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

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Just-in-Time manufacturing systems, subcontracting and geographic proximity

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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

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

Holl et al.

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

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

Just-in-Time Produktionssysteme, Auftragsweitervergabe und geografische Nähe

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

Just-in-Time, neue Produktionstechnologien, Auftragsweitervergabe, Nähe, Agglomeration

Sistemas de producción "just-in-time", subcontratación y proximidad geográfica

Este artículo estudia la dimensión espacial de las relaciones de subcontratación en una muestra de empresas industriales de tamaño mediano y grande que operan en las industrias españolas del automóvil y la electrónica. En particular, analizamos cómo la organización "just-in-time" (JIT) de la producción se relaciona con el patrón espacial de dichas relaciones de subcontratación cuando se tienen en cuenta las características estructurales y organizativas de los clientes (subcontratantes). Encontramos que las empresas que han adoptado nuevas tecnologías y sistemas de producción al nivel del establecimiento industrial tienden a preferir subcontratar regionalmente, más bien que extra-regionalmente. Este hallazgo es coherente con las necesidades de los sistemas "just-in-time" en términos de flexibilidades en los pedidos, rápidas y frecuentes entregas, así como fechas de llegada confiables que permitan garantizar un sistema de producción libre de interrupciones facilitado por la proximidad. Nuestros resultados apoyan el punto de vista de que, en el contexto de la subcontratación productiva, JIT incrementa la importancia de la proximidad.

Just-in-Time, nueva tecnología de fabricación, subcontratación, proximidad, aglomeración.

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.[1] 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).[2] Plant location studies

also provide evidence for the importance of highway access in ensuring punctual delivery on a just-in-time basis (Smith and Florida, 1994). Klier (1999; 2000), drawing on the U.S. auto supplier industry, argues that agglomeration takes place principally at the regional level, and that access to transportation which allows deliveries “within a day's drive” is more important than close proximity between suppliers and assembly plants. Sadler (1994) and Echeverri-Carroll (1996) argue, with regard to the European automotive industry, that JIT does not necessarily lead to agglomeration.

With decreasing transport costs, advanced communication and the increasing importance of non-material flows, analysts have cast doubt on the importance of physical distance as a barrier to inter-company relations. However, even if pecuniary costs for goods transport are assumed to be low, the increasing importance of the cost of time, of flexibility in the ordering of inputs and of the reliability of scheduled transport flows (Hummels, 2001; Harrigan and Venables, 2006) must nevertheless be taken into account.

The literature regarding the relationship between geographical proximity and JIT is principally based on case studies in the automotive industry, in which many first-tier suppliers and subcontractors undertake JIT deliveries (Sadler, 1994; Frigant and Lung, 2002; Larsson, 2002). Today, JIT is also being increasingly adopted in other sectors (Gale, 1999) e.g. the electronics industry (MC Cann and Fingleton 1996, Gallander & Larsson, 2000). A different strand of literature has examined the spatial pattern of inter-firm relations in a more general context (Clarke, 1994; Hendry, 2000; Britton, 2003; Holl and Rama, 2009), but has not considered the specific role of JIT.

This article contributes to research into the spatial dimension of inter-firm linkages by focusing specifically on the effect of Just-in-Time manufacturing systems (hereafter, JIT manufacturing) upon the spatial pattern of subcontracting relations. JIT manufacturing is a flexible system of production aimed at reducing lead time and excessive work in progress inventories at the plant level, while helping to improve productivity and product quality. It often involves the use of new technology, such as computer integrated manufacturing, cellular layouts and advanced information systems. This new technology is also frequently associated with the implementation of innovative management practices, such as JIT sourcing.

The present article analyses detailed survey data for a sample of Spanish electronics and automotive producers, in order to determine whether contractors using new technology and organisation display the same geographical patterns as contractors who employ a more traditional approach to manufacturing. We argue that the implementation of a new organisation of production within factories encourages firms to develop geographically closer external relationships.

