

The spatial patterns of networks, hierarchies and subsidiaries

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Abstract: Understanding the spatial extent of inter-firm linkages is important for policymakers and academics, as it provides an idea of how far a region is integrated with the national and international economy as well as the regional embeddedness of companies. In this paper we review evidence and arguments linking networking behaviour of firms with geographic distance, before we examine the spatial relationships of electronics firms, in the three major electronics centres in Spain. We focus on the spatial pattern and extent of different types of inter-firm relations. Based on the analysis of 184 surveyed establishments displaying different ownership and organisation characteristics, our results show that while regional linkages are important, significant extra-regional linkages are also maintained by firms in regional clusters. The spatial extent of linkages depends on the mode of relations; arm's-length, network, and hierarchy relations show different spatial patterns, as do different types of cooperations. The importance of extra-regional linkages also varies with firm and plant-specific characteristics. Extra-regional linkages are more common among larger and more R&D-intensive firms, firms with greater presence in the rest of the country and firms with more experience of cooperations and more stable relationships.

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1. Introduction

The last two decades have seen important changes in the organisation of production towards interconnected production, outsourcing of non-core activities and global sourcing. Firms have become increasingly perceived as part of networks of inter-linked businesses, which has led to a growing interest in networks as organisational forms which affect company performance (Dyer and Singh 1998, Lechner and Dowling 2003, Witt 2004) as well as local and regional economic competitiveness (Sornn-Friese and Sørensen 2005). At the same time, many economic fields have increasingly recognised the role played by space, yet our understanding of the spatial pattern of inter-firm linkages remains limited. Although numerous studies assume that spatial proximity between firms stimulates inter-firm linkages, they rarely investigate this relationship specifically. A key question is whether the spatial proximity of economic activities actually reflects the strength of economic linkages among neighbouring firms.

Using a unique data set of questionnaire survey collected in the three major electronic centres in Spain, we explore the spatial linkages of electronics companies. We argue that the geographical extension of linkages in which a company is involved will depend on the nature of such linkages, on the characteristics of the firm and on the governance of networks. The objective of our empirical analysis is threefold. Firstly, we assess the relative importance of regional versus extra-regional linkages of electronics firms in industry concentrations. Secondly, we explore whether markets, hierarchies and external networks could involve different spatial patterns. Thirdly, we identify the

type of firms most likely to engage in regional networking or, alternatively, in extra-regional networking.¹

This analysis attempts to contribute to the literature on agglomeration and spatial proximity by providing a quantitative view of the spatial patterns of distinct types of inter-firm and intra-firm linkages. Given that relatively little is still known about the spatial patterns of different types of linkages and that evidence is fragmented and compilations of stylised facts are still virtually unavailable in this line of research, we first present a review of the research available related to the spatial patterns of inter-firm linkages to identify key issues and formulate a set of research lines. However, attempts to formulate a theory of the spatial linkages adopted by different organisations would be beyond the scope of this paper. Also, our analysis is of an exploratory nature in that it does not explicitly model firms' decisions to engage in short or extended linkages. However, we do make an important contribution by focusing on different types of inter-firm relations and their geographical dimension. More specifically, we study the spatial dimension of different relationships for the same set of spatially concentrated companies, a method which facilitates the analysis and comparison of a variety of situations. In general, most previous research has focused on one particular type of relationship (e.g. subcontracting).

Understanding the spatial extent of inter-firm linkages is important for policymakers and academics, as it provides an idea of how far a region is integrated with the national and international economy and of the regional embeddedness of specific types of companies (e.g. multinational enterprises). This type of information could be useful for policymakers who aim to promote regionally-based industrial development. From an academic point of view,

improved comprehension of the spatial extent of inter-firm relationships could contribute to the empirical evaluation of agglomeration economies and spatial spillovers.

2. Theoretical and empirical background and research lines

There is no general theory of the spatial pattern of inter-firm linkages, and nor do we attempt to formulate one here. Our research exploits various approaches to inter-firm relations to identify key issues and provide the background for the empirical analysis, our primary concern, on which to formulate a set of research lines.

2.1. Agglomeration and industrial districts literature

Theory suggests that the importance of agglomeration economies derives from a pattern of close relationships between firms, thereby providing advantages to locations in which economic activity is concentrated rather than dispersed.

Agglomeration literature: Inter-firm linkages underpin the classical agglomeration economies, according to Marshall (1920), who listed the three principal advantages of spatial proximity: access to specialised suppliers (of both intermediate goods and producer services), pools of workers with specialised skills, and knowledge spillovers. While interest has been growing in research into agglomeration economies and the clustering of firms in particular locations, the spatial scale in which such externalities operate has to date rarely been statistically tested. Notable exceptions, are Rosenthal and Strange (2003, 2005) and Overman and Duranton (2005). Overman and Duranton (2005) develop distance based test of economies of localisation for the UK. They find

that while only half of the sectors at four-digit level are localised, such localisation takes place mostly below 50 kilometres. Rosenthal and Strange (2003 and 2005) also show how localisation and urbanisation economies rapidly attenuate with increasing distance. While these studies provide very valuable information on the geographical scope of urbanisation and localisation economies, they can not shed light on the spatial patterns of specific kinds of inter-firm relations underlying the potential benefits stemming from agglomeration economies.

