Old and New Forms of Clustering and Production Networks in Changing Technological Regimes : Contrasting Evidence from Taiwan and Italy

Paolo Guerrieri and Carlo Pietrobelli

Science Technology Society 2006 11: 9
DOI: 10.1177/097172180501100102

ARTICLES

Old and New Forms of Clustering and Production Networks in Changing Technological Regimes: Contrasting Evidence from Taiwan and Italy

PAOLO GUERRIERI and CARLO PIETROBELLI

The selected evidence discussed in this paper suggests three interrelated propositions. First, there is no one best model for organising an industrial district or an industrial cluster, since a diversity of institutional arrangements is possible and each has proved successful in different circumstances. Second, clusters are not cast in iron, but they evolve over time. Third, globalisation reshapes the upgrading options for SME-based clusters, by providing a variety of international knowledge linkages. In a nutshell, globalisation changes both the concept of proximity and the scope of competition: a necessary pre-requisite for competitive survival is the capacity to foster the co-evolution of local and global linkages and networks, and to develop new interactive modes of knowledge creation. This paper presents original evidence on Taiwanese and Italian SME-based clusters. A key explanation of the success of SMEs competing in globalised high-tech industries, supported by our survey evidence, is the co-evolution of domestic and international knowledge linkages.

Professor Carlo Pietrobelli is Professor of International Economics and Director of the Research Centre on the Economics of Institutions (CREI), at the University of Rome 3, Department of Law and Economics, Via Ostiense 161, 00154, Rome, Italy, Phone: +39-06-4402547 or +39-06-57067476, Fax +39-06-57067511, Email: c.pietrobelli@uniroma3.it; www.pietrobelli.tk

Paolo Guerrieri is Director of the Centre of International Economics (CIDEI) and Professor of Economics, Department of Public Economics, University of Rome 'La Sapienza', Via del Castro Laurenziano, 9 I-00161, Roma, Italy Tel: +39-06-4976-6345, E-mail: paolo.guerrieri@uniromal.it

Science, Technology & Society 11:1 (2006)
SAGE PUBLICATIONS NEW DELHI/THOUSAND OAKS/LONDON
DOI: 10.1177/097172180501100102

Introduction

FOR SEVERAL DECADES, in many countries and industries, enterprise clustering has offered a competitive alternative to the advantages achieved through a larger production scale, and through the ensuing economies of scale.[1] This has proved true, in different ways, also in countries characterised by a wide presence of Small and Medium-sized Enterprises (SMEs), such as Taiwan and Italy.

The peculiar features of technology and technological change that have been emerging in recent years, and especially the all-encompassing nature of globalisation (Archibugi and Pietrobelli 2003), are changing the way geographical agglomeration of economic activities occur and affect economic performance. On the other hand, globalisation 'shrinks' the space and helps agglomeration and interaction to take place across notable distance. On the other hand, in spite of globalisation, physical proximity still matters, as shown by the remarkable clustering of several economic and innovation activities (UNDP 2001).

This task is made even harder by the variety of visions on the notion of Industrial Districts (IDs) and clusters in the literature, and by the very vast array of experiences of enterprise clusters and agglomerations recorded worldwide. In fact, some 'concrete instances of industrial districts are closer to a set of stylised facts than a model' (Humphrey 1995: 152), and none of the IDs is strictly equal to another. Moreover, the scope and variety of inter-firm organisations are continuously expanding in relation to the globalisation of technology and the increasing internationalisation of economic activities.

To this aim, we shall first briefly review the literature on the typology of IDs, and in general on the variety of visions on the phenomenon of enterprise clustering. We shall notice how little attention has been paid to the transformation of IDs, and to models geared to explaining the different responses in terms of organisation of inter-firm linkages, within and outside the cluster.[2]

Among the crucial factors explaining the evolution of the clusters' industrial organisation we especially focus in this article on the recent changes in technological paradigms and trajectories. To give empirical content to this discussion, we explore the pattern of success, the similarities and the differences, and the evolution of enterprise clusters in Taiwan and Italy, on the basis of the results of recent field research conducted in the two countries.[3]

Categorisations of Clusters and IDs and the Dynamics of Industrial Organisation

The literature on enterprise clusters and IDs is sizeable, and was started by the classical contribution of Alfred Marshall (1896) on the importance of external economies for IDs. Then, following the increasing complexity and variety of real world inter-firm organisation, several categorisations of industrial clusters and districts have been proposed, often grouping widely different realities under the same label.