Focusing specifically on JIT manufacturing and subcontracting permits the identification of those characteristics of manufacturing technology which may make partner proximity more important. This approach helps to explain why the agglomeration of industry, and in particular of high technology sectors, is a continuing phenomenon, despite important reductions in transport and communication costs.

Below, Section 2 discusses the role of proximity in the organisation of production. Section 3 describes our data. Section 4 presents the model and

discusses the determinants of the geographical extent of subcontracting linkages. Section 5 offers our empirical results and a discussion and Section 6 is dedicated to our conclusions.

2. SPACE IN THE ORGANISATION OF PRODUCTION. THE ROLE OF PROXIMITY

There exists no general theory of the spatial dimension of inter-firm linkages (and of subcontracting relations in particular). However, spatial economic analysis, focusing on the determinants of the location of economic activity across space, is a long-standing research field. Costs and interdependence between firms have been accepted as the principal factors explaining the role of proximity in company location. A further branch of the literature has analysed why companies engage in inter-firm relations instead of vertically integrated production. Transaction Cost Theory (TCT) concentrates on the trade-off of the costs and benefits associated with different forms of governance: markets, hierarchies (firms) and hybrids (e.g. subcontracting networks) (Williamson, 1991). Inter-firm relations involve costs of establishing and maintaining an external relationship (Williamson 1985). This involves search and information costs, bargaining and decision costs, and monitoring and enforcement costs (Grossman and Hart 1986). Williamson (1985) also refers to the costs involved in product flows, such as transport costs and those of product losses and damages. Transaction costs increase when these transactions are frequent (David and Han, 2004), as in the case of JIT systems. Though distance and location are constants in earlier TCT abstract models (Williamson, 1991), recent work by Harrigan and Venables (2006) and Feenstra and Spence (2006),

among others, shows that these costs are presumably more of a deterrent in long-distance relations.

Today, although transport costs may represent a relatively small percentage of total costs for most firms, other logistic costs may still be substantial (McCann, 2001). In the inventory model proposed by McCann (1993), optimum firm location depends on the balancing of inventory holding costs, procurement costs and transport costs. JIT implies more frequent deliveries. At the optimized Economic Order Quantities (EOQ), this increases transport costs and encourages localization (McCann 1993, 1998).

Focusing specifically on the implications of JIT for agglomerations, Harrigan and Venables (2006) show, in a theoretical model, how the need for timeliness in delivery encourages clustering. Proximity between supplier and customer is important to provide flexibility and to reduce demand uncertainty. Harrigan and Venables study two types of uncertainty. Firstly, there is greater uncertainty regarding delivery times for components from remote suppliers. This implies a greater risk of costly production delays caused by late arrival, while localised sourcing benefits from timeliness. Secondly, decisions regarding inputs from remote sources have to be taken earlier and thus involve greater uncertainty regarding the level of demand or cost. By contrast, decisions concerning locally produced inputs can be taken at later stages, once a greater degree of uncertainty has been resolved. In both cases, uncertainty encourages the clustering of component producers. Producers in the clusters benefit from flexibility in ordering, which leads to higher productivity compared to producers in other locations, who do not enjoy the benefits of timeliness in delivery from local sourcing. Harrigan and Venables (2006) argue that proximity is a

quantitative dimension of the cost of exchange and interaction, but is also an important qualitative aspect of reducing uncertainty.[3]

Proximity not only reduces distance costs and permits greater flexibility, since inputs can be more easily obtained in smaller quantities or on an as-needed basis, but also facilitates close contacts between clients (contractors) and suppliers (subcontractors) in collaborative arrangements which require frequent face-to-face contact.

A further theory may help to explain geographic distance through the interdependence of firms. In management literature, network theory stresses that inter-firm relations will be affected by cost-minimising concerns as well as by power (see, for example, Sacchetti and Sudgen, 2003). This approach focuses on the uneven distribution of resources, information and control within inter-firm relations and the consequent unequal abilities of actors within networks to dominate the behaviour of others. Firms with more exchange alternatives and greater resources enjoy a better negotiating position (Lee, 2002). Powerful firms are better equipped to impose their own distributive rules not only within the network, but probably upon even extra-regional partners. However, the distribution of power within networks may change, depending on the duration of relations. Grandori and Neri (1999) and Sacchetti and Sudgen (2003) believe repeated and long-lasting relations are a necessary condition for the adoption of “fairness rules” and the basis of mutual relationships in which power becomes evenly distributed amongst network partners; they argue that such mutual relationships create “proximity”.[4]

Despite these theoretical developments, few empirical studies have specifically analysed the spatial extent of inter-firm relations. Hendry et al. (2000), Britton

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

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[6]. 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.