Industrial district literature: Closely related to agglomeration research is the concept of industrial districts; for a comparison of the agglomeration concept and industrial districts, see, for example, (Gordon and McCann 2000). Industrial districts studies emphasise shared values, trust and social embeddedness among network partners (Becattini 1990, Brusco 1999). Traditionally, this literature has focused on the formation and benefits of network relations among small and medium-sized enterprises (SMEs) and other local actors. Recent research within this strand of literature, however, indicates that the importance of relations that firms in clusters maintain with firms outside has been both underestimated and largely overlooked (see, for example, Henderson et al. 2002, Coe et al. 2004, Giuliani et al. 2005, Wai-chung et al. 2006). Relations with firms outside clusters are based on relational networks rather than on spatial proximity. Extra-regional relations are believed to constitute important mechanisms for accessing knowledge produced in different spatial contexts; this increases local capabilities by enhancing firms' ability to respond to change in a rapidly evolving and global economy.

2.2 Explaining inter-firm relationships

Several theories have been employed in an attempt to explain why companies engage in inter-firm relations; most such studies are based upon transaction cost theory.

Transaction cost theory: According to the seminal work of Coase (1937), a firm will use external relations for an activity when the perceived costs are lower than those of undertaking the activity in-house. This trade-off is affected by three main factors: uncertainty associated with the transaction (such as fluctuations in market demand), the frequency of transactions and the need for transaction specific investment (asset specificity). The decision is also determined by the cost of establishing and maintaining an external relationship (Williamson 1975, 1985). This involves search and information costs, bargaining and decision costs, and monitoring and enforcement costs (Grossman and Hart 1986). These costs are presumably more of an impediment in long-distance relations. Proximity not only reduces transport costs and permits greater flexibility, since inputs can be more easily obtained in smaller quantities or on an as-needed basis (e.g. in a just-in-time delivery system), but also facilitates close contacts between clients and suppliers in collaborative arrangements which require frequent face-to-face contact, as well as the search for suitable network partners.

Organisational proximity versus geographical proximity: A basic assumption of agglomeration and industrial districts literature is that firms located in clusters maintain stronger local linkages. Torre and Rallet (2005), however, stress the difference between co-location and geographical proximity, and argue that co-location is not a sufficient prerequisite for interaction and cooperation; they

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.

Power theory: Power 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. Power depends, on the one hand, on the alternatives available to each network partner and, on the other, on resources. Network partners with more exchange alternatives have more power, since they enjoy a better negotiating position (Cook and Emerson 1978), as do firms with greater resources (Easton 1992). Such firms are better placed to impose distributive rules within the network, probably even upon extra-regional partners. 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”. Such literature suggests that geographical scope should also be analysed in the context of governance style and power relations.

2.3. Empirical evidence and research lines

The objective of the present study is to explore the spatial pattern of inter-firm relations of electronics companies in three Spanish concentrations of electronics firms (Madrid, Catalonia and the Basque Country). Using the literature available as a basis, various lines of research are developed to study regional and extra-regional linkages patterns.

2.3.1 Co-location and regional linkages: Much of the industrial district and agglomeration economies literature assumes that firms benefit from being located near other businesses. However, co-location may occur without linkages being produced among proximate firms (Gordon and McCann 2000, Torre and Rallet 2005, Wai-chung et al. 2006). Britton (2003) studies the electronics industry in the Toronto metropolitan region, and reports a median proportion of material inputs obtained from the Toronto region of only 25%. Rankings of input sources reveal that first- and second-ranked input sources for basic materials, as well as components and sub-assemblies, are frequently outside the Toronto region. Hendry et al. (2000), who study the clustering of opto-electronics companies in six regions of the UK, the US and Germany, find that national and international relationships are much stronger than local ones. Arita and McCann (2000) show that alliances among US semiconductor firms extend over a large geographical space of inter-urban connections. These studies suggest that linkage patterns are not necessarily local, but rather span over larger geographical areas. Spatial agglomeration seems to be one reason for maintaining linkage structures but, with adequate transport and communication infrastructure, linkages can also be maintained over larger distances. Increasingly, such linkages take the form of networks which operate

interregionally or even internationally. Johansson and Quigley (2004) argue that networks may in fact act as substitutes for agglomeration by providing similar utility gains and productivity increases. In the same vein, Cabus and Vanhaverbeke (2006, p. 47) show that network economies and 'agglomeration economies fuelled by geographic proximity' are two complementary types of external economies.

McCann (1995) argues that firms may choose to locate in the same area not because of the local linkages which unite them, but instead because the location maximises potential linkage contacts with other locations through, for example, access to infrastructure (e.g. airports, motorways, high-speed railway stations). In highly competitive and rapidly changing markets, the optimum location of firms with regard to other producers, inputs and customers changes frequently, and thus the potential for contacts can act as a location factor. Firms with very complex linkage structures presumably favour locations with a higher likelihood of access to potential suppliers and customers in different areas. Generally, these are areas of industrial agglomeration, as these tend to be locations with good transport connections to a variety of other locations. A sorting effect may thus occur i.e. there is increased networking among firms in industrial core areas, but this does not necessarily signify local or regional interactions among the firms located in the area.