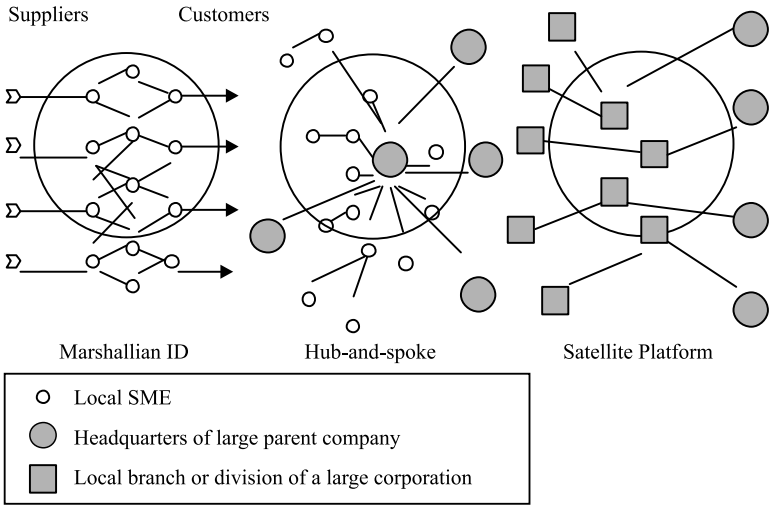
In a study of the Italian evidence on how production is spatially organised, Garofoli (1991) proposed a typology of models of local development that has been rather influential on later work. This classification introduced concepts such as *local production systems* and *system areas*, and described the rise in the complexity of the local system that may occur, with inter-firm and inter-institution synergies becoming widespread and effective. Another interesting categorisation explicitly introduces asymmetries among the clustered enterprises and it is centred on the concept of '*leader-firms*' and of the *constellation* surrounding them (Lorenzoni 1990).

Markusen (1996) broadens the picture to include several different forms of industrial organisation within the definition of an ID. She argues that the emergence of 'sticky places' in a 'slippery space'—characterised by dramatically improved communications, and increasingly mobile production factors and enterprises—may be related to numerous variants of IDs. Thus, she opts for an expansive connotation of ID which does not confine it to the most common usage (for example, the Marshallian—'Italian' variant—district). Therefore, the definition of ID utilised is the following: '…an ID is a sizeable and spatially delimited area of trade-oriented economic activity which has a distinctive economic specialisation, be it resource-related, manufacturing, or services' (Park and Markusen 1994).[4]

It is clear that adopting such a definition implies considering a cluster or an ID essentially as synonyms to describe a reality of a location that provides '… the *glue* that makes it difficult for smaller firms, to leave, encouraging them to stay and expand, and attracting newcomers into the region' (Markusen 1996: 294).

The conceptualisation proposed, focuses on the following essential classificatory principles: firm-size, inter-firm relations and internal *versus* external orientations (see Figure 1).

FIGURE 1
Typology of IDs



Source: Adapted from Markusen (1996) and Castellano (1999).

The concept of the ID, and its Italian Variant, owes its popularity to Alfred Marshall, who first noted the external economies due to the co-location of small firms, and to several scholars that resuscitated his insights to explain the superior economic performance of regions such as the Third Italy, or Silicon Valley in the US, in the 1980s and 1990s. They emphasised concepts such as the 'industrial atmosphere',[5] the local long-term socio-economic relationships among local firms, involving trust and a blend of competition and collaboration, and the role of local institutions, the latter especially in the Italian version.[6]

The second category of ID proposed by Markusen and empirically detected in the US and elsewhere is the hub-and-spoke district (Markusen, 1996). It occurs where one or more firms/facilities act as anchors or hubs to the regional economy, with suppliers and related activities spread around them like the spokes of a wheel. A single large—often vertically integrated—firm (for example, Boeing in Seattle and Toyota in Toyota City) or several large firms in one or more sectors (such as Ford, Chrysler and GM in Detroit, or the biopharmaceutical industry in New Jersey) may act as hubs, surrounded by smaller and dominated suppliers. The spokes may represent strong ties, as in the previous example, or loose ties, such as the externalities enjoyed as agglomeration economies derived

from proximity.[7] The large hub firms often have substantial links to suppliers, competitors and customers outside the district. This may represent an interesting dynamic feature of this model, insofar as these 'long arms' act as 'sensors' for innovation and creativity in other locations and thereby enable the transfer of new ideas and technology to the home region. However, such long arms may also inform the hub company of the potential benefits and opportunities elsewhere and drive the major firm out of the region. Cooperation among competitors within this form of ID is remarkably lacking, and inter-firm relationships occur between the hub firm and their (often long-term) suppliers. However, the terms of cooperation are always set by the hub firm. Thus, in principle the hub might even be interested in deliberately playing off one supplier against another as a way of getting more favourable conditions.