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

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

The total sample includes 162 companies, of which 24.7% operate in the electronics industry, 65.4% in the automotive field and 3.7% in the "other transport equipment" sector. The sample also includes 10 firms (6.2%) which supply part of their output to these industries but are classified under other headings (e.g. rubber and plastics or machinery and mechanical equipment). Firms in the automotive and electronics industries and in auxiliary industries were asked to rate, using a 1-5 Likert scale, the importance of 32 different economic activities (e.g. the manufacture of electronics components). We identified a group of firms involved in the manufacture of automotive and electronics products, even if this was not their principal activity. A company which indicates “machinery and mechanical equipment” as its main activity, for instance, may also produce parts and components used in motorcycle manufacture. In other words, part of its production may consist of “other transport equipment”. Our sample includes affiliates of companies such as Siemens and Samsung in the electronics industry and Volkswagen, Renault and Daimler-Chrysler in the automotive industry.

The sample includes vertically integrated firms and firms participating in outsourcing networks as contractors (clients), subcontractors (suppliers) or both. We use this sample of 162 companies to determine the diffusion of JIT and subcontracting in the industries selected and the general relationship between the two. As stated in the Introduction, however, our more specific intention is to establish whether contractors using new technology and organisation display the same geographic patterns as contractors who employ a more traditional approach to manufacturing. Thus, in section 5 we focus on the sub-sample of firms which subcontract part of their production activities.

Sectors analysed

After Germany and France, Spain is the third largest European producer of automobiles[7]. 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.[8] 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

time, quality and quantity" and now means producing with minimum waste of time and resources.[9] Inside the factory, the implementation of JIT manufacturing includes new practices such as improved quality control, preventive maintenance, the avoidance of mistakes, eliminating waiting time wastage due to product defects, greater cleanliness and more efficient organisation, a multi-skilled workforce, ensuring a smooth flow of products through the factory, etc.. For instance, timewasting may consist of workers remaining idle, which is not uncommon in a sequential line production process. To solve this problem, factories which implement JIT manufacturing can, among other solutions: smooth the flow of products through the plant; reduce set-up time; train their employees to use alternative machines, etc...

Subcontracting and JIT in our sample

Table A1 provides information for both the total sample of 162 companies and the sub-sample of 130 companies that subcontract. Subcontracting and JIT manufacturing are common strategies among the sample firms. From among all the sampled firms, approximately 80% subcontract and 58% report that they use JIT manufacturing. 61.8% of the plants in the total sample also report JIT sourcing and approximately 75% report the use of JIT for at least half of deliveries to their customers. Although few firms use JIT in all their sourcing and deliveries, the companies studied are linked quite closely by JIT relationships. In fact, only 16 firms (9.9%) in our total sample make no use whatsoever of JIT.[10] While electronics firms are more likely to subcontract, JIT manufacturing is more common in the automotive industry. Nevertheless, almost half of the electronics companies are also JIT manufacturers.

In their analysis of the Los Angeles Basin, Suarez-Villa and Walrod (1997) find that 54% of the electronics producers utilised JIT production methods as early as the mid-1990s. Comparison with our results suggests that Spanish electronics producers adopted such methods relatively late. By contrast, outsourcing of production is far more common in our sample of electronics firms than in that of Suarez-Villa and Walrod (58%). Since the implementation of JIT usually entails both risks and substantial investment, many Spanish electronics producers may have preferred to fully exploit a cooperation strategy to achieve flexibility, benefiting from an enduring "network culture" in their sector (Estevan, 1988; Suarez-Villa and Rama, 1996). We shall return to companies' search for flexibility below.

