New Economic Agents and New Forms of Concertation in the Electronics Industries of Madrid: Lessons for Emerging Regions

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Abstract:

Because outsourcing networks are a defining characteristic of modern industrial districts and embody alternative forms of co-operation or concertation, we propose that an analysis of actors involved in outsourcing will prove useful for developing a strong empirical basis for comparing the nature of economic agents, their resilience faced with industrial crises and the long-run potential for innovation at the local level. In this paper, we derive the outsourcing characteristics hypothesized in contemporary typologies of industrial districts and test them against a sample of 79 producers from the electronics district of Madrid. First, while most previous research classifying industrial districts emphasizes the degree of local embeddedness, plant size, and internal connectedness of producers, we present a model elaborating on this latter characteristic by focusing on the incidence of subcontracting among producers and their respective roles, both symmetrical or assymetrical, in networks. Second, we calculate several key indicators (size, degree of embeddedness, ownership, involvement and role in subcontracting) of electronics producers in Madrid, and test them against our model. Finally, we characterise the subcontracting relationships among these producers and distinguish them from those associated with several other well known "archetypical" industrial district forms. Our findings suggest that Madrid's emerging electronics and telecommunications industrial district resembles a high-technology district based strongly on non-hierarchical forms of concertation. Distributed processes of innovation take place chiefly among small and large firms, both domestic and foreign-owned, during outsourcing rather than between public institutions and companies.

To further apply our methodology we also analyse the Campinas (Brazil) electronics and telecom equipment district. We propose that before the implementation of structural policies in Brazil, the Campinas district was a "state anchored-district". Providing funding for R&D and captive markets for new products, the state was an important stimulus to innovation. However, the Campinas district has evolved towards a hub-and- spoke district that is based on hierarchical forms of concertation. The large subsidiaries turn now toward their parent firms for R&D. Local SMEs, deprived of both public funding for their innovative activities and non-market linkages with other firms, exited the telecom equipment market or, at least, that of the most sophisticated items

The electronics industry of Madrid and the telecom cluster of Campinas (Brazil) were each affected differently by the privatisation and liberalization of markets for telecom services and equipment in their respective countries. After a period of industrial turbulence, closings and destruction of jobs, such policies had a long-run positive impact on the Madrid district. However, they had a negative impact on the Campinas district, at least as the local industry and local capabilities were concerned. We suggest that the pre-existing relationships among firms and the prevailing forms of concertation in each of the district before policies were implemented had something to do with such differences. The reshaping and alternative strategies of key agents (or the absence of such strategies) also help to explain the divergent evolution in each of the electronics districts under similar initial shifts in public policy.

Key Words: electronics industry, telecommunications, industrial districts, Madrid, Brazil, subcontracting, networks, concertation

Regional scientists have in recent years proposed typologies of "new industrial districts" as frameworks for comparing dynamic regional economies at the turn of the twenty-first century. These efforts spring from our need to identify why some regions seem to anchor productive and R&D activity in a world of increasing capital mobility – or as MARKUSEN, 1996, questions, why some places remain "sticky" within an increasingly "slippery" global economic space. It is especially important to find common, objective ground for comparing districts and, hence, for possibly applying policies found to be successful in one type of district to others. Recent literature documents a number of local industrial district configurations (PARK, 1996; MARKUSEN, 1996), beyond the paradigmatic "flexibly specialized" district of small, innovative Italian producers studied by PIORE and SABEL, 1984, and others (BRUSCO, 1986; BECATTINI, 1990) which appear to be capable of sustaining rapid growth or weathering industrial decline. While these new typologies have advanced over important theoretical terrain[1], empirical studies exploring or testing them are relatively few, frequently due to a paucity of appropriate data. Empirical studies confirming or amending these models continue to be relatively few in number. Moreover, with few exceptions (e.g., SIGNORINI, 1994), current empirical literature on local industrial districts tends to be more qualitative than quantitative in nature.

In this paper, we contribute to a more practical and refined definition of industrial districts by 1) identifying, in the literature, some of the key subcontracting characteristics of industrial districts and the type of distributed R&D they involve and 2) testing to which archetypical industrial district form the attributes and roles of Madrid's electronics establishments are associated. Finally, to apply further our methodology, we briefly compare the Madrid and the Campinas (Brazil) telecommunication districts.

Key aspects taken into consideration in this paper are the forms of concertation[1] in subcontracts and characteristics (size, ownership) of agents involved in subcontracting networks.

We analyse local subcontracting because it is a central, defining characteristic of modern industrial districts, yet varies significantly in its scope and nature across different kinds of districts. The shift to subcontracting as a general trend in electronics production, or perhaps, even as a new production *paradigm* (STURGEON, 1999), has been driven by a number of factors, including the introduction of modern flexible manufacturing technologies, rapidly

[1] Following COOMBS et al (2001), we use the neutral term concertation to describe vertical subcontracting relations recurring on a regular basis rather than the term co-operation, which has a positive connotation that is not always realistic.

changing final markets, the greater importance of specialized and flexible services within production chains, and the explosion in information technologies. Yet, we still see wide variations across regions and industries in the spatial and organizational forms of production subcontracting and their corresponding district "type." Outsourcing networks are often identified as important sources for the diffusion of new technologies and best practices for smaller firms (BROWN and HENDRY, 1997; COOKE and MORGAN, 1993; DE BRESSON and AMESSE, 1991; DEARDOFF and DJANKOV, 2000; FREEMAN, 1991). As a result, the spatial and functional organization of subcontractors in relation to their client firms bears directly on the quality and degree of technological learning – and the pace of innovation – in local production complexes. In this way, regional outsourcing structures are then closely related to variations in regional competitiveness and development. A conventional view, for example, is that a region with a few dominant manufacturers who are the sole clients to a cluster of smaller subcontractors (a "hub-and-spoke" model) is less likely to foster the diffusion of technical knowledge and innovative products or processes than a region whose firms are more autonomous, acting as both clients and subcontractors, in a network of non-hierarchical collaborative linkages (e.g., a reflexive "high technology" model). A high incidence of two-way subcontracting, a characteristic of high technology districts, can have a positive effect on innovative activities as establishments involved in such arrangements are likely to display higher R&D outlays with respect to the number of employees or revenues than other plants (SUAREZ-VILLA and RAMA, 1996).

New approaches to innovation often emphasize the distribution of activities among a variety of interacting agents (both firms and institutions). They focus on the importance of enduring and socially embedded relationships, as opposed to ad-hoc collaboration, among innovators (COOMBS et al, 2001). This view considers that identification of power asymmetries in networks and the role of agents is essential for understanding distributed systems of production and innovation. Given that subcontracting networks may feature a range of possibilities in governance, identifying the incidence and nature of subcontracting within regional industrial districts highlights the potential for endogenous innovation within specific sectors or industries.

In the next section, we briefly describe several of the archetypal industrial districts that have been proposed and their subcontracting attributes. We then present the development context of the Madrid electronics industries, followed by a section outlining the nature and location patterns of electronics producers in the region. Then, we analyse the attributes and roles

of Madrid' s electronics subcontractors, testing the degree to which their structure conforms to several of the district models. In both sections, we present a dynamic view of the districts. Comparing our results with research on the Campinas telecommunication district, we deduce from our analysis some lessons for emerging regions in Southern Europe and in semi-industrialized nations. We finish with concluding remarks in the last section.

IDENTIFYING SUBCONTRACTING CHARACTERISTICS OF INDUSTRIAL DISTRICTS

Although there is wide variation among different types of industrial districts, we can study them by focusing on several core elements. Departing from its earlier "Marshallian" or more recent "Italianate" formulations, the term "industrial district" has come to include a number of possible configurations of productive activity (HARRISON, 1992; MARKUSEN, 1996; PARK, 1996; STORPER, 1990; STORPER and HARRISON, 1991; STORPER and SCOTT, 1989). While there is still little agreement on exactly what constitutes an "industrial district" (MALMBERG, 1996), we consider an industrial district as a set of producers (establishments) in relatively close territorial proximity who participate in a common input-output system, with each contributing to the production of a relatively narrow set of related products overall. What separates an industrial district from other forms of organization are its relative industrial specialization, its dynamism or sustainability over time, a marked territorial agglomeration of a significant number of establishments, a significant share of total regional employment, and a relatively high measure of inter-firm exchange in products, services, and information. Contemporary industrial district theory emphasizes the importance of non-economic institutions, common codes of behaviour, and relations of "trust" among firms in the district (HARRISON, 1992). However, we argue that while quite valid and important, such phenomena, or "untraded interdependencies" (STORPER, 1995), are difficult to observe, much less quantify, and that constraining the definition of "industrial district" to a subjective assessment of the institutional context hampers efforts at developing, testing, and refining industrial district models. Moreover, it has been shown that even within regions branded as "industrial districts," the social relations underlying the cohesion of each district can be quite varied (DIGIOVANNA, 1996), and supporting institutions (organizations) vary widely in importance (RABELLOTTI, 1995).

Within this broad definition, one may find a range of fundamentally different types of districts, each with presumably different consequences for regional development, growth and innovation. Foremost among these characteristics are the modes of concertation in the district.