In our empirical analysis we explore the relative importance of regional and extra-regional linkages of firms in regions of electronics sector concentration.

2.3.2 Different types of inter-firm relations may imply different spatial patterns

Various organisational solutions exist to overcome the costs and problems related to the coordination of spatial extent relationships: market processes, in-company hierarchical structures and inter-firm cooperation. Transaction costs may make alternatives such as networks and hierarchical organisational structures more efficient than market solutions.

We explore whether markets, hierarchies and external networks involve different spatial patterns. To do so, we analyse the geographical dimension of different types of inter-firm linkages: relationships among firms in arm's-length markets; networks in general (including subcontracting and other types of cooperation); and subcontracting networks. We also explore whether the spatial pattern of subcontracting differs when the company is deeply involved in intra-firm or inter-firm networking.

The relative importance of regional versus extra-regional linkages may vary between companies chiefly involved in inter-firm networking and firms predominantly involved in intra-firm networking based on hierarchies. Compared to other companies, multi-plant firms, and specifically multinational enterprises, may maintain stronger intra-corporate linkages that span over greater distances (Arita and McCann 2002). Rugman and Verbeke (2001) advise researchers to pay more attention to the non-location-bound FSAs (firm-specific advantages) created by the *subsidiary* to be diffused to the rest of the multinational network. In order to access skilled labour abroad and reduce costs, many electronics MNEs are currently offshoring their R&D (D'Costa 2002). To protect proprietary business procedures and other intellectual property rights, innovative activities are developed by subsidiaries or joint ventures located in host countries rather than by external subcontractors (Bardhan n/a). Some of the specialised high-

tech multinational laboratories recently launched in the Madrid electronics cluster are intended to cater primarily to the rest of the multinational network (Rama and Ferguson 2007).

The nature of the activity involved in the network relation may also influence the relative importance of regional versus extra-regional linkages. Where face-to-face contacts are required and where contracts and linkages must be renegotiated frequently, network partners will have a greater need for proximity. We explore whether different types of cooperation involve different spatial patterns of networking. To do so, we compare the geographical patterns of subcontracting i.e. of joint production and a variety of other activities performed by firms in conjunction with other companies.

2.3.3 Different company profiles may be associated to different spatial patterns of inter-firm linkages

Specific company characteristics may affect their spatial behaviour. Power theory and the transaction cost approach suggest that, on the one hand, the costs involved in setting up 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, as well as organisational capabilities. The leadership of specific firms in hierarchical networks is often based on the leader possessing these types of resources and, as a result, increased decision-making capacity within the network.

Size and age: 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. With age, firms gain experience of the quality and reliability of potential network partners, making it easier for established firms to find suitable partners, even in extra-regional locations. However, the literature is inconclusive with regard to the relationship between a company's age and its spatial patterns of inter-firm linkages. For instance, Bardhan and Jaffe (2005, p. 24) note, in relation to the high-tech companies located in Silicon Valley: 'Earlier, companies used to first outsource domestically, and perhaps later considering the foreign option. However, more recently, companies have shown tendencies to offshore business activities directly bypassing the domestic option'.

R&D: R&D intensity could discourage inter-firm linkages, as innovators attempt to protect specific know-how and intellectual property rights (Teece 1986). Nevertheless, companies in high technology sectors require an increasingly wide range of technologies to produce products, which forces them to look for outside suppliers for at least part of their innovation needs (Dyer and Singh 1998, Brusoni et al. 2001). Such knowledge might not be available locally, requiring firms to engage in extra-regional networking. At the same time, intangible assets such as technological know-how can also constitute an important resource in managing inter-firm relations. In particular, long-distance relations may require higher technological capabilities (Bartel et al. 2005).

We investigate whether certain company characteristics, such as size, age and technological intensity, may be related to specific spatial patterns of inter-firm linkages.

Company background in networking and the stability of relations: Firms furthermore differ in the degree to which they have previously established relations with other companies. If learning effects are important, then experience can provide firms with relevant networking information and reduce uncertainty. At the same time, companies with greater experience in inter-firm networking will already possess the ability to negotiate and enforce long-distance collaborations.

In exchange relations, trust is an additional resource, constructed upon stable relations and reducing the risk of opportunism. 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. Hoare (1985) argues that if inter-firm relations are stable, they can be planned more easily, and thus proximity is less important. In contrast, long-distance linkages are more difficult to organise and maintain than *ad hoc* relationships.

We investigate whether previous company experience of cooperation affects the spatial pattern of its inter-firm linkages.

Ownership and corporate organisation: 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. Similarly, foreign ownership may influence company management style and consequently affect spatial linkage patterns.

As Sudgen and Wilson (2003, p. 16) note, 'there is a clearly acknowledged regional dimension to globalisation'. According to international business (IB) literature, multinational enterprises (MNEs) are frequently attracted by agglomerations of value-added activities which are related to their own (Dunning 1998). The FSAs (firm-specific advantages) of certain subsidiaries result in part from the interaction of these companies with external networks, a situation that could encourage MNEs to imbed in specific regions (Rugman and Verbeke 1999). Conversely, policymakers have often sought to link localities to global markets by offering incentives to MNEs willing to invest locally (De Propris and Driffield 2006).