4. SELECTION OF THE MODEL AND VARIABLES

We analyse whether companies that subcontract regionally display specific characteristics, notably the adoption of JIT manufacturing. We estimate the probability that a firm's main subcontractors are exclusively located within its same region. The regional dimension of subcontracting patterns is important for policymakers. Regions in Spain enjoy a high degree of self-determination and fiscal autonomy and develop their own territorial programmes (Suarez-Villa and Cuadrado Roura, 1993).

We represent intra-regional subcontracting y_i by firm i = 1, 2, etc. by a binary choice model:

$$y_i = \begin{cases} 1 \ if \ y_i^* \geq 0 \\ 0 \ otherwise \end{cases} \qquad (1)$$

where the latent variable y_i^*, which represents firm *i*'s underlying propensity to subcontract within the region in which it is located is a linear function of observable firm-specific characteristics c_i, characteristics of the production process p_i, and characteristics of the specific subcontracting relation r_j.

$$y_i^* = c_i\beta_1 + p_i\beta_2 + r_i\beta_2 + \nu_i \qquad (2)$$

The term ν_{it} captures the effects of unobserved factors and is assumed to be i.i.d. normal. Since we focus on the spatial extent of subcontracting, estimations are based on a sub-sample of 128 firms which subcontract out part of their production and provide information regarding the location of their main subcontractors.[11]

Independent variables

We include in our model variables which the existing empirical and theoretical literature has related to the spatial extent of outsourcing linkages. These can be grouped into three sets of independent variables (see Appendix A2 for a description). The variables concern, respectively: company characteristics, the characteristics of its organisation of production and relation-specific characteristics.

Firstly, the literature shows that specific company characteristics may affect firms' spatial behaviour. On the one hand, the costs involved in setting up distant network relations will be less onerous for certain firms and, on the other, access to specific resources can lower transaction costs and increase firms'

ability to enforce contracts, particularly in the case of extra-regional relations. Such resources include financial and human capital, information, knowledge and other intangibles.

Size*:* Costs related to establishing, monitoring, and enforcing network relationships over longer distances should be less of an impediment for larger firms. Larger firms are likely to have the necessary human and physical capital and market power necessary to gain information and enforce contracts over distance. Conversely, some empirical studies show that smaller companies have more limited geographical range, and thus are more deeply embedded in the regional economy, than large companies (Gray et al. 1996; Suarez-Villa and Rama, 1996). Here, we test whether smaller firms are more prone to outsource production regionally.

Foreign ownership and single plant status*:* Arita and McCann (2002) argue that organisational structure influences the spatial behaviour of firms. The spatial linkage pattern of businesses which form part of multi-plant companies may be dictated by corporate structure. Such establishments are more likely to be integrated in a wider network, and are correspondingly more likely to engage in spatially broader inter-firm relations than single-plant companies (Holl and Rama, 2009). Similarly, foreign ownership may influence company management style and consequently affect spatial linkage patterns. Here, we test whether the likelihood of outsourcing intra-regionally is associated with specific types of company organisation.

Product innovation: The literature demonstrates that when high-tech sector firms search for new technology, they may cooperate with both co-located companies and with extra-regional firms, On the one hand, the search for

knowledge externalities may stimulate firms to co-locate. Empirical studies have shown that, in R&D-intensive industries where knowledge spillovers are substantial, the location of production tends to be geographically concentrated (Audretsch and Feldman, 1996). An analysis of the Spanish industry finds that electronics plants, for instance, tend to locate near their customers and suppliers (Alonso-Villar et al., 2004). This supports the idea that contractors outsource manufacturing locally in order to benefit from spillovers generated at the local level. On the other hand, companies in high-tech sectors require an increasingly wide range of technologies to manufacture their products, which may force them to use extra-regional suppliers to satisfy at least part of their innovation requirements (Dyer and Singh 1998, Brusoni et al. 2001). A different issue is whether, within a high-tech sector, the most R&D-intensive companies are actually willing to network with co-located firms. Innovative companies may prefer a degree of physical isolation from other clustered companies, so as to avoid the unintended spillover of new knowledge (Kearns and Görg, 2002; Nachum and Wymbs, 2002; Suarez-Villa, 2002). Ahuja (2000) also demonstrates that innovators may even be reluctant to network with other firms, although he does not explore the spatial dimension of company behaviour. Here, we test whether companies which generate internal or external product innovations are more likely to outsource intra-regionally (for definitions, see Appendix A2).