For example, whether transactions among firms are horizontal (subcontracting) or vertical (supply chains), or in the form of non-market relations, are questions closely tied to the social division of labor within the district, or the level of phase or product specialization found among companies within the district. Furthermore, the nature of inter-firm contracting and relations in large part set the conditions for upgrading, innovation, and entrepreneurship within the district.

While these have become "standard" developmental referents in the industrial districts literature, they have arisen mainly inductively, from a relatively narrow sample of case studies of particular industries and locations. Some authors (MARKUSEN, 1996; PARK, 1996) have amalgamated these findings to propose typologies of industrial districts as a step toward relating the formative elements above to several aggregate characteristics, such as:

- *Firm size.* Is the district dominated by one or several large local producers ringed by a network of small producers, or does it consist of many small, local firms, or is it dominated by branch plants of firms located elsewhere? The mix of firms by size in the district is taken to reflect the social division of labor and distribution of power within the district.
- *Connectedness in networks.* How much and on what basis do local producers within the district interact with each other? Which and what share of firms play the role of "client," "subcontractor," or both? The role of producers in supplier and/or customer networks reflects the direction of information flow (hierarchy) and the degree of collaboration within the district's networks, which may ultimately affect the pace of innovation and specialization.
- *Local versus non-local embeddedness.* Are supplier and/or customer networks primarily local or non-local? A greater local embeddedness of production increases the likelihood of greater inter-firm interaction and incremental innovation. However, some degree of non-local interaction is also important to prevent technological "lock-in."

Using these three characteristics, both Park and Markusen develop models of industrial districts. Three "archetypal" types are common to both authors: the Marshallian district (including the Italianate version), the hub-and-spoke district, and the satellite platform district. While Park also develops several hybrids (for a total of nine specific types) based strictly on the characteristics above, Markusen proposes an additional, qualitatively distinct "state-anchored" district, a special case where much of the stimulus to the district comes from one or several large, government institutions, such as a military base, research laboratories, universities, or from proximity to state or national capitals. Long-term prospects of growth depend on prospect for government facilities at the core of district.

In each of these archetypal industrial districts, the intensity and nature of inter-firm linkages, which, we argue, are increasingly dominated by subcontracting linkages for intermediate goods, are central defining characteristics. While many other forms of concertation may and do exist, we take the level of subcontracting as a common and precise definition of the meaning of firms "being related" (MALMBERG, 1996, p.399), and as a concept which is reproducible and quantifiable in various settings. In his studies of intra-metropolitan location, SCOTT (1983a, 1983b, 1983c) has also identified the nature and intensity of subcontracting relations as being of "first importance" in understanding the character and spatial configuration of industrial districts. Depending on the district type, the nature and degree of subcontracting will vary, as outlined in Table 1.

--Table 1 about here--

From the perspective of intra-district subcontracting, industrial districts may be characterized by two major types of subcontracting. *Capacity* subcontracting characterizes the hub-and-spoke archetype, where subcontracting is substantial but mostly unidirectional, with a ring of small producers supplying large, dominant producers with intermediate products. The "hub and spoke" configuration typifies the dominant role played by large producers within a region in managing their needs for production capacity, resulting in a hierarchy of "simple" subcontractors (e.g., GRAY *et al*., 1996). In this hierarchical configuration, very large client firms are surrounded by a myriad of small to medium sized satellite contractors, who are often dependent on clients for new technologies and innovations.

Alternatively, *collaborative* subcontracting characterizes the non-hierarchical "Marshallian" archetype, where subcontracting is substantial and bi-directional, with small producers acting as both suppliers and customers. This "egalitarian" industrial district may rely on non-hierarchical inter-firm interdependencies grounded in both formal networks of production and informal networks of cooperation, often locally embedded in distinct locations where historical and institutional circumstances permit more intensive collaboration, and ultimately, greater innovation and a competitive edge in rapidly serving new or specialized markets. The most studied model representing this type is that said to describe Italian industrial districts, where high levels of cooperation among small and medium sized firms enable them to compete with vertically integrated large firms which are seldom deeply involved in subcontracting networks (BECCATINI, 1990; SIGNORINI, 1994).

Collaborative subcontracting is also a hallmark of the "technology district," the third type of district outlined in Table 1, which has been prominently studied by regional scientists (LYONS, 1995; STORPER, 1997). PARK (1996, p. 484) identifies the "pioneering high

technology" district, which exhibits a "complete network system" of suppliers and customers, with producers' roles in the network independent of their size (thus, distinguishing it from the Marshallian district). Production and cooperation in these districts are locally embedded, as well as linked with external producers through cooperative agreements or strategic alliances. This type of district is characterized by both local and non-local intensive linkages among both suppliers and customers, reflecting its specialization and ability to compete globally. Both large and small production units make use of flexible production systems, with small units engaging in two-way, decentralized subcontracting and larger system houses providing linkages to extensive non-local networks of production and final markets. This configuration is largely that described by STORPER (1997, Chapter 8) as a technology district being able to carry out continuous product innovation and "product based technological learning," and thereby capturing export-oriented "absolute advantage." In Table 1, we hypothesize that the high technology district is characterized by a substantial degree of both intra- and inter-district subcontracting, as well as a prominent share of producers, both large and small, engaged in two-way subcontracting.

The subcontracting characteristics of the "state-anchored" district, not shown in Table 1, warrant mention. In MARKUSEN's (1996) "state-anchored" district, noted above, subcontracting occurs mainly among the district's few dominant institutions and suppliers, rather than among a decentralized array of small and large producers as in the "classical" district model. Co-operation among private firm sector companies to share risk and innovation is low. The sources of innovation are mainly institutions and large local Universities.

As noted by MARKUSEN (1996), these are archetypes. In practice, one observes mixtures of such models. Moreover, the characteristics of industrial districts may change significantly over time. The management literature provides important tools for understanding such changes. In considering the dynamics of economic concertation, it focuses on the formation of vertical relationships between economic agents, patterns of dependency and power, and processes of reformation or decline (COOMBS et al, 2001). Examples of such changes include the break-up of monopolies, the incorporation of new agents having different capabilities, etc.

In the following section, we briefly describe the history and current status of Madrid's electronics and telecommunications industrial district. While the district was initially influenced by the strong presence of the state, it already displayed some of the traits of an emerging high-tech district by the late 1980s. We propose that such traits have been accentuated by a

diversification of private clients and increased international linkages, following the period of crisis and increased competition inaugurated by telecommunications liberalization in Spain.

THE REGION OF MADRID AND THE ELECTRONICS INDUSTRIES

The region of Madrid

As the capital region of Spain, Madrid is one of the most economically dynamic of Spain's 17 autonomous communities (MYRO, 1999), and perhaps of the EU (IRANZO *et al*., 1993). The region is home to about 13% of Spain's population, with over 5 million inhabitants, and generates about 16% of the national GDP. Since Spain's entrance into the EU in 1986, the region's economy has undergone rapid development of services and modernization.

The Spanish electronics industries

The Spanish electronics production amounted to around 8 bn € in 2001[2]. Spain ranked fifth in the EU-15 in telecommunication equipment and in consumer electronics products (YEARBOOK OF WORLD ELECTRONICS DATA, 1999). The most important products are telecommunications equipment (28% of Spanish electronics production), followed by components (23%), consumer electronics (20%), and professional electronics, which include defence and industrial equipment (14%)[3]. The consumer electronics industry is arguably Spain's most export-oriented, given the combination of its high share and rapid growth of exports since 1994 (24% and 22% annually, respectively). However, telecommunications equipment contributes the greatest share to electronics exports (49%), though its exports have grown relatively slowly since 1994 (ANIEL, 1997, 1998a, 1999).

Spanish electronics firms tend to cluster mainly in Madrid, Catalonia and the Basque Country (79% of the total number of plants). Each regional group of electronics industries display distinct features and structures. While Catalonia specializes in consumer electronics and components, professional electronics production in Spain, primarily defence and industrial equipment, remains concentrated in Madrid (59%), as does telecommunications and information systems (hardware and software) production (ANIEL, 1998a). Madrid's specialization in professional electronic and telecommunications equipment is largely a political result of the initial importance of the state in its purchases of electronic equipment, and the establishment of the state monopoly in telecommunications (ESTEVAN, 1988; DE DIEGO GARCÍA, 1995).

[2] www.aniel.es
[3] ANIEL, 2001 data.

Madrid's electronics firms show a high degree of technological autonomy – a dependence on in-house innovation rather than on licenses and other external sources – when compared among 582 other innovating regional companies (MOLERO and BUESA, 1996, p. 652).

Contract electronics manufacturing (CEM) in Spain is growing at a rapid rate. This prompted the national electronics industry association, ANIEL, to begin tracking the growth of CEM activity in 1997. Production of Spanish subcontractors (including telecommunications service providers) grew by nearly 50% between 1997 and 1999, a rate that was well above that of the total electronics sector in Spain, which amounted to 20% (ANIEL, 1997, 1999).