According to the majority of the empirical literature, however, the co-location of foreign facilities in an agglomeration does not necessarily entail strong linkages between subsidiaries and local firms. Empirical analyses of the electronics industries in different regions show two different patterns; some MNEs pursue a vertical integration strategy, having few linkages with local firms in spite of co-location, while others prefer an embeddedness strategy (Hendry, Brown and Defillippi 2000; Kearns and Görg 2002; McCann, Arita and Gordon 2002; Morris 1992; Turok 1993). When analysing subcontracting networks, previous research has usually ignored an important distinction, namely that between MNEs acting as clients and MNEs acting as subcontractors.

We investigate the linkages of firms with foreign ownership (FFOs) i.e. subsidiaries and joint-ventures, with local suppliers and clients; FFO spatial patterns are studied with regard to arm's-length markets, cooperation in general and, more specifically, in outsourcing relationships. When analysing subcontracting networks, we study FFOs as both clients and subcontractors.

3. Data

The data used in the following statistical analyses were obtained from an establishment-level survey conducted in 1999. The survey targeted electronics establishments whose chief activity was manufacturing. The sample of firms included in the survey was selected by consulting the ANIEL (the National Association of Electronics Industry) directory. From the 322 questionnaires sent to establishments in the Madrid, Catalonia, and Basque regions, we obtained 184 responses able to be employed in the present analysis.²

Our study is limited to the electronics industry for several reasons. First, by concentrating on a particular sector, the problem of unobserved heterogeneity is reduced, since firms in different sectors are likely to show different patterns of spatial behaviour, due to fundamental differences in product characteristics. One of the reasons for selecting the electronics sector is that cooperative agreements of the type studied in this paper have been increasingly used in this industry (see, for instance, European-Commission 1997). The electronics sector has attracted increasing attention from researchers, although analyses of Southern European countries, such as the present study, are rare. The particular interest in this sector stems from the fact that many successful firms are apparently clustered and benefit from local linkages (Arita and McCann 2002).

We concentrate on electronics firms located in Madrid, Catalonia and the Basque Country. According to figures based on the National Survey of Companies by the Spanish Statistical Institute (Instituto Nacional de Estadística- INE) for the year 1997, these three regions comprise 77.3% of all

establishments in the Spanish electronics industry. Madrid accounted for 28.2%, Catalonia for 41.2% and the Basque Country for 7.2%, and ANIEL (1998) estimates that together these account for over 84% of Spanish electronics production. Rama and Calatrava (2002) define these three regions as distinct clusters of electronics firms; remaining Spanish production is geographically dispersed among many other regions. The three selected regions include different sub-sectors of electronics production (Rama and Calatrava 2002): Madrid specialises in telecommunications, defence and industrial electronics, Catalonia in consumer electronics and the Basque Country in industrial electronics (for more details on the specific characteristics of production networks in these three regions, see Rama and Calatrava 2002). The sample is representative of establishments with over 20 employees³. The survey covers 61% of all such establishments in the Madrid region, 65% in Catalonia and 80% in the Basque Country. The survey also targeted small firms; in the final sample, 76 firms have 20 or less employees. However, our sample is less representative in this case, covering approximately 35% of such firms in Madrid, 10% in Catalonia and 20% in the Basque Country.⁴

The sampled companies were asked about the geographical origin of their purchases of inputs and their sales of outputs in arms'-length markets. Furthermore, with regard to cooperation in general (i.e. all types of cooperation), they were asked about the geographical location of their partners. Cooperations include, in addition to joint production or subcontracting, other joint activities of companies, such as inputs and machinery purchases, marketing, domestic commercialisation, exporting, after-sales services and R&D. Focusing more specifically on subcontracting, we asked clients to report on the geographical

location of their suppliers (subcontractors) and, similarly, subcontractors to indicate that of their clients.⁵ In order to evaluate the importance of intra-firm versus inter-firm networks, respondents were also asked to rate the importance of subcontracting within the group and with “external” companies i.e. firms unrelated to the respondent by ownership ties.

Other data collected by the survey at the establishment level list size, age, ownership, R&D intensity and prior cooperations. At company level, the survey includes information on the location of headquarters and the number of both local and extra-regional plants owned by the company.

Though the data refers to the late 1990’s, neither regional statistics nor recent studies point to recent crises or disruptions that might have changed the situation of the regional industries (ANIEL 2003; Molero and Hidalgo 2003).

4. Empirical results

4.1. Networks- general descriptions

Cooperations are very common among electronics firms in the three Spanish regional clusters, with subcontracting as the principal form of cooperation. Of the 184 companies in the sample, 94 engaged in some form of cooperation, and 88 of these in subcontracting.⁶ Within this latter group, 54 companies were involved in two-way subcontracting, by acting as both clients and suppliers. Underlining the importance of this specific form of subcontracting in the Spanish electronics industry, our result is consistent with Suarez and Rama’s (1996) findings on the electronics industry in Madrid.