Second, the literature emphasises that in addition to companies' structural characteristics, the way they organise their production may also be linked to the spatial extent of inter-firm relations. We specifically focus on how JIT

manufacturing affects the spatial pattern of subcontracting relations, but also control for a number of other production-specific characteristics.

JIT: JIT manufacturing potentially favours local outsourcing, due to the need for flexibility and for fast, frequent and reliable deliveries and communication, in order to keep component delivery scheduling tight (Allen et al. 1994). As Harrigan and Venables (2006) show, proximity is important to facilitate flexibility and reduce uncertainty in input ordering in timeliness production e.g. JIT. There are further reasons why JIT encourages, at least in theory, proximity between clients and suppliers. Car assemblers using JIT may prefer proximity if they feel that it simplifies social relations and facilitates control, and because willingness to locate in the vicinity of the assembly plant represents a sign of commitment on the part of the supplier (Larsson, 2002); the location of several suppliers near the assembly plant might increase the contractor's bargaining power with respect to the rest of the network (Aláez-Aller and Erro-Garcés, 2006). Furthermore, as argued by Echeverri-Carroll (1996), JIT is not merely a delivery programme. The ability to produce components which conform to the specifications requested by the client requires the close coordination of manufacturing processes, implying the continuous sharing of information between client and supplier.

Although the literature on this issue is almost non-existent, there exists some evidence to suggest that the implementation of JIT may heighten the importance of proximity in subcontracting relations. Clarke and Mia (1993) find that, in some Australian industries, geographic proximity of customers and suppliers and a low level of vertical integration of the company, which denote a prevalence of outsourcing, are good predictors of the successful implementation

of JIT manufacturing at the plant level. Analysing two large companies operating, respectively, in the Swedish automobile and electronics industries, Gallander and Larsson (2000) argue that "outsourcing may and may not have location implications" (p.2). Focusing on JIT deliveries (rather than on JIT manufacturing, as in this article), they conclude that sequential JIT with short lead times is the most important location factor explaining local outsourcing. Here, we test whether firms which implement new technologies and manufacturing systems, such as JIT, are more likely to outsource intra-regionally than those using more traditional manufacturing systems.

Small batch production: JIT is a key characteristic of flexible production strategies. Flexible production organisation is also often associated with low-volume and customised production (D'Costa, 2004). Small batch size involves the shortening of production cycles, the reduction of finished goods inventories (Milgrom and Roberts, 1990), the production of smaller quantities and more customer-specific manufacture. As with JIT, small batch production tends to entail greater buyer-supplier cooperation and, according to some empirical evidence, the increased importance of suppliers' geographic proximity (D'Costa, 2004). Here, we test whether companies which define their type of production as small batch production are more likely to outsource intra-regionally.

CAD/CAM: JIT manufacturing can be implemented using either computer-aided design/computer-aided manufacturing (CAD/CAM) or traditional machinery. Here, we test whether the employment of CAD/CAM may increase the importance of proximity between the implementing plant and its suppliers.

Third, the particular characteristics of the subcontracting relation may also be linked to its spatial pattern.

Subcontracting stage*:* The precise nature of the activity involved in the subcontracting relation may determine the relative importance of proximity. Depending on the production stage at which subcontracting takes place, the relation may involve either more face-to-face contact or an increased exchange of parts and components. If the need for face-to-face contact is great, proximity may become more important, but the exchange of bulky and submodular parts that involve high transport costs may also favour the proximity of supplier and client (Lee, 2002). Moreover, suppliers probably locate closer to their clients when they provide parts and components rather than finished products, as the former generally require more frequent delivery.[12] It is common for system suppliers delivering finished products to form part of large domestic groups or multinational enterprises which supply car assemblers in a number of locations. Here, we test the relationships between the likelihood of outsourcing intra-regionally and four different stages of the production process at which subcontracting takes place (see Appendix A2). These stages also reflect the type of goods or services outsourced.

