/dstools/process/jit.html](http://www.ifm.cam.ac.uk/dstools/process/jit.html), November 2007.  
31

32  
33 <sup>10</sup> It is difficult to put these figures into perspective, due to the lack of information  
34  
35 regarding the incidence of JIT manufacturing. A 1997 survey, however, reports  
36  
37 that 48.5% of Spanish manufacturing enterprises with more than 50 employees  
38  
39 used JIT systems (Huerta Arribas et al., 2003) .  
40  
41

42  
43 <sup>11</sup> Out of the 130 firms in our sample that subcontract production, 2 firms did not  
44  
45 provide information on the location of their main subcontractors. Some of the  
46  
47 contractors also perform subcontracted work on behalf of other companies.  
48  
49

50  
51 <sup>12</sup> Aláez-Aller et al. (1999) find, in a study of automotive supplier firms in the  
52  
53 Basque Country and Navarre, that suppliers of parts and single processes tend  
54  
55 to be local firms.  
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58 <sup>13</sup> Some authors (Pennings and Harianto, 1992) find, for instance, that firms  
59  
60 which have previous experience of networking are more likely to participate in  
technological alliances.



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<sup>14</sup> The principal results are qualitatively identical, when we restrict our sample to electronics and automotive establishments.

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