Table 1A in the Appendix summarises various plant and company characteristics.⁷ Establishments involved in some form of cooperation or

specifically engaged in subcontracting are generally older, larger, and multi-plant. This contradicts the view that it is particularly small firms which employ external linkages to supplement and complement limited internal resources. The networking firms in our sample are also more R&D-intensive. It suggests that subcontractors are no longer mainly used as a source of cheap labour for the client, as was the case in an early phase of the Madrid electronics industry (Benton 1990). In line with other recent linkage studies, innovators in our sample make greater use of external linkages (see, for example, Eraydin and Armatli-Koroglu 2005).

4.2. Co-location and linkages

Do companies in industry agglomerations necessarily have intra-regional linkages? What is the relative importance of intra- and extra-regional linkages? Table 1 shows that, with few exceptions, firms in industry concentrations prefer to maintain links to the regional economy; extra-regional linkages are only more important than regional ones in the case of product sales and some types of in-house subcontracting, although they play a certain role in all company relations. Overall, almost 60% of network partners are located in the same region. This percentage is even higher when we confine our analysis to subcontracting relationships. For the pooled sample of the three regions, 82% of subcontracting firms externalised production principally to regional producers, 13% to producers in the rest of the country and only 5% to international producers. These figures are very similar to those of López (2001) and Rama et al. (2003) for subcontracting patterns among electronic firms in Spain and Madrid respectively, and confirm strong regional linkages among companies in

the three electronic concentrations in Spain. Rama and Calatrava (2002) suggest that these regions host relatively embedded electronics clusters.

However, while in the case of outsourcing regional companies are strongly preferred by the firms in the regional clusters, many of the latter also work for subcontracting clients outside their own region. This suggests an asymmetry in the spatial pattern of subcontracting; while clients find a large proportion of their suppliers within the region, subcontractors have a substantial number of their clients outside the region (though their regional clients are nevertheless more numerous than their extra-regional clients). As will be seen below, this asymmetry is probably explained in part by the characteristics of the linkages of subsidiaries and large firms.

4.3. Linkages and different types of inter-firm relations

In table 1 we also compare cooperations and, more specifically, subcontracting relations with relations among firms in arm's-length markets and relations based on hierarchical structures. Firstly, there is a clear geographical dimension to different inter-firm linkages. Network linkages are in general shorter than arm's-length⁸ input-output transactions. This suggests 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. Secondly, our results also indicate that subcontracting patterns differ between companies deeply involved in intra-firm networking and those primarily engaged in inter-firm networking. As table 1 shows, companies which declare that intra-firm linkages are very important to them tend to be more involved in geographically

extended networks, while those who place greater importance upon inter-firm linkages are more likely to form part of geographically limited networks. Firms which work as subcontractors within a company group extend linkages even further (i.e. beyond national boundaries) than output linkages based on arm's-length relationships. As discussed below, the international dimension of these subcontracting linkages may be attributable to Spanish subsidiaries and joint ventures undertaking subcontracted tasks for the rest of the multinational network.

This result suggests that organisational structures are important for securing outsourcing contracts over long distances and, particularly, internationally. The plants in our sample which report significant in-group subcontracting are also more likely to maintain other types of cooperations, such as joint purchasing of inputs and materials, joint commercialisation in Spain, joint post-sales services and joint R&D.

Table 2 presents the geographical location of partners of sampled firms that have engaged in various forms of cooperation. Production networking (e.g. joint production or subcontracting) is the most localised type of cooperation, together with the joint purchasing of inputs and materials. In contrast, firms engaged in cooperations involving joint export activities and joint technological innovation have more spatially extensive relationships. On average, approximately 17% of firms' network partners are located in other countries. Firms engaged in networks that involve joint export activities and in networks involving technological innovation display a greater extent of cross-border cooperations than other types of cooperation. Comparing the average percentage of international linkages of firms involved in these types of cooperations with those

not involved shows a statistically significant difference. Firms with joint exporting cooperations report on average 32.4% of cooperations with partners located in other countries versus 14.7% of firms with no such type of cooperation (significant at the 5% level). For firms with R&D cooperations, 27.8% of partners are located in other countries versus 9.3% of firms with no R&D cooperations (significant at the 1% level). Little information is available regarding international cooperation agreements and cross-border linkages, but the above figures suggest that such linkages are far from negligible in the electronics industries. Henderson et al. (2002) and Dicken et al. (2001), for example, have emphasised the complexity of international inter-firm relations.

4.4. Linkages and different company profiles

We now analyse which establishments maintain predominantly regional linkages and which prefer extra-regional linkages. The results offered in Table 3 indicate that larger establishments are more successful in participating in extra-regional subcontracting networks. Size appears to be particularly important in securing subcontracts outside a plant's own region. The difference in age does not seem significantly different when we compare the percentage of firms established before 1980 for regional and extra-regional networking. However, we do find that older plants (those created before 1980) have a higher percentage of cooperations within the European Union (16.6% compared to 6.7%, significant at the 10% level). In contrast, plants established after 1980 have a higher percentage of cooperations within the rest of Spain (28.7% compared to 14.8%, significant at the 5% level), although companies in both age groups show very similar percentages of regional cooperations.