Stable subcontracting relations*:* Johanson and Mattson (1992) argue that the stability and duration of exchange relationships is especially important where the actors must adapt their heterogeneous resources to each other and the relationship becomes highly specialised. Stability generates trust (Sturgeon, 2003), and in turn trust reduces the risk of opportunism and thereby lowers transaction costs (Ring, 1999). The literature on the automotive industry in the US, Japan and some European countries shows that most of the contracts between assemblers and their suppliers are relatively long lasting (Aláez-Aller and Erro-Garcés, 2006; Baudry, 1993; Torreguitart-Mirada and Martínez-Parra,

2000); according to Chanaron (1998), the new post-Fordist system of production means that assemblers select suppliers on the basis of their past relationship and proven performance record (rather than on the basis of tenders). Hoare (1985) argues that if inter-firm relations are stable, they can be planned more easily, and thus proximity is less important. However, in *ad hoc* relationships and, more generally, in relations that must be renegotiated periodically, the subcontracting partners may have a greater need for proximity. In particular, short-term contracts involve frequent renegotiations of price and new rounds of competition among suppliers (Baudry, 1993), which may encourage them to cluster around the assemblers in order to obtain updated information. We test whether companies are more likely to outsource intra-regionally when the duration of contracts is relatively short.

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

Flexibility motive: This variable considers the client (contractor) motivation to outsource production. Certain characteristics of clients' organisation of production (e.g. flexible production) are taken by the literature to constitute a

new form of manufacturing which is replacing Fordist factories (Milgrom and Roberts, 1990). This search for flexibility is a general strategy, aimed principally at speeding up company operations (Milgrom and Roberts, 1990). Thus, while firms' principal motive for subcontracting is the need for greater flexibility, proximity may also become increasingly desirable. Therefore, we test whether the likelihood of outsourcing intra-regionally is greater when the company is highly motivated by the search for flexibility.

Finally, the model also includes dummy variables to check for differences between sectors.

5. EMPIRICAL RESULTS

As Table 1 shows, there is an important regional dimension to subcontracting linkages. The pattern is very similar to that reported in López (2001), Rama et al. (2003) and Holl and Rama (2009) for subcontracting among electronic firms in Spain, and confirms that important intra-regional linkages exist. Table 2 shows a strong relation between local subcontracting and JIT manufacturing.

Table 3 presents the results of the multivariate probit analysis, and a number of interesting findings emerge. Firstly, JIT manufacturing has a significant positive influence on the probability of subcontracting locally. Secondly, with regard to company characteristics other than JIT manufacturing, the coefficients are weak, in line with McCann and Fingleton (1996). In a study of the Scottish electronics industry, these authors found JIT sourcing to be the single most important factor influencing firms' propensity towards local expenditure. In our analysis, only the dummy variable for companies which introduced product

innovation in collaboration with external innovators (firms or institutions) is significant in Column 1, indicating that such firms are more likely to subcontract to suppliers outside their own region. A possible explanation is as follows: technological networking with extra-regional partners, often a necessity for firms in high-tech industries (Dyer and Singh 1998, Brusoni et al. 2001), may provide such companies with useful information on the "market" for possible outsourcing partners in distant localities.[13] This may increase the willingness and ability of companies to outsource production extra-regionally. In our sample, the coefficient for innovators who produce and develop their new products in-house is also negative, although not statistically significant. The relatively low pseudo-R^2 indicates that other factors are also likely to be influential.