The end of the telecom services and telecom equipment monopolies

The privatisation and liberalisation of telecom services and equipment put much stress on Madrid electronics producers. However, they proved resilient to the crisis and many took advantage of the new opportunities provided by the entry of new agents and, especially, by the reshaping of the old monopoly.

By the middle to late 1970s, Telefónica[4] (the state-run monopoly), INTELSA, its parent company and "national champion" in telecommunications equipment, and the state-owned trust, INI (Instituto Nacional de Industrias), came to control a powerful manufacturing infrastructure (SUÁREZ-VILLA and RAMA, 1996). INTELSA's location in Madrid encouraged other electronics producers to locate there. Greater competition swept over the sector at the beginning of the 1990s with the anticipation of the liberalization of telecommunication services[5], forcing Telefónica to rationalize its purchases of equipment. National suppliers were no longer systematically preferred, introducing greater competition in the market for telecommunications equipment in several ways. In addition, the market for terminals was liberalized in 1991[6]. While

[4] Unlike other European telecom monopolies, Telefónica was founded, in 1924, as a private company. It was a subsidiary of the US telecom firm ITT (VELAZQUEZ-GAZTELU, 1995), and never was dependent on government budgets. Nationalized in 1945, the government subsequently sold part of its stake in the company. By the mid 1990s, the government only controlled 21% of the capital. However, it had still a great influence on decision-making and strategies. Other large stockholders included some of the largest Spanish commercial banks -- one state-owned -- and savings banks. Owing to the great influence of the government on decision-making and - until privatisation – its capital stake in Telefónica, we refer to the company as a "state-run", as opposed to a "state-owned" monopoly. After the privatisation, the Spanish government still kept some decision-making power in Telefónica.

[5] The EU regulation played an important role in the liberalization of telecommunication services, as shown by Commission Directive of the 28th of June, 1990, on competition in the markets for telecommunications services (90/388/EEC; OJ L192/10, 24.7.90); and Council Directive of the 28th of June, 1990, on the establishment of the Internal Market for telecommunications services through the implementation of the Open Network Provision (90/387/EEC; OJ L192/1, 24.7.90).

[6] The Spanish law liberalising telecommunication equipment markets (telephones, answering machines, and phone network systems) was implemented only in 1991. Up until 1993, Telefónica still controlled around 87% of these

consumers had been previously obliged to purchase their terminals from Telefónica, after liberalization they could buy imported goods or products marketed by a variety of other manufacturers. These developments had several consequences. First, Telefónica abandoned the manufacture of equipment and focused strictly on services, leaving the opportunity for smaller suppliers to obtain a greater market share. Second, the company shifted from political to solely economic criteria in equipment acquisitions. Third, a wave of new suppliers, both foreign and domestic, entered the formerly protected Spanish market. In 1999, the most important suppliers of telecom equipment to the Spanish market were, in this order: Motorola, Ericsson, Nokia, and Alcatel (*Expansión*, Nov 7, 2000).

In 1989, Telefónica lost its special, advantageous fiscal regime (VELAZQUEZ-GAZTELU, 1995); in 1993, its monopoly in data transmission and, two years later, that in cellular phone services. By 1997, Spain's former monopoly became privatised with a 4 billion US$ stock offering. At the end of 1998, three new operators had entered the fixed communication services in Spain as well as one mobile telecom (MYRO & QUIROS, 1999). The new entrants[7], around which revolved constellations of Madrid-based suppliers of equipment[8], offered reduced prices for long-distance calls, the industry's most lucrative product. This obliged Telefónica to follow.

However, anticipating well in advance the end of its various monopolies, the company had been developing a global strategy since the mid-1980s. The first steps toward the reshaping of the old monopoly were Telefónica's new stock offerings in the most important international stock markets where it obtained not only capital but also financial expertise, international visibility and contacts that would prove most useful when it went international a few years later (DURAN and GALLARDO, 1996; CASANOVA, 1998). A domestic firm for 70 years, the company invested, over the brief period of 1989-1996, in nine countries and quickly established market leadership in the recently liberalised Latin American telecom (SANTILLANA DEL BARRIO, 1997). By 1997, Telefónica's investment in the region was valued around 35 billion US$. By 2000, it became the leader of the Brazilian telecom market, with more than 12 million fixed lines and four million in mobile phones. As explained by the theory of international

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markets. Terminals were manufactured both by its affiliate (Interisa) and by two large subcontractors (Alcatel, a French multinational, and Amper, a large Spanish company).

[7] In general, joint ventures between EU telecom companies with large Spanish banks and industrial enterprises.

[8] Airtel, a joint venture between Vodafone and British Telecom, for instance, had direct contracts with around 50 Spanish SMEs who supplied the new entrant chiefly with cards, software and antennas (RAMA and MELERO, 2000 a). Indirect linkages with local SMEs were also important. The large foreign manufacturers of equipment who supplied the new operator externalised around 20% of their production, in turn, to such firms, many of them located in Madrid.

business (DUNNING, 1993), common culture and language were important ingredients of the expansion[9].

The most important ownership advantage of Telefónica in Latin American markets was probably its ability for building telecom networks in very short periods of time[10]. This was a valuable skill given the circumstances. Just in São Paulo, for instance, 4 million people were still waiting for a fixed line by 1998[11]. To solve this type of problem, the company was able to mobilize quickly a large number of workers, subcontractors, technology (sometimes cheaper or adapted technology)[12] and financial resources, a combination of skills acquired at home just when it went international (CASANOVA, 1998). Unlike other developed countries, Spain had suffered, as did Latin America, a shortage of telephone lines[13]. At the beginning of 1989, there were still half a million people in Spain waiting for a fixed line (VELAZQUEZ-GAZTELU, 1995). However, by 1993, there was no longer a waiting list[14]. In addition to being insufficient, the infrastructure was also backward because in earlier years Telefónica had given a priority to restoring its finances, thus undercutting investment in new technology (SUAREZ-VILLA and RAMA, 1996). Thus, at the same time that new telecom networks were built, the company also substituted old analog equipment with new digital equipment[15]. In addition, backed by Spanish regional governments and municipalities, which contributed 25% of the investment, it also developed rural telecom by using radio technology for fixed (as opposed to mobile) communications[16]. In remote areas or isolated villages, radio technology was less expensive than laying cable. This prompted the installation of around 400,000 new lines in rural municipalities over 1993-96. In contrast, operators from other developed countries were, in general, not as experienced in quickly installing thousands of new networks because in their home countries the market for fixed telecom was saturated so that business consisted more of

[9] *The Wall Street Journal*, 13-05-96, quoted by CASANOVA (1998).
[10] According to CASANOVA (1998), from 1990 to 1998, it doubled the number of lines in Argentina, Chile, Perú and Brazil. Just in 1999, it built nearly 3 million new networks in Brazil.
[11] *The Economist*, "Telephones from Toledo to Tierra de Fuego", December 12th 1998.
[12] Teléfonica I+D , the Madrid-based R&D centre of the company, backed the expansion.
[13] By 1991, the number of telephones per 100 people was still 34 in Spain while it amounted to 50, on average, in the EU.
[14] Telefónica built not only the new networks demanded each year but also an annual average of around 100,000 new networks to reduce the waiting list. To put this figure in perspective, consider that, in their respective home-countries, where the demand for fixed communications was already saturated, other European telecom companies built only 30,000-40,00 new networks a year.
[15] The catching-up process was an example of the "windows of opportunity" (PEREZ and SOETE, 1988; BREZIS et al , 1993) opening of new technology to peripheral European countries or semi-industrial nations. According to this view, countries with fewer investments in old technology were more inclined to adopt new technology more quickly than nations with heavy previous investments in older technologies (in this case, analog systems).
[16] According to VELAZQUEZ-GAZTELU (1995), Spain has been, with Germany, a pioneer in the diffusion of this type of technology.

repair or renewal than of adding new capacity (in addition to mobile telecom and other more sophisticated services).

At the same time, while liberalisation and privatisation policies caused industrial turbulence and closings, the globalisation of the old monopoly favoured the evolution of Madrid's district towards an emerging high-tech district. One of the reasons was that it provided linkages with international networks. From the start, the district supplied Telefónica's foreign subsidiaries and was connected through outsourcing networks to multinational suppliers of equipment. As Telefónica's operations in Latin America exceeded the domestic figure (23.5 telephone customers in the region *versus* 21.6 in Spain)[17], new geographical markets were opened for Madrid's equipment manufacturers. As early as 1995, 50% of the telecom equipment produced in the district was exported (HIDALGO NUCHERA, 1997). In her analysis of the telecom innovation system in Campinas (São Paulo), SZAPIRO (2002) argues that liberalisation negatively affected the district because, among other reasons, the new operators entering the Brazilian market kept their traditional suppliers, rather than contracting with local suppliers of equipment. Given its haste in installing new phone lines in Latin America, Telefónica probably preferred keeping its traditional networks of suppliers, rather than creating new local networks from scratch. Building business networks to combine, adapt and develop human, financial and physical resources takes time and money (HAKANSSON and FORD, 2002). The traditional suppliers were the Spanish subsidiaries of multinational manufacturers of equipment, most of them Madrid-based, and the domestic companies with which the Spanish carrier had maintained long-run relationships. Taking advantage of economies of scale on both sides of the Atlantic, the company established global agreements that let it benefit from reduced costs[18] with suppliers such as Nokia, Ericsson, Motorola and Nortel. The Madrid district was thus elevated to international operations. Some suppliers expanded their plants in the region and used their pre-existing local networks of subcontractors as a means to more quickly supply Telefónica's Latin American subsidiaries. Lucent Technologies and Siemens even reduced the capacity, respectively, of their Dutch and their Belgium plants in order to transfer such capacity to Madrid[19]. In 1998, the subsidiary of Ericsson in Madrid became one of the company's five

[17] By 1998, Latin America accounted to 16% of Telefónica's US$ 15.6 billion in revenue and a slightly smaller share of its US$ 1.25 billion in profits. The company has also invested in Asia, the rest of Europe and the US (*The Economist*, 23-03-98).