In principle, within this type of cluster, an interesting development process may be envisaged. The spark could be represented by the agglomeration of skilled labour and business services around the hub, with the spoke firms setting up alternative and independent links and benefiting from the agglomeration economies generated by the district. In this event, the presence of a large hub firm with several activities and multiple linkages with other firms and providers would foster (or even *lead*) the ID to venture into new sectors, diversifying away from the traditional specialisation. This is likely to occur more frequently when hubs are active in more than one industry, and may explain the evolution of clustering and IDs and the reorganisation of their network of linkages.

The satellite platform is the third type of ID described by Markusen: it consists of a congregation of branch facilities of externally based multiplant firms. It is often induced by the policies of national/local governments to stimulate regional development. Key investment decisions are made out of the ID, and tenants of the satellite platform must be able to more or less 'stand alone', that is to be spatially independent from upstream or downstream operations as well as from the agglomeration of other competitors and suppliers in the same area. There tends to be minimal collaboration among platform firms, often engaged in different activities and industries. Differently from what happens in the hub-and-spoke version, the large, often multinational, corporation is not locally based.

When industrial activities are 'anchored' to a region by a public or nonprofit entity, such as a military base, a university or a concentration of public laboratories or government offices, then a state-anchored district may emerge. The local business structure is dominated by the presence

of such facilities, which follow a logic that is different from private-sector firms' view. Politics may play a central role in the development of such a form of ID. Indigenous firms will play a smaller role here than in the previous forms of ID. However, some new SMEs may emerge out of specialised technology transfer (for example, via universities) or business services provided by (or spilling over) the anchor institution. This type of ID may represent a useful way to portray an ID emerging from a government-planned initiative, take, for example, a business park, a science park, a training centre, a quality control agency, or a technology diffusion centre.

In this class of ID, the growth of local SMEs, and their diversification into various industries is likely to depend on several specific features of the ID, such as the specificities of the prevailing industry, the technology in use and its transferability from the 'anchor' to local firms, and the existence of local additional competitive factors.

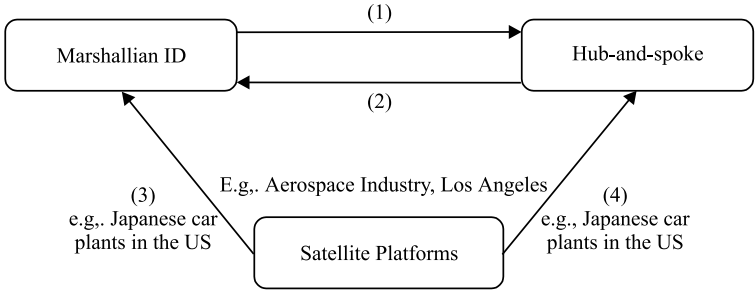
Of course *a real-world cluster may be an amalgam of one or more types*.[8] In order to simplify these categories even further, at the cost of lacking precision, firms may tend to share a geographical agglomeration along three broad modalities:

1. *(Casual) geographical clustering of firms*, with occasional inter-firm linkages, no (or little) experience of cooperation, non-existent or little developed local institutions.
2. *Marshallian (Italian) ID*, with smoother inter-firm transactions, much better developed practices of cooperation, more developed and effective local institutions, economies of scale at the district level made possible by substantial enterprise specialisation, deep integration between economic activities and the local socio-cultural fabric.
3. *Enterprise network with some form of leadership* prevailing, with the leader providing the strategic services and impetus for diversification into different products and sectors.

It is important to note that these are not necessarily sequential stages, as clusters may remain persistently different, depending on industry or local characteristics or historical circumstances and 'lock-ins'. However, over time, enterprise clusters may mutate from one type to another. Some possible transitions through different types of clusters are illustrated in Figure 2. Thus, instances of a transition from a Marshallian ID to a hub-and-spoke, with the emergence of larger oligopolistic companies

(1 in Figure 2), are provided by Detroit (automotive industry) and Pittsburgh (steel industry) respectively in the first decades of the twentieth century and at the end of the nineteenth century (Markusen 1996: 301). In principle, the same process might occur through the incubation of a hub within the ID, or in the event a state-anchored ID turning into a hub-and-spoke, with a private company replacing the public firm/institution (for example, in Colorado Springs, Markusen 1996: 308).

FIGURE 2
Possible Transitions through Types of Enterprise Clusters
e.g., Detroit (cars), Pittsburgh (steel), Colorado Springs



Similarly, satellite platforms may transform into a Marshallian ID by strengthening and intensifying backward and forward linkages among SMEs, both suppliers of intermediate goods and competitors for the same final markets (3). In the event larger firms prevailed, or SMEs grew bigger and established leader-follower links, then a hub-and-spoke district might prevail (4).