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

In Column 4 of Table 3 we introduce additional variables to control for the stage at which subcontracting takes place. Stage1 (subcontracting of parts and modular components) increases the probability of local subcontracting, while Stage3 (subcontracting of final production) reduces this probability, compared to

the control stage of subcontracting services to be integrated in the final product. This confirms that the subcontracting of parts and components manufacture has a greater local dimension. By contrast, if the subcontracted activity is located at the end of the production process, the subcontractor could be located closer to the final customer (to whom the product must be delivered) than to the subcontracting client i.e. proximity to the principal client is less important. Since these variables indirectly control for the characteristics of different types of suppliers, it is also possible that the suppliers of high-tech, non- standardised goods (e.g. final products) of our sample are limited in number and manufacture their products in only a few locations, as the suppliers analysed by Arita and McCann (2004). These qualitative aspects of local sourcing were also detected in the study of the Brazilian automotive industry performed by Frigant and Lung (2002). Column 5 includes a dummy variable for subcontracting relations lasting over two years. As expected, we find that when relations are stable they can be more easily organised, even over longer distances. Column 6 includes as an additional control variable a dummy that indicates whether the subcontractor assumes complete responsibility for the subcontracted activity. Full responsibility is also significantly associated, in our sample, with a lower probability of local subcontracting. Suppliers who accept entire responsibility need less supervision, and are probably less involved in local subcontracting relations, thereby making proximity less important. As in the case of the stages of subcontracting, the introduction of this new variable in the model may also suggest that local suppliers have lower skill levels and produce items of lower added value.

Finally, Column 7 includes information on the role of flexibility as a motive for production subcontracting. The results indicate that the greater the importance of flexibility, the greater is the probability of local outsourcing. Since flexibility is also a key characteristic of JIT manufacturing, our results support the view that co-location of supplier and client facilitates flexibility in modern production organisation (Harrigan and Venables, 2006).

To test the predictive accuracy of the model, we calculate a classification matrix, which contains both the real and predicted classifications of the sampled firms. In the progression from model 1 to model 7, the percentage of correctly classified cases increases from 76% of the total to 86%. The goodness of fit of model 7 suggests that the microeconomic aspects selected for analysis here are instrumental to understanding why firms outsource production at the intra-regional level.

We find stronger evidence that proximity is more the result of production-specific characteristics than of companies' structural characteristics.[14] Firstly, most of variables specifically related to production technology and relations display a consistent effect across different model specifications. Secondly, the inclusion of these variables produces a greatly improved pseudo-$R^{2.}$

By contrast, in our sample, companies' structural characteristics show much weaker and less robust effects. In Specification 7, only company size displays a statistically significant coefficient, indicating that larger firms are less restricted in their spatial extent of subcontracting, even when flexibility is a prime concern. As suggested by network theory, resources which represent elements of power can make it easier for companies to manage inter-firm relations over greater distances. Overall, however, our results provide only limited support for network

theory, although a possible explanation may be the difficulty of operationalisation. Company power may produce, in our view, divergent outcomes regarding geographic proximity. As stated earlier, powerful contractors can not only enforce contracts over distance, but also pressurise their suppliers to co-locate (Aláez-Aller et al. 1999; D'Costa, 2002; Lee, 2002). If the size of a company and its possession of intangibles are also indicators of its power within a network, as the above theory suggests (Easton, 1992), then we find no evidence, in our sample, that companies are exploiting such power to oblige their suppliers to cluster around them.

Regarding sectoral differences, Specification 7 shows that the dummy variables for both electronics establishments and for other transport equipment display a significant negative effect. Compared to the automotive establishments in our sample, these plants are less likely to subcontract locally.

A final note of caution is necessary; it is important to emphasise that the results should not be understood as evidence that causal relations exist. Firms make simultaneous decisions regarding their production organisation and the spatial extent of their subcontracting relations. Moreover, unobserved company characteristics (e.g. managerial governance skills) may also influence such choices. Survey data of the type available in this study do not permit us to control for all these factors, or for the simultaneous nature of these decisions. Nevertheless, our analysis provides new exploratory empirical evidence regarding the particular circumstances in which proximity matters.

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

strengthened even further. According to our findings, however, firms are likely to outsource at the local level principally goods of low added value. High value-added, complex goods, by contrast, appear instead to be outsourced in extra-regional locations. Secondly, firms which engage successfully in technology networking are likely to outsource extra-regionally. These two factors, taken together, suggest that most proximity localizations may involve low-tech activities and, probably, relatively limited job creation. These circumstances may reduce the potential of JIT, in the context of subcontracting relationships, to the stimulation of new growth poles.