[18] Domínguez Ayuso, G., Bories Valencia, M. And J.L. del Miguel y Antón, "La internacionalización de los servicios móviles de Telefónica", *Comunicaciones de Telefónica I+D*, on line wwww.tid/presencia/publicaciones/docs_comsid/numero15.pdf (09-07-2002)

[19] "Lucent concentra en España la fabricación de su producto estrella para toda Europa y Latinoamérica", *Expansión*, 24-02-97.

global centres for fixed telecom production[20]. To rapidly respond to clients' orders, an important consideration given the operators' febrile activity, some large multinational suppliers started externalising in Madrid part of the production they had previously manufactured in-house[21]. The reasons for locating in Madrid or for expanding pre-existing capacity were not only the presence of the telecom's multinational headquarters, but also the previously established competence of the electronics district, with its networks of specialized subcontractors, services and auxiliary firms.

Among its suppliers and at the company itself, the expansion of Telefónica encouraged the development of new innovative activities in Madrid. Over the 1990s, Ericsson and Lucent Technologies[22], among others, expanded substantially their R&D facilities in the region. The staff of Telefónica I+D, the company's R&D centre, also grew, from 300 researchers in 1988 to 1,208 in 2001[23].

Regional weight and role of Madrid in Spain's electronics industries

While Madrid lacks of many of the common socio-cultural values that define industrial districts, it displays several other important traits that suggest the presence of an industrial district. These features are, among others, the marked territorial agglomeration of electronics firms (see Figure 1), some degree of specialization among electronics establishments, a web of outsourcing relationships, the local embeddedness of electronics production, and the importance of electronics employment in the region. These features were observed in 1993 by SUÁREZ VILLA and RAMA (1996) and seem to have persisted.

Madrid displays a strong degree of specialisation, which is a relevant indicator for assessing the strength of industrial clusters from a regional perspective (PADMORE and GIBSON, 1997, p. 632). Madrid is the most important Spanish producer of telecommunication equipment (77%) and the second most important of components (34%)[3]. Though electronics is by no means its only industry, Madrid specializes in electronics. The index of value-added specialization is 1.5 to 2.5 times the national average in computers and 3.5 to 4.5 times the national average in other electronics industries, such as telecom equipment (ESPINA-MONTERO, 1995). Technological competence in electronics and, especially in telecom

[20] The production of the local plant supplies Southern Europe, the Middle East, Africa and, especially, Latin America.
[21] *Expansión*, 11-1-98, interview to Raimo Lindgren, the CEO of Ericsson Spain.
[22] By 2000, R&D staff accounted for one fourth of the 1,200 employees of the affiliate, which is located in Madrid (RAMA et al, 2003)
[23] Telefónica's innovative activities were exclusively located in Madrid until 1998, when the company opened two other centres in Valladolid and Barcelona (RAMA et al, 2003)

manufacturing, is also concentrated in Madrid. SANZ-MENÉNDEZ and ALONSO (1998), who use patent analysis to measure technological specialization, also find a relative specialization in electronics technology in the region. Finally, Madrid accounts for 84% of the Spanish R&D in radio, television and communications[24].

Many of Madrid's electronics firms have responded to the recent crises and subsequent new opportunities with cooperation. As seen before, new opportunities were especially seen in the digitalisation of lines in Spain and in the export market. Cooperation among electronics firms has not been encouraged by industrial lobbies as in Silicon Valley (SAXENIAN, 1994), nor has it received specific public encouragement as in other European nations, until the mid-90s, when the web of suppliers was already well in place. The Government only finances one type of R&D co-operation in Spanish firms: that involving an EU partner. Most subcontracting in Madrid's electronics industries takes place within the region (RAMA and CALATRAVA, 2002), as suggested by the high degree of two-way subcontracting, discussed later in this paper. As early as 1993, SUÁREZ-VILLA and RAMA (1996) found that two-way-subcontracting among Madrid's electronics producers was substantially higher than in electronics firms located in Austria and Sweden, for example.

Nature and location of electronics establishments in Madrid

In the 1980s and early 1990s, many of the newly created establishments were chiefly subcontracted by large and medium-sized firms who tried to increase their market share without incurring new costs (SUAREZ-VILLA and RAMA, 1996). Largely self financed from the private resources of engineers and professionals[25], such SMEs used their subcontracting networks as a means for specializing and devoting more resources to own R&D. This strategy enabled companies to keep their independence. As noted by SUAREZ-VILLA and RAMA (1996), as early as 1993, one could observe few financial links with multinationals or state-owned firms.

Many of such firms survived a period of rationalization and firm extinction around the beginning of the 1990's. The economic crisis produced a sharp decline in the number of establishments between 1988 and 1992, hitting small and medium sized firms (20-100 employees) especially hard, whose numbers still had not recovered to their original levels by

[24] Encuesta de Empresas Innovadoras, INE, Madrid, 1997.

[25] As early as 1984, a survey showed that 52.5% of the owners of SMEs in the electronics industries of Madrid were engineers. Another 18.5% were college graduates specializing in other fields (CAM, Consejería de Economía, "La industria electrónica en la Comunidad de Madrid", 1988).

1998. In addition to the effects of liberalization and privatisation in the telecom sector, overproduction of printed circuits and the subsequent fall in their prices by the mid- 90s induced a new phase of industrial turbulence among Madrid producers (MARTINEZ-ROMERO, 1998; RAMA, 1999)[26].

Many of the new small firms were started by engineers displaced during the previous crisis years, bringing specific skills or knowledge important to Madrid's production system as well as informal contacts. As explained by the literature on industrial districts, trust and common social ground were important elements in the consolidation of the district (SUAREZ-VILLA and RAMA, 1996; RAMA at al, 2003). The new large establishments represented infusions of new capital, mostly in the area of telecommunications equipment and other kinds of "dedicated" electronic equipment, such as defence and industrial goods.

Small producers within the region of Madrid tend to be concentrated near the centre of the city, while large firms are principally located in the peripheral industrial areas of the city.

–Figure 1 about here–

According to information collected by the mid-1990s**,** electronics subcontractors in the Madrid district deliver a great variety of customized items and enjoy economies of scope (RAMA and CALATRAVA, 2002). The same subcontractor is often able to supply contractors with core electronics products, R&D to order, assembly and post-sales services. Furthermore, many subcontractors also market their own products and parts in the open-market, including items that are considered high-tech by domestic standards. In the literature, the evolution of subcontractors towards complete companies is often considered positive since exposure to market forces encourages the technological upgrading of such firms (BABA et al, 1995) in addition to evidencing more possibilities for self-sustained regional development (TUROK, 1993). In short, webs of companies in the Madrid electronics district are complex, involving both co-operative and open-market arrangements. Largely based on trust, co-operative arrangements tend to be stable (RAMA et al, 2003)

Producers offering services are an important segment of the Madrid electronics district, at least as much as producers specializing in Madrid's traditional telecommunications and professional electronics products (FERGUSON, 2000). While "electronic components"

[26] Workers also paid a considerable cost in the restructuring of this industry. By 1991, total employment of Madrid's electronics industries was about 35% below the mid-1970s, in spite of the net creation of new firms (SUAREZ-VILLA and RAMA, 1996).

producers are often cited or included in studies of high technology districts, they were much less frequently involved in subcontracting relationships, acting more as suppliers for local or national markets than subcontractors. However, the co-location of component producers is often an integral feature of advanced electronics districts (SCOTT, 1983b; DE DIEGO GARCÍA, 1995).