Regarding R&D, our results show that there is not only a positive relationship between R&D intensity and inter-firm networking, but also that extra-regional networking is more common among R&D-intensive firms. As suggested earlier, such firms may not be able to find the necessary capacities within their own region, and thus openness seems particularly important in terms of knowledge and information exchange. The results also confirm the importance of experience and lend support to the hypothesis of trust being essential to the establishment of extra-regional subcontracting networks. Firms integrated in such networks generally have a substantially higher number of prior cooperations, while 80% of such companies also report that more than half of their prior relationships are still functioning, compared to 53% of firms which have only local subcontracting relationships. Sacchetti and Sudgen (2003) believe stability and duration in relationships to be key determinants of mutually dependent (polycentric) networks that create entrepreneurial instead of geographical proximity.

Our results also indicate that the organisational structure of a company outside its own region is related to the spatial extent of subcontracting. Regional subcontracting is more common among firms whose headquarters are in the same region and which have fewer plants in other regions. In other words, having headquarters or plants in other regions seems to facilitate extra-regional subcontracting, which may be due to subcontracting taking place primarily within the group to which a plant belongs. To control for this possibility we exclude establishments which declare that intra-firm subcontracting is important to them. There is still, however, a significant difference in the mean number of extra-regional plants between those companies that subcontract mainly locally

and those that predominantly subcontract across localities (3.2 compared to 0.4, mean difference significant at the 5% level).⁹ The positive relationship between extra-regional company headquarters and plants and higher extra-regional subcontracting suggests that local knowledge about possible network partners is important. Company presence outside an establishment's own region might help to access such knowledge, while firms with a presence in multiple regions are also more likely to have the necessary power to supervise and enforce contracts with firms in other regions. The spatial configuration of establishments within firms is an important factor that has not been examined sufficiently in the existing empirical literature.

Regarding ownership, the difference between the share of FFOs (i.e. subsidiaries and joint ventures)¹⁰ in extra-regional networks and local networks is not significant. Nevertheless, there are significant differences in the spatial network pattern of FFOs and domestic companies (table 4). Confirming their greater import intensity, FFOs source fewer inputs locally and more from abroad than domestic firms; almost half of their inputs are sourced from abroad, while sales also take place predominantly abroad. Similarly, FFOs have a significantly lower percentage of local network partners and a significantly higher percentage of partners outside Spain. On average, over one-third of their network partners are located abroad, compared to 14% in the case of domestic firms.

As clients in subcontracting networks, FFOs subcontract more to international partners than domestic companies do; however, as table 4 shows, the FFOs' proportion of regional suppliers is still considerable. As subcontractors, FFOs also tend to be involved in geographically extended networks, which must be seen in the context that FFOs prefer intra-group to inter-group cooperation. Our

results show, for example, that 42.9% of FFOs network partners rate intra-group networking as important, compared to only 16.2% of domestic network partners. The circular business activity of MNEs might be as follows: as FFOs in our sample are R&D-intensive, they are likely to perform some offshore work as subcontractors to other members of the multinational network (the clients). Conversely, acting as clients, these FFOs outsource chiefly within the Spanish regions in which they are located. Spain can probably offer competent and trustworthy subcontractors who, most importantly, are usually cheaper than their competitors in the home country of the MNE. In turn, location in agglomerations can provide FFOs with accurate information about potential subcontractors. In other words, such FFOs would simultaneously pursue an embeddedness strategy and a strategy of cross-border vertical integration. Although further research is needed to clarify the question, this preliminary interpretation is consistent with the current literature on offshoring in the electronics industry (Bradham and Jaffe 2005) and with research into this sector in Madrid (Rama and Ferguson 2006).

5. Conclusions

This paper explores the spatial patterns of economic linkages of firms in three Spanish regional concentrations of electronics firms. While our results show that regional linkages are generally the most important, the evidence also indicates that firms in clusters maintain significant extra-regional and international linkages. The spatial extent of linkages depends on the mode of relations; arm's-length, network and hierarchy relations display different spatial patterns, while proximity is more important for networking than for arm's-length

relationships. Secondly, different types of cooperation imply different spatial patterns, with joint exports and R&D cooperation involving more extra-regional and international linkages. Thirdly, subcontracting linkages are among the most localised relations, suggesting that they involve close contacts for which proximity is desirable. However, our results also indicate that subcontracting relations within company groups are much less spatially constrained. This provides support to the concept of organised proximity and its importance in overcoming geographical distance. Different company profiles are associated with different spatial patterns of inter-firm linkages; our analysis suggests that such differences may have been responsible for the inconclusive results provided by the academic and policy literature.

Extra-regional and international linkages are more common among firms with characteristics which imply the exercise of power within a network of companies i.e. considerable size, ownership of intangible assets, multi-plant organisation or multinational organisation of production. However, the sampled subsidiaries also have important regional linkages; our results do not support the idea that such companies are centred on relationships with their headquarters and the rest of the multinational network.

The results also confirm the importance of prior experience in cooperation and trust among partners for the establishment of these types of network. This result appears to confirm Sachetti and Sudgen's (2003) theory that the stability and duration of relationships are fundamental for the creation of networks of mutually dependent firms that create entrepreneurial rather than geographical proximity.