Our findings are important, because both outsourcing and JIT production organisation have become two key features of modern economies. In general, our results indicate that the spatial organisation of firms is closely related to modes of production organisation and probably, comparing our results to those of previous studies (Britton, 2003; Holl and Rama, 2009), also to the style of company governance.

This has important theoretical implications. Existing theories are only partial, insofar as they explain the spatial dimension of subcontracting. Our empirical analysis shows that different types of production organisation are associated with different spatial patterns of subcontracting, even among firms with similar governance styles. This question has not been sufficiently analysed in existing theoretical approaches. Moreover, the increasing significance of timeliness in modern production organisation, as reflected in JIT, requires more in-depth review. Analyses of those outsourcing characteristics which increase or restrict the impact of JIT on regions are needed.

The present study focuses on the characteristics of the client company, its type of production organisation and the subcontracting relation. Other factors may, nevertheless, also influence the spatial dimension of subcontracting. Future research may benefit from a more direct analysis of the characteristics of local suppliers, the role of local policies in shaping subcontracting patterns and the quality of logistics (e.g. technological parks) in the environment.

From a policy point of view, understanding the spatial extent of subcontracting linkages is important, since this indicates the degree to which regions are integrated into the national and international economy and to which companies are regionally embedded. Such information should be of particular interest to policymakers and planners who aim to promote regionally-based industrial development. Our results provide some support for the view that modern time-based production strategies may lead to greater local linkages and the agglomeration of related activities. For any regional development effects taking place, it will require not only provisions in land use, such as increased local availability of industrial sites or technology centres, as well as skilled workforces, but also the existence of an industrial base that is already sufficiently large to attract new producers and suppliers.

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Appendix A1. Subcontracting and JIT by sector:

	Full sample		Sub-sample of firms that subcontract	
	% 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
Stage of subcontracting: Respondents followed a Likert 1-5 scale, where 1 is "Never" and 5 is "Always"			
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	22	55
	60.0	40.0	100
	34.4	64.7	42.3
JIT production	63	12	75
	84.0	16.0	100
	65.6	35.3	57.7
Column total	96	34	130
	73.9	26.1	100
	100	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)
Plant Characteristics							
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)
Production Characteristics							
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)
Subcontracting Relation Characteristics							
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)
Sector dummies							
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^2	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:

[1] 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.

[2] 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).

[3] 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.

[4] 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.

[5] 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).

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

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

[7] Cajamar, Boletín Económico Finaciero, no.25, January 2006.

[8] JIT is a production as well as a purchasing philosophy. Previous studies have mainly focused on JIT sourcing. While JIT production and JIT sourcing tend to be related, the latter, however, is only an indirect indication of a plant's production system. Moreover, the concept of JIT manufacturing is more precisely defined by the use of specific technologies at the plant level. By contrast, the concept of JIT sourcing is more likely to depend on less objective criteria.

[9] University of Cambridge, Department of Engeneering, www.ifm.cam.ac.uk.dstools/process/jit.html, November 2007.

[10] It is difficult to put these figures into perspective, due to the lack of information regarding the incidence of JIT manufacturing. A 1997 survey, however, reports that 48.5% of Spanish manufacturing enterprises with more than 50 employees used JIT systems (Huerta Arribas et al., 2003) .

[11] Out of the 130 firms in our sample that subcontract production, 2 firms did not provide information on the location of their main subcontractors. Some of the contractors also perform subcontracted work on behalf of other companies.

[12] Aláez-Aller et al. (1999) find, in a study of automotive supplier firms in the Basque Country and Navarre, that suppliers of parts and single processes tend to be local firms.

[13] Some authors (Pennings and Harianto, 1992) find, for instance, that firms which have previous experience of networking are more likely to participate in technological alliances.

[14] The principal results are qualitatively identical, when we restrict our sample to electronics and automotive establishments.