Data and sample characteristics

The data used in the following statistical analyses were obtained from an establishment-level survey and on-site interviews conducted in 1999. Establishments' employment, sales, and financial data correspond to the year of 1997, while data pertaining to subcontracting refer to the period 1995-97. Of the 228 questionnaires sent, 101 were returned, of which 79 were usable for the following analyses. It is difficult to calculate the statistical representativeness of the sample, given the lack of detailed statistical information on the population of Madrid electronics manufacturers. However, the sample amounts to most of the establishments with more than 20 employees and its distribution is similar to that of the population in terms of product specialization and location within the region. The sample includes about 35% of electronics (CNAE-32[5]) establishments in the Madrid region, and 61% of all establishments with more than 20 employees, which is a size class constituting about 93% of total employment in Madrid's electronics industries. In this stratum, the size distribution of the sample is similar to that of the population[27]. However, our sample is less representative of establishments with less than 20 employees (about 20% of all such establishments)[28]. Thus, in the results that follow, those for establishments with more than 20 employees can be taken as being representative of the actual population of establishments, while those for micro producers are somewhat less reliable. We performed separate tests for the sample including all firms, and excluding firms with less than 20 employees. In general, the results of the second set of tests did not differ from the results for all firms (presented below). For this reason, we chose not to truncate the sample, retaining the

[27]

Size of the establishment (No. of employees)	Sample (%)	Population (%)
20-50	48	57
51-100	21	14
101-500	21	19
+500	10	10
TOTAL	100	100

[28] The reasons for this situation are industrial turbulence and frequent changes in location in this stratum. Given that the available directories of companies are not updated frequently, it proved difficult to keep up with the current addresses of micro-establishments.

information contained in the segment of micro producers for exploratory and discussion purposes (CARROLL and HANNAN, 2000).

In the analyses that follow, we divide the region of Madrid into central and peripheral zones, with the boundary as the municipal boundary of Madrid. As indicated in Table 2, the size distribution of producers between central and peripheral locations in the sample is fairly even overall, although there was a greater concentration of sampled producers with 20-50 employees in peripheral areas.

--Table 2 about here--

The sample is, thus, geographically representative of the population of electronics manufacturers in Madrid. The sample is also representative of the product specialization known to exist among Madrid's electronics producers, being concentrated in telecommunications equipment, "other" electronics products (defence and industrial equipment), components, as well as services (e.g., maintenance, installation, design, and development of telecommunications networks and equipment).

In terms of ownership, foreign affiliates and joint ventures are 19 percent and wholly Spanish-owned producers, 81 percent of the sampled establishments. In their 1993 survey, SUAREZ-VILLA and RAMA (1996) find that 74 percent of the establishments are domestic-owned, 3 percent joint-ventures and the rest, foreign affiliates. A comparison of the surveys does not support the idea that liberalisation and privatisation induced generalised de-nationalisation in Madrid district, unlike other emerging telecom or electronics clusters (DORIA PORTO et al, 2002; SZAPIRO, 2002).

Summary measures of the amount of subcontracted production and the location of suppliers and customers in the sample reveal a locally embedded network of production, with the majority of subcontracted production occurring within the region. Thirty-three of the 43 producers acting as clients responded that they externalise production principally to local producers, while 17 of 28 subcontractors responded that they principally supply local clients (Table 3). Within Spain, those figures climb to 41 and 25 producers, respectively. The majority of intra-regional externalisation and subcontracting among the sampled producers is done by small firms (less than 100 employees). In fact, the single large firm supplying subcontracted production does so principally for clients outside of Spain. Purchases of inputs are more localized for smaller (less than 100 employees) producers, as are their final markets, with the sample averages at 50 percent of purchases and 55 percent of sales, respectively. Conversely, larger producers are less embedded, purchasing inputs and selling most products outside of

Spain. This finding is consistent with findings from a 1993 survey (SUÁREZ-VILLA and RAMA, 1996).

--Table 3 about here--

PATTERNS OF SUBCONTRACTING

In this section, we test for whether the degree and nature of subcontracting in Madrid's electronics industry conforms to that expected for each of the industrial district types outlined previously (see Table 1). Since we are interested in the dynamics of concertation, we compare our results with those of previous research to observe changes in the incidence of subcontracting and agents' roles during the 1990s.

We analyse, in turn, each aspect of subcontracting among the sampled producers: the incidence of subcontracting and actors' roles in subcontracting. The definitions of variables used in the analysis are shown in Table 4.

--Table 4 about here--

The incidence of subcontracting

In our sample, around 61 percent of the establishments are involved in subcontracting either as a contractor, a subcontractor or both[29]. These results are similar to those found by SUÁREZ-VILLA and RAMA (1996) based on a 1993 survey.

Is participation in outsourcing relationships associated with the size of actors? According to original variants of the flexible specialization hypothesis, the incidence of subcontracting should decrease with firm size, reflecting larger firms' reliance on an internal division of labor among various phases of production (which may or may not be fulfilled locally). This would be observed as a lower frequency of participation by larger firms in subcontracting relationships, and a higher incidence among smaller firms. More recently, however, it has become clear that large "original equipment manufacturers" (OEMs) are outsourcing with increasing frequency in order to focus on core competencies and cope with design and logistical complexities, and that some contract manufacturers have likewise grown to become very large, multinational corporations, offering an array of production-related services covering both collaborative and capacity forms of subcontracting (STURGEON, 1999). Thus, we hypothesize that engagement

[29] In terms of production, outsourcing is also important in this regional electronics industry (RAMA et al, 2003).

in outsourcing relationships is independent of plant size. Using Monte Carlo[30] estimates for exact tests, we find no significant association between subcontracting and establishment size, confirming the latter trend within the electronics industries (table 5A) [6]. Similar results were found by RAMA and MELERO (2000), who analyse 1993 data.

While employment is somewhat indicative of the level of vertical integration among producers, size measured by total sales of the parent firm better reflects the resources available to individual units who may be part of multi-plant firms. Nearly a third of the units sampled indicated that they pertain to multi-plant companies, and thus may specialize in particular aspects of production within their firms, as would be found in a satellite platform district. Thus, we test the statistical association between incidence of subcontracting and size of the parent. Results shown in Table 5B indicate that we may accept the null hypothesis of no association between parent firm resources as a measure of firm size and the incidence of subcontracting. Again, these findings confirm an analysis based on 1993 data (RAMA and MELERO, 2000).

Actors' roles in subcontracting

Are roles in outsourcing relationships associated with the size of actors? The high incidence of two-way subcontracting among the sampled producers suggests the existence of a complex, non-hierarchical inter-firm organization of production in Madrid's electronics district. Thus, we test for the association between actors' roles and size.

We find that there appears to be no significant relation between actors' roles and the size of production unit by either the establishment size as measured by employment or the parent sales, although smaller establishments do appear more likely to be involved in two-way contracting (Tables 6A and 6B). Results are comparable to those of RAMA and MELERO (2000).

Technological characteristics of sampled producers

On average, the R&D spending to sales is 5.5 percent, with smaller establishments of fewer than 100 employees (hereafter, designated as "smaller" establishments)[31] displaying higher ratios (6.0 percent). Establishments belonging to smaller parent firms, having sales below the median sales of all firms, show higher ratios (6.9 percent) than those belonging to larger (above median sales) parents (3.7 percent). This may be due to the fact that large multinational firms in

[30] Due to some thin cells in the contingency tables, we use the more reliable Monte Carlo probability estimates instead of the asymptotic Chi-square test.

[31] Our classification by size of the establishment, as measured by employment, is as follows: small establishments (<100 employees), medium sized establishments (100-500 employees) and large establishments (>500 employees).

this industry, with some exceptions mentioned above, rarely develop their most innovative activities in Spain. In our sample, the R&D-to-sales and R&D-to-costs rates are only 3.5 percent and 3.2 percent in joint ventures and subsidiaries; by contrast, in domestic-owned firms they account to 6.1 percent and 6.9 percent, respectively.

The situation has apparently not changed over the 1990s. Previous research reports that the statistical association between employment and costs, on the one hand, and R&D expenditures, on the other, was stronger in the smaller electronics establishments located in the centre of Madrid, especially among two-way subcontractors, than in the larger plants located in the periphery (SUAREZ-VILLA and RAMA, 1996). This was interpreted as a supportive relationship between plant size and R&D, with personnel more involved on average in innovative activities.

Other measures of technological intensity are the number of engineers to the total number of employees, and the number and weight of new products and processes. Totalling 2,308 among all sampled producers, engineers account for 23 percent of employees [32]. Around 80 percent of the establishments declare that they have launched new products in the last three years, the sales of which account, on average, to 30 percent of total sales. More than one-third of the sampled establishments report the introduction of new industrial processes over the same period.

In addition to the spillovers and joint learning that can take place informally during the outsourcing of production, around one fifth of the surveyed establishments also maintain co-operative R&D inter-relationships with other companies. In this respect, no differences between the behaviour of wholly Spanish-owned firms and joint ventures or subsidiaries could be detected ($\chi^2 = 2.7945$; Monte Carlo $p = 0.1735$).

Characterizing the Madrid electronics district

Based on its development history and these sample data, it seems appropriate to characterize Madrid's electronics district as an emerging technology district. The early

[32] This figure does not include owners, only employees. As early as 1984, a survey showed that 52.5 percent of owners of SMEs in the electronics industries of Madrid were engineers. Another 18.5 percent were college graduates specializing in other fields (CAM, Consejería de Economía, "La industria electrónica en la Comunidad de Madrid", 1988).

beginnings of Madrid's electronics industries were tied to the state-controlled monopoly in telecommunications manufacturing and the state's purchase of defence-related equipment. However, even in this early stage the district already displayed some of the characteristics typical in high-tech districts: A mix of small and large plants both locally and foreign-owned, an intricate web of subcontracting links, a high incidence of two-way-outsourcing, some export activity, and R&D financed by internal sources and interaction among firms, rather than by institutions.