Our results suggest that different types of linkages should be stimulated, in order to promote local economic development. While inter-firm subcontracting is particularly important to promote regional linkages, encouraging extra-regional sales and inter-firm cooperation through joint R&D and joint exports can contribute to the openness of networks. Our study indicates that encouraging SMEs and the creation of new firms could promote more regional linkages, as claimed by De Propris and Driffield (2006). Subsidiaries are likely to engage not only in regional linkages but also extra-regional and, especially, international linkages, further contributing to the openness of localities. Attracting FDI is one potential way of promoting local and regional economic development. However, it should be noted that, in our study, the three electronics concentrations existed before most MNEs arrived (Rama and Ferguson 2007), and it has been claimed that the launching of subsidiaries is more likely to play a positive role at the local level when clusters and networks already exist (De Propris and Driffield 2006).

A final note of caution should however be sounded. In this paper, we have presented relationships between different types of cooperations, a number of plant-level characteristics and the spatial extent of these relations. It is important to emphasise that the findings show associations and are exploratory, but should not be taken to suggest causal relations. Firms make decisions regarding cooperations and their spatial extent together with a series of other decisions concerning other company- and plant-level characteristics. With the data available in this study it is beyond the scope of this paper to control for all this factors as well as the simultaneous nature of many of these decisions.

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Notes:

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- ¹ By extra-regional linkages we understand relations with firms located outside the Autonomous Community where the surveyed plant is located, including both inter-regional and international linkages.
- ² Of the sampled establishments, 79 are located in Madrid, 82 in Catalonia and 23 in the Basque Country.
- ³ We study establishments with over 20 employees because this is the size of establishments considered in Spanish statistics, and we can therefore compare our sample to the population.
- ⁴ The analysis presented in the following section has been re-run with a size-weighted sample, producing very similar results.
- ⁵ Subcontracting refers to the outsourcing of production activities and does not include the outsourcing of services which could show a very different spatial pattern.
- ⁶ 85 establishments subcontracted, while three worked exclusively as subcontractors.
- ⁷ Analyses in this table as well as the remaining tables are based on TTest of mean comparison for continuous data and cross tabulations with Pearson χ^2 for categorical data.
- ⁸ 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).
- ⁹ Similarly, for those companies that report high levels of subcontracting with other firms, the mean difference in the number of plants outside their own region between companies that subcontract primarily locally and those whose subcontracting is predominantly across localities is also significant.
- ¹⁰ In joint ventures, the share of foreign capital is 50% or less.

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Table 1. Spatial extent of inter-firm linkages: markets, hierarchies, and networks

	% Same region	% National	% Inter- national
Markets			
Purchase of inputs ¹	51.0 *	24.6 *	24.3 *
Sales of outputs ¹	46.2 *	36.2 *	17.5 *
Networks in general			
Cooperations ²	59.2 *	22.8 *	18.0 *
Subcontracting (location of provider) ²	81.9 *	13.3 *	4.8 *
Subcontracting (location of client) ²	54.7 *	34.0 *	11.3 *
- External networks: inter-firm subcontracting			
Cooperations ³	57.2	25.9	16.9
Subcontracting (location of provider) ⁴	79.3	15.5	5.2
Subcontracting (location of client) ⁴	58.3 **	36.1 **	5.6 **
- Hierarchies: intra-firm subcontracting			
Cooperations ³	52.0	19.6	28.4
Subcontracting (location of provider) ⁴	80.0	13.3	6.7
Subcontracting (location of client) ⁴	46.2 **	23.1 **	30.8 **

Note: * denotes significance at the 1% level, ** the 5% level, and *** the 10% level.

¹ Ttest of equality of group means between % of inputs obtained from and outputs sold in the respective zones compared to location of subcontracting providers and clients respectively

² Ttest of equality of group means between % of network partners, subcontracting providers and clients located in the respective zones.

³ Ttest of equality of group means between % of network partners located in the respective zones of external networks versus hierarchies.

⁴ Pearson chi² test of independence between main location of subcontracting providers and clients in external networks versus hierarchies.

Table 2. Type of cooperation and spatial extent of linkages

Cooperations involving:	% of network partners located			international		No. of firms
	in same region	national	inter-national	of which EU	of which others	
Joint production	60.9	22.2	17.0	10.6	6.4	86
Joint purchases	61.5	19.5	19.0	13.0	6.0	20
Joint marketing	52.0	27.8	20.3	9.5	10.8	20
Joint sales	53.7	26.1	20.2	13.3	6.9	35
Joint exporting	52.2	15.3	32.4	16.5	16.0	15
Joint after-sales service	53.0	27.6	19.3	11.7	7.6	23
Joint tech. innovation	51.5	20.7	27.8	15.3	12.6	39
All cooperations	57.2	22.0	17.3	10.2	7.2	94

Note: Statistically significant tests as indicated in the text.