The restructuring after liberalisation has introduced new competition and an emerging production unit specialisation in high-technology products and services. The origin of this structure as a spontaneous response to a turbulent industrial history has freed a number of professionals to specialize in certain aspects of production and encouraged inter-firm collaboration in a number of ways as a method of minimizing capital risk.

As in the previous phase, we observe a great deal of two-way contracting and no association between firm size and propensity for subcontracting or actor functions (whether as a client or a provider of subcontracted products and services). Large and small firms alike appear to be involved in subcontracting networks, with the majority of these involved in two-way subcontracting. This departs from the "Marshallian" industrial district, in which small firms tend to cooperate to compete against larger, vertically integrated firms. Additionally, Madrid's organization departs from the "hub-and-spoke" model, in which one-way subcontracting (with large firms as clients and small firms as suppliers) predominates.

Important also is the relatively high degree of local embeddedness of Madrid's electronics industries, both in terms of subcontracted production and open market purchases. While small firms are more prone to purchase, sell, and subcontract within the region, a significant portion of transactions are external to the region, reflecting the complete network system hypothesized by PARK (1996) in his characterization of a "pioneering high technology" district. The reshaping of the old monopoly provided linkages to extensive non-local networks of production and R&D.

THE CAMPINAS TELECOM DISTRICT

Using information from published studies, here we discuss to which archetypical district the forms of concertation in the Campinas district are associated[33].

[33] This section is mainly based on the following studies: CASSIOLATO et al (2001and 2002), SZAPIRO (1999 and 2002) and DORIA et al (2000). It benefited from extensive discussion with Marina Szapiro.

From the beginning of the 1970s to the mid-1990s

At the beginning of the 1970s, the situation in the Brazilian telecom industry was similar with that of Spain. Telebrás, a state-controlled [34]company, held a monopoly of telecom services. Though it strongly influenced the Brazilian market for telecom equipment through its monopsony purchasing power, Telebrás, unlike Telefónica, was not a manufacturer. Telecom equipment was supplied by a small number of multinationals that either imported or locally assembled the products using foreign technology. Since the mid-1970s, the scheme also included an important public R&D institution (CPqD). Dependent on Telebrás' budget and hosted in the Campinas district, the aim of CPqD was the development and diffusion of new national technology. Local Universities, especially Unicamp (University of Campinas), also played an important role in the regional system of innovation.

A local supplying network was soon established in the Campinas district because, among other things, the Brazilian government forced multinationals to buy locally. Such companies built large plants where most of the phases of manufacturing tended to occur. Though firms outsourced some production, most of their transactions took place in open markets. The few networks were *"under the control of large, mostly foreign-owned firms"* (Cassiolato, et al, 2002).

Non-local connections were less developed. Even by the 1970s and 1980s, when production of the district accounted to around 10 percent of Brazilian industrial production, Campinas telecom manufacturers exported only a very small part their output. Shipments to the rest of Brazil, especially to the region of São Paulo were substantial. However, some types of shipments outside the São Paulo region were limited. Extra-regional shipments of large systems, for instance, were limited as the government allotted different regional markets to different subsidiaries. In this arrangement, Ericsson was assigned the market of São Paulo and, hence, the region of Campinas (in addition to other, smaller regional markets); it could not dispute, for instance, the Curitiba market for large systems that was allotted to Siemens. In other words, the government established regional monopolies for some types of telecom equipment. These circumstances somewhat limited connections with non-local networks and the possibilities for external competition in the Campinas district.

[34] As Telefónica before privatisation, Telebrás was not completely owned by the state, being partly owned by a variety of small stockholders.

At least in the short run, the policies implemented by the government where highly successful. First, they contributed to greater embeddedness of the district. At the end of the 1980s, 90 percent of value-added was produced locally. Moreover, a number of domestic SMEs were launched in a high-tech sector previously controlled only by multinationals. Second, such policies promoted local innovation. In collaboration with Universities and both domestic and foreign-owned firms of the area, CPqD developed valuable new technology, the most important a switching system adapted to tropical climate and to the specific conditions of communication traffic in Brazil. Even by international standards, the average rate of R&D to sales in the district was quite high. The local Universities generated a few spin-offs.

Characterizing the Campinas telecom district

Though innovation was substantial, even in its golden years the Campinas district was not a "pioneering high-tech district," as described in the literature (Peck, 1996). Non-local connections, an important ingredient in such districts, were insufficiently developed, a shortcoming that probably undermined, in the medium to long run, the competitive edge of the Campinas district. Moreover, non-hierarchical interdependencies among establishments of different size and nature were limited. This situation probably reduced the potential for imitation and learning by interacting in the district, especially among domestic firms who, unlike subsidiaries, lacked international networks prepared to supply them with state-of-the art technology.

The results of the PAEP[35] survey of 1996, i.e. before the implementation of most of the structural policies that shook the Campinas district, seem to confirm this interpretation (COSTA and REIS DE QUEIROZ, 2002). According to these authors, in a sample of large firms (more than 250 employees) of the São Paulo region, domestic firms in the electronic material and telecom equipment industry were ranked about three times lower than foreign subsidiaries and joint-ventures when differences were measured by an imitation index[36]. The index indicates duplicative innovation involving less complex and creative capabilities, just a modest first step in the innovative process. Moreover, domestic firms ranked about two times lower than subsidiaries in an index that proxies learning by interaction in the production chain, i.e. know-how acquired from suppliers, clients, etc. By contrast, domestic and foreign firms ranked

[35] Innovation Survey for the State of São Paulo.

[36] In this respect, the domestic companies in this sector ranked below the average domestic company in the 34 industrial sectors analysed in the São Paulo region. By contrast, the imitative capacity of the foreign subsidiaries in electronics material and telecom equipment is the highest in São Paulo manufacturing sector.

similarly in know-how acquired from Universities and research centres, confirming the positive impact of such institutions among both types of companies.

We would describe the Campinas district as a "state-anchored" district with some traits of the hub-and spoke model[37]. The stimulus to the district came from the state-owned monopoly, Telebrás, and from CPqD, its R&D centre. Moreover, regulation, as opposed to spontaneous arrangements, was the key element in the organization of production networks and innovation. The government forced the suppliers of equipment to buy locally and also to interact, for innovation, with CPqD and local Universities. National technology produced by local firms enjoyed a captive market in Telebrás. The low incidence of outsourcing in productive networks limited permanent and continuous inter-relationships among companies. In addition, the presence of a few large suppliers of telecom equipment, most of them multinationals, who organized the networks of local suppliers, continue to provide an element of the hub-and-spoke model. As mentioned above, with respect to some specific products, the hub was a sole subsidiary. This situation must have restricted the bargaining power of SMEs and other domestic suppliers vis-à-vis a few very large, multinational clients and contractors.

The crisis

Faced with the disruptive forces set in motion by structural policies, the Campinas district proved fragile. At the end of the decade, telecom services were liberalised and new international carriers entered the Brazilian market. Again, the government allotted different regions to each of the foreign operators, creating duopolistic regional markets with Telebrás' regional affiliates. Telefónica won the telecom services of the most lucrative regions, São Paulo and Río de Janeiro. CPqD was privatised[38]even before Telebrás. Thanks to commercial liberalisation, imports grew sharply[39]. By 2000, they amounted to ten times the value of exports of the Campinas district, even as exports themselves also increased. New multinational manufacturers of equipment entered the Brazilian market, including Lucent Technologies, one of the most important suppliers of the Spanish carrier. Pressed to supply state-of-the-art technology and, simultaneously, cut the costs of their products, manufacturers of equipment in the Campinas district preferred to "downsize". There was a shift back to assembly and import-intensive plants.

[37] In this interpretation, we follow MARKUSEN (1996) who, based on DINIZ and RAZARI (1994), classifies the Campinas district both among "state anchored" and among "hub-and-spoke" districts.
[38] To guarantee the survival of the centre, again, the government forced the companies to contract a certain amount of services from CPqD until 2001, the end of the transition period.
[39] However, after liberalisation the government provided fiscal incentives to the local production of telecom equipment.

As in the Madrid district, closings and destruction of jobs were commonplace at that time, though some ex CPqD engineers and technicians launched some spin-offs. Entire lines of electronics production, such as components, were swept out[40]. Domestic firms found it increasingly difficult to participate in supplier networks. Many of the largest firms were finally acquired by foreign manufacturers of telecom equipment. In general, the new entrants showed little interest in linkages with local firms. Operators acquired enormous bargaining power vis-à-vis suppliers of equipment; only the largest multinational suppliers were able to cope. According to DORIA PORTO et al (2000), by 2000 the national industry was virtually eliminated. With respect to innovation, local capabilities were downgraded in some respects. Owing to budgetary problems, the government, which had previously funded most R&D, drastically reduced its contribution. However, though R&D regional expenditures fell briefly by 50 percent over the 1990s, they have since recovered in recent years (DORIA PORTO et. al, 2000). To cope with increased imports and reduce their costs, local firms cut their investments in innovation and concentrated in a few market niches, losing competence in core technologies. Multinationals reduced their local collaboration in R&D, thus limiting the possibilities for the diffusion of upgraded technology in the area. Instead, they turned to their respective parents for new technology or launched their own R&D centres. In their sample of 12 Campinas suppliers of equipment, DORIA PORTO et al (2000) find higher R&D-to-sales rates among subsidiaries (11 percent) than among domestic firms (5 percent). To obtain finance, the CPqD augmented consultancy and training activities to the detriment of research projects.

CONCLUDING REMARKS

The electronics industries of the Madrid region, after the turbulent period of the late 1980s and early 1990s during which Spanish telecommunications services and product markets were liberalized, have emerged from a state-anchored district to a high technology district, encompassing a complex, non-hierarchical subcontracting network. The geographic and professional proximity of actors, as well as the similar origins of a large number of entrepreneurs, encouraged the development of relatively stable subcontracting relationships seen today among electronics producers. While the district has lacked the local institutional support or "thickness" (AMIN and THRIFT, 1993), or the common cultural-historical embeddedness cited in other "canonical" districts (BECATTINI, 1990; SIGNORINI, 1994), these circumstances stimulated the relations of trust and common values among entrepreneurs taken to be essential

[40] As mentioned above, the co-location of components producers is often cited in the literature as an ingredient of advanced electronics districts.

for enhancing cooperation and minimizing the problem of moral hazard (SUÁREZ-VILLA and RAMA, 1996). The electronics and telecom equipment district of Campinas (Brazil), also conforming mainly to the "state-anchored" model in its early years, has evolved towards a hub-and-spoke district after the break-up of the telecom service monopoly.

In this paper, we have proposed that identification of the forms of concertation within industrial districts is useful for assessing districts according to current typologies. While many types of inter-firm relations exist within industrial districts, we proposed that subcontracting relations are useful foci for several reasons. First, subcontracting is a primary ingredient of the glue that holds industrial districts together, and can serve as an important channel for technological learning and innovation. Second, subcontracting, as a relatively homogeneous activity, is more easily observable and quantifiable than other forms of concertation, and provides an objective measure for inter-district comparisons which has been called for by others (MARKUSEN, 1996). Third, some government units and industry associations are beginning to track subcontracting as an activity, such as the Spanish electronics industry association cited in this article, ANIEL, which should aid in more accurately identifying industrial district types and their dynamics as more data become available.

Having proposed subcontracting as an object of analysis, we hypothesized specific differences in the degree and nature of subcontracting across district types, and tested first these hypotheses with the case of electronics producers in Madrid. Here it was shown that, if based solely on the incidence of subcontracting one may conclude that Madrid's electronics industries conform to a hub-and-spoke district, an analysis of producers' *roles* in subcontracting reveal no association of subcontracting role with size of the establishment or its parent, leading us to reject the hub-and-spoke district model in favour of the high technology model for the case of Madrid. In its early phase, the Campinas district was very similar, at least at first sight, to the Madrid district. Production mainly occurred under a state-controlled monopoly, which had a strong influence on the market for telecom equipment. However, by contrast with the Madrid district, large manufacturers of equipment tended to buy parts and components in the open market, with only a small incidence of subcontracting within the Campinas region.

The results of this study carry several implications for the analysis of industrial districts, as well as for regional strategies to enhance inter-firm cooperation and foster growth and innovation.

While the identification of specific forward and backward linkages requires a more extensive effort at data acquisition from producers, basic measures such as those used in this paper or more easily obtainable through surveys or censuses, and can be used to identify local industrial sectors with subcontracting as a dominant form of production organization. Increasingly, the answer to the old question of the comparative benefits of pouring regional resources into promoting single-plant, small enterprises or attracting large branch plants of multi-plant, multinational corporations rests on identifying the region's subcontracting relations and their associated multiplier effects (KELLEY AND HARRISON, 1990). At the same time, identification of subcontracting relations is essential for formulating ways to promote technological improvement within the district.

Identifying forms of concertation and distributed processes of innovation within regional industrial districts highlights the potential for endogenous technological change within specific sectors or industries. It also helps us to understand why some sites seem to anchor high-tech production and innovation in an increasingly "slippery" global economic space. As anticipated by MARKUSEN (1996), the prospects of "state-anchored" districts are linked to prospects of the institutions that provide stimulus to the district. Faced with the crisis, the Campinas district, characterized above as a "state anchored" district, was less resilient[41] than, for instance, the Madrid district, which showed from the outset many of the traits of a high-tech district. One of the most important capabilities of Campinas' equipment producers, local innovation, was seriously hampered by the new policies. The level of R&D expenditure and the direction in knowledge flows within the district had depended, to a large extent, on government budgets and a regulated environment. Technological development was not anchored within the district, but instead was tied to macroeconomic policies adopted outside the region. By contrast, the resilience of the Madrid district can be explained, among other things, by socially embedded interactions in a model in which both large and small plants made use of flexible production systems.

Though elucidating this question would clearly require more thorough empirical testing, it seems that modes of concertation within districts could also affect the way innovation is

[41] Our interpretation of the decline of local innovation after the implementation of structural policies is based on the nature of pre-existing relationships among firms and institutions in the Campinas district. It does not contradict, but rather complements, the interpretation proposed by CASSIOLATO et al (2000 and 2002) and SZAPIRO (1999 and 2002), who emphasize, rather, the *way* (our emphasis) liberalisation and privatisation were conducted in Brazil. The hasty implementation of such policies and the virtual absence of an alternative strategy on the part of Telebrás can certainly help to explain why the district proved less resilient than others faced with similar disruptive forces. In contrast to Telefónica, a key agent in the Madrid district, Telebrás, who played a similarly substantial role in the Campinas district, was unable to reshape before the monopoly broke up.

distributed among different firms and institutions. In the Campinas district, most relationships among firms, including those related to innovation, have taken place in markets, a characteristic probably accentuated after the crisis (DORIA PORTO et al, 2000). With regard to innovative co-operation between firms and institutions, an important feature of the district, the power and size of collaborators were quite different[42]. Controlling both the market of new products and R&D finance, the large innovator, i.e. the government, dictated the pace and direction of technological change. While the smaller innovators (private firms) enjoyed little autonomy in the R&D area, they benefited from low levels of uncertainty and commercial risk. In the Madrid district, small units engaged in two-way decentralized subcontracting while larger systems houses provide extensive non-local networks of production and access to final markets. Though some large plants co-operate with local Universities (RAMA and MELERO, 2000), distributed processes of innovation continue to take place chiefly among companies of all sizes and capital origin. Given the importance of subcontracting arrangements, imitative innovation and learning by interaction are more likely to develop in such co-operative industrial processes.

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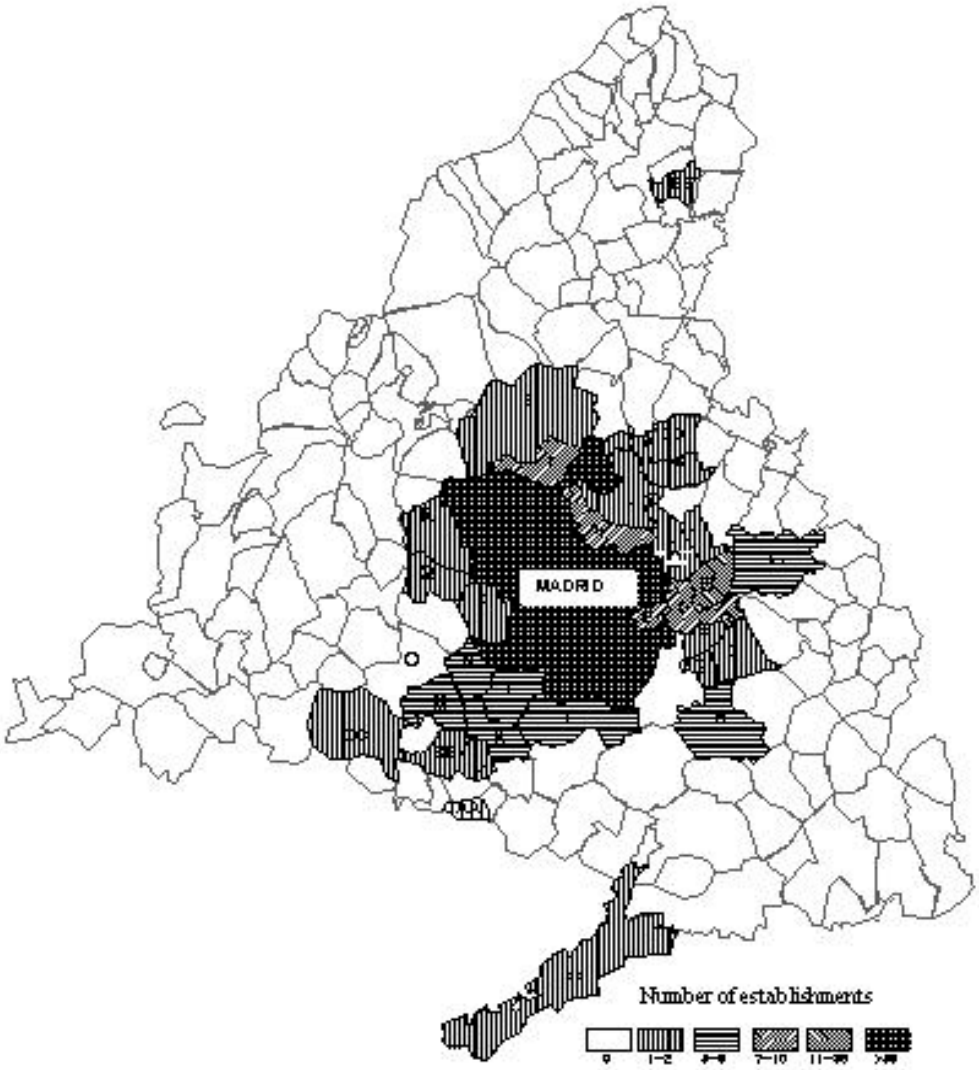
Figure 1