Table 3. Regional versus extra-regional networking and establishment characteristics

	Cooperations		Subcontracting		Work as subcontractor	
	Regional	Extra-regional	Regional	Extra-regional	Regional	Extra-regional
Number of establishments	47	38	68	15	29	24
Age and size						
Age: % of establishments created before 1980 ²	53.3	65.8	53.7	60.0	67.9	45.8
Size: average number of employees ¹	206.1	416.6	135.0	267.3	31.4	142.6 *
Size: average sales (in thousand euros) ¹	7936.4	68592.9***	36633.2	78415.1	3330.9	20344.4*
R&D						
R&D per employee (in euros) ¹	6614.2	13750.8 ***	9312.5	15147.4	7760.7	10486.7
Average number of engineers ¹	7.1	53.0 *	24.8	80.2 **	7.3	40.2
Firms that launched new products ²	90.70	92.1	92.2	93.3	89.4	91.7
Average number of new products ¹	13.0	6.2	13.4	7.3	12.9	11.9
Average share of new products in total sales ¹	36.2	38.1	34.5	37.5	31.0	42.6
Firms that launched new processes ²	50.0	55.9	46.7	71.4 ***	54.2	72.7
Average number of new processes ¹	3.17	1.46	2.5	2.3	1.3	1.5
Prior cooperations						
Average number of prior cooperations ¹	12.5	23.2	12.3	42.1 *	12.9	21.7
>50% of cooperations still existing ²	62.1	66.7	53.3	80.0 ***	58.3	57.1
% of firms that describe relationships as stable ²	65.8	67.4	66.7	60.0	60.7	56.5
Ownership and corporate organisation						
% of multinational firms ²	12.77	16.22	16.1	7.1	10.3	8.7
% of headquarters outside the plant's region ²	4.26	10.53	5.9	26.7 **	6.9	16.7
% of multi-plant firms ²	27.66	36.84	32.3	26.7	31.0	45.8
Average number of plants in same region ¹	1.09	1.16	1.2	1.03	1.03	1.25
Average number of plants in the rest of Spain ¹	0.6	1.89	0.6	2.7 **	0.8	2.3

Note: Columns headed “local” summarise the characteristics of establishments with more than 50% of their network partners located within the same region. Columns headed “cross-locality” report characteristics of establishments with more than 50% of network partners outside their own region. * denotes significance at the 1% level, ** 5% the level, and *** the 10% level.

¹ Comparison is based on Ttest of equality of group means between firms with predominantly regional and extra-regional networking.

² Comparison is based on cross tabulation and Pearson Chi-square test of independence.

Table 4. Spatial extent of linkages: domestic firms versus FFOs

	% Same region	% National	% Inter- national
Domestic firms			
Purchases of inputs ²	54.5	25.4	20.1
Sales of outputs ²	49.5	35.7	14.7
Cooperations ²	63.3	22.6	14.1
Subcontracting (location of provider) ³	82.4	14.7	2.9
Subcontracting (location of client) ³	56.5	37.0	6.5
FFOs¹			
Purchases of inputs ²	29.7 *	21.0	48.9 *
Sales of outputs ²	28.3 *	38.9	32.9 *
Cooperations ²	40.6 **	23.4	36.1 **
Subcontracting (location of provider) ³	85.7 ***	0.0 ***	14.3 ***
Subcontracting (location of client) ³	50.0***	16.7 ***	33.3 ***

Note: * denotes significance at the 1% level, ** the 5% level, and *** the 10% level.
¹Firms with foreign ownership (subsidiaries and joint ventures)
² Comparison is based on Ttest of equality of group means between domestic firms and FFOs..
³ Comparison is based on cross tabulation and Pearson Chi-square test of independence

Appendix

Table A1: Networking and plant and firm characteristics

	Cooperations		Subcontracting out		Work as subcontractor	
	yes	no	yes	no	yes	no
Number	94	90	85	96	57	121
Age and size						
Age: % of establishments created after 1990	17.4	22.2	13.3	24.0 ***	16.4	19.8
Size: average number of employees	326.3	42.7	356.8	41.0 ***	373.4	106.3
Size: average sales (in thousand euros)	39830.0	5447.7**	43670.3	5171.7 **	12006.8	27511.4
R&D						
R&D per employee (in euros)	9285.2	4024.0 *	10194.7	3922.9 *	8361.4	6072.0
R&D expenditure as proportion of total sales	6.6	3.7*	7.0	3.6*	6.8	4.4 **
Average number of engineers	32.4	5.9 *	35.1	5.6 *	20.9	18.9
Firms that launched new products	91.1	67.8 *	92.5	67.7 *	90.7	74.4 *
Average number of new products	11.8	3.9 *	12.3	4.0 *	12.4	6.0 ***
Average share of new products in total sales	35.6	21.9 *	34.7	22.9 *	36.6	25.0 **
Firms that launched new processes	51.2	42.4	50.7	42.9	61.2	40.0 *
Average number of new processes	2.3	0.99	2.40	1.03	2.95	1.05 ***
Ownership and corporate organisation						
% of multinational firms	17.20	5.56 *	15.48	6.25 **	10.71	9.92
% of headquarters outside establishment's region	8.51	1.11 **	9.41	1.01 *	10.53	2.48 **
% of multi-plant firms	31.91	5.56 *	32.94	6.25 *	36.84	9.92 *
Average number of plants in same region	1.17	0.99 ***	1.21	0.97 **	1.19	1.04
Average number of plants in the rest of Spain	1.11	0.16 **	1.16	0.19 **	1.6	0.18 *

Note: * denotes significance at the 1% level, ** the 5% level, and *** the 10% level. Statistical tests as in Table 3.