Geographical distribution of Madrid´s electronics establishments, 1992*



A Paracuellos del Jarama	L Leganés	V Alcobendas
B Torrejón de Ardoz	M Móstoles	X Ajalvir
C Alcalá de Henares	N Alcorcon	Y Algete
E Coslada	O Villaviciosa	Z Loeches
F Mejorada del Campo	P Pozuelo de Alarcón	AA Cubas
G Velilla de San Antonio	Q Majadahonda	BB Moraleja de En medio
H Arganda del Rey	R Las Rozas	CC Navalcamero
I Getafe	S Colmenar Viejo	DD Fuente el Saz
J Humanes	T Tres Cantos	EE Robledillo de la Jara
K Fuenlabrada	U San Sebastián de los R.	FF Aranjuez

Source: Authors'calculation from data in Directorio Industrial de la CAM, 1992.
Note: *Last available information

Table 1. Subcontracting characteristics of industrial districts

Characteristic	**Marshallian District** *substantial collaborative subcontracting (a)*	**Hub-and-Spoke District** *substantial capacity subcontracting; some collaborative (b)*	**Technology District** *substantial collaborative subcontracting (c)*
Firm size and ownership	Many small, locally owned firms; Firms often specialize in a few products and/or services	One or several large, vertically integrated firms surrounded by suppliers; Firms may be locally or externally-owned	Mix of small and large firms both locally and foreign-owned
Incidence of subcontracting	High incidence of intra-district subcontracting	Medium incidence of intra- and/or inter-district subcontracting	High incidence of both intra- and extra-district subcontracting
Nature of subcontracting (actors' roles in networks)	Non-hierarchical; Small firms are clients and subcontractors; Large firms less involved in subcontracting, usually as clients in one-way subcontracting	Hierarchical; Large firms are clients; Small firms are contractors; One way subcontracting more common than 2-way subcontracting; Little 2-way subcontracting	Non-hierarchical; Majority of firms are involved in subcontracting; Two-way subcontracting common

(a) See, for example, BECCATTINI (1990), SIGNORINI (1994)
(b) See, for example, GRAY *et al* (1996)
(c) See, for example, PARK (1996)

Table 2. Characteristics of the sample

	Number (Subs)	Percent	Number of establishments in:	
Establishment Size			*Center (Sub)*	*Periphery (Sub)*
1-19 employees	**31** (19)	**39%** (40%)	**17** (12)	**14** (7)
20-50	**23** (11)	**29** (23)	**7** (4)	**16** (7)
51-100	**10** (6)	**13** (14)	**4** (4)	**6** (2)
101-500	**10** (7)	**13** (14)	**5** (4)	**5** (3)
500 +	**5** (5)	**6** (10)	**3** (3)	**2** (2)
All establishments	**79** (48)	**100** (100)	**36** (27)	**43** (21)
Products* *(rated as "important")*			*Center (Sub)*	*Periphery (Sub)*
Electronic Components	**17** (6)	**22%** (13%)	**4** (4)	**13** (2)
Telecommunications Equip.	**23** (12)	**29** (25)	**10** (7)	**13** (5)
Computers & Office Equip.	**6** (2)	**8** (4)	**2** (1)	**4** (1)
Consumer Electronics	**4** (2)	**5** (4)	**1**	**3** (2)
Other Electronics Products	**29** (19)	**37** (40)	**15** (10)	**14** (9)
Non-Electronics Products	**8** (5)	**10** (10)	**4** (3)	**4** (2)
Services	**31** (19)	**39** (40)	**19** (13)	**12** (6)
Ownership			*Center (Sub)*	*Periphery (Sub)*
100 % domestic	**63** (37)	**81%**	**31** (22)	**32** (15)
Affiliate or part foreign-owned	**15** (10)	**19**	**5** (5)	**10** (5)
Number of single- establishment firms	**58** (32)	**74%**	**25** (18)	**33** (14)

Notes: Bold figures refer to all establishments in the sample, while figures in parentheses refer to firms involved in outsourcing (sub). N = 79, except for Ownership (N = 78)
Subs: subcontractors

***** Establishments answering 4 or 5 on a scale 0-5 of importance; percentages refer to share of all establishments and share of all subcontracting establishments (in parentheses)

Source: authors' calculations from survey data

Table 3. Embeddedness of subcontracting and supply chains in Madrid electronics district

	Employment size of establishment			
	< 100 employees	100-500 employees	> 500 employees	All Producers
Location of subcontractors and clients for Madrid producers				
Location of subcontractors (N=43):*				
Region of Madrid	26	5	2	33
Other Spanish region	6	1	1	8
Other country	-	1	1	2
*Location of clients (N=28)**:*				
Region of Madrid	16	1	-	17
Other Spanish region	5	3	-	8
Other country	2	-	1	3
Origin of basic inputs and destination of final market sales of Madrid producers				
Origin of inputs (%) N=77				
Region of Madrid	50%	33%	24%	46%
Other Spanish region	28	30	22	28
Other country	22	37	52	26
Destination of final market sales (%) N=77				
Region of Madrid	55	34	33	51
Other Spanish region	35	42	25	36
Other country	10	23	42	13

* Clients were instructed to select the principal region where Subcontractors were located.
** Subcontractors were instructed to select the principal region where Clients were located.
Source: authors' calculations from survey data.

Table 4. Variables used in statistical analyses

Variable	Definition	Values
Location	Geographic location of establishment within the Madrid region	Center=1 Periphery=2
Subcontracting (incidence)	Participation of the establishment in subcontracting relationships	Yes=1 No=2
Function (actor's role in network)	Role of the establishment in subcontracting networks	Strictly Client=1 Strictly Subcontractor=2 Client & Subcontractor (2-ways) = 3
Size	Size of establishment measured as average annual number of employees	Small... < 100 employees Medium... 100 – 500 employees Large... > 500 employees
Sales	Sales of parent company of establishment compared to median of sample (2.45 million €)	Less than median=1 (Size 1) Greater than median=2 (Size 2)

Table 5. Subcontracting, and size of establishment and parent

A. Size of establishment				
Subcontracting	< 100 emp.	100 - 500 emp.	> 500 emp.	Total
Yes	57.1	63.6	100.0	60.8
No	42.9	36.4	0.0	39.2
Total	100.0	100.0	100.0	100.0

N=79

Statistical Tests	Value	DF	Significance
Pearson Chi^2	3.613	2	0.164
Fisher's Exact		1	0.196
Monte Carlo			0.200

B. Sales of parent company			
Subcontracting	Size 1*	Size 2*	Total
Yes	45.7	65.7	55.7
No	54.3	34.3	44.3
Total	100.0	100.0	100.0

N=70

Statistical Tests	Value	DF	Significance
Pearson Chi^2	2.8371	1	0.090
Fisher's Exact (2-tailed)		1	0.148
Monte Carlo			0.150

* Size 1 and Size 2: Above or below median sales of the parent firm of the establishment (2.45 million €). We use the median as a measure of centricity, instead of the mean, owing to the skewness of the variable distribution.

Table 6. Role in subcontracting, and size of establishment and parent

A. Size of establishment				
Role	< 100 emp.	100 - 500 emp.	> 500 emp.	Total
Client only	29.4	42.9	40.0	32.6
Subcontractor only	2.9	0.0	0.0	2.2
Client and Subcontr	67.7	57.1	60.0	65.2
Total	100.0	100.0	100.0	100.0

N=46

Statistical Tests	Value	DF	Significance
Pearson Chi^2	0.890	2	0.926
Fisher's Exact		1	0.760
Monte Carlo			0.910

B. Sales of parent company			
Role	Size 1*	Size 2*	Total
Client only	31.3	34.8	33.3
Subcontractor only	6.3	0.0	2.6
Client and Subcontr	62.5	65.2	64.1
Total	100.0	100.0	100.0

N=39

Statistical Tests	Value	DF	Significance
Pearson Chi^2	1.4837	1	0.476
Fisher's Exact		1	0.699
Monte Carlo			0.700

* Size 1 and Size 2: Above or below median sales of the parent firm of the establishment (2.45 million €) We use the median as a measure of centricity, instead of the mean, owing to the skewness of the variable distribution.