Among the three modes of clustering, the enterprise network requires, as well as offers, the largest opportunities to reach out much further away, breaking the geographical borders without losing its identity and preserving its specificity and uniqueness. This feature may prove remarkably useful with increasing globalisation, when technological paradigms change, like in recent years, with the co-evolution of technology, and industrial structures. This is explored in the following section.

The Link between Clusters Evolution and Technological Regimes

Two new major features of the social and economic systems are emerging and have characterised the last two decades. On the one hand, technology changes rapidly and increasingly plays a central role in all economic

activities. On the other hand, the scope of all economic and enterprise activities has become global (Archibugi and Michie 1998; Archibugi and Pietrobelli 2003). These two dominant features are intrinsically interrelated and mutually reinforcing.

It has been widely shown that technology has become a crucial input, with the knowledge intensity of production growing remarkably. Consistently, since the late 1970s, intangible investments including R&D, training, software development, and design and engineering, have been growing at three times the rate of tangible investments (OECD 1992). New technologies such as ICTs, biotechnology and new materials are creating new products (UN 1995) while at the same time changing the characteristics and performance of many traditional products (UNCTAD 1995).

The second dominant feature of the prevailing techno-economic model is the widespread internationalisation of all economic and technological activities. International trade and investments now account for larger proportions of national income in all countries. Technological knowledge needs to be sourced from different origins and the nature of technology makes it more convenient for a company to extend its technological activities by sourcing technology abroad and striking R&D and technology partnerships with other companies and institutions (Cantwell and Iammarino 2001; Pietrobelli 1996).

The literature on the relationships between the technology in use and the pattern of technological change has been centred on the notion of *technological regimes*. This concept was first introduced by Nelson and Winter (1982), and later developed by others (Malerba and Orsenigo 1995, 1996). Within this framework a firm's rate of innovation is influenced by the technological (and industrial) environment facing the firm, that is by:

- *Opportunity conditions*: the firm's likelihood to innovate, given the investment in research.
- *Appropriability conditions*: the possibility of protecting innovations, and the profits thereby derived from imitation.
- *Degree of cumulativeness*: the extent to which the amount of innovations produced in previous periods raises the probability of innovating in the present period.
- *Knowledge base*: the type of knowledge upon which the firm's activities are based.

In this framework two polar models of innovative activities have been developed following Schumpeter (1934, 1942). The first pattern of innovative activities has been called the Schumpeter Mark I Model. It is characterised by conditions of medium-low opportunity, low appropriability and low cumulativeness. Typical features of this pattern are technological ease of entry in an industry, a relatively large number of innovators, a major role played by new firms in innovative activities which are continuously breaking through the current way of production, organisation and distribution. The second pattern of innovative activities, known as the Schumpeter Mark II Model, is characterised by conditions of high opportunity, appropriability and cumulativeness which are more likely to lead to a low number of innovators and the dominance of a few firms that are continuously innovating through the accumulation over time of technological and innovative capabilities. They employ their accumulated stock of knowledge, thereby creating barriers to entry in an industry for new entrepreneurs and small firms. Importantly, it has been shown that technological regimes are technology-specific (Malerba and Orsenigo 1996b), that is to say that the pattern of innovations in one sector is very similar throughout every country.[9]

Does the technological regime within which firms operate have consequences upon enterprise clusters, and especially on their internal organisation, geographical location and innovative behaviour?

It is reasonable to expect that innovators will emerge from the location where technological opportunity is available and accessible (Baptista and Swann 1998).[10] When there are conditions of high opportunity, high appropriability and high cumulativeness, as in the Mark II Model, innovators are geographically concentrated. This is also related to the firm's knowledge base, since the more technological knowledge is tacit, complex and systemic, the more constant inter-firm interaction will be needed; so one can expect a greater concentration of innovators, as this type of knowledge can only be learned through daily use, and requires informal personal contacts and exchanges (Lundvall 1988; Nelson and Winter 1982). This is what typically happens in a localised cluster. Conversely, geographical concentration should be less important when the industry's knowledge base is simple and well codified and conditions of low opportunity, low appropriability and low firm cumulativeness prevail. Here, a high degree of geographical dispersion of innovators is likely to emerge (Schumpeter Mark I Model).

Do these hypotheses hold in the present context of globalisation and changing technological paradigms? The prevailing techno-economic model, with the diffusion of the ICTs and the rapid internationalisation of all economic and technological activities, would seem to lead towards an increasing relevance of Schumpeterian dynamics of the first type. Resources, capital and other inputs can be efficiently sourced in global markets. Furthermore, information and technologies become generic, increasingly codifiable and readily available via globalisation. This diminishes some of the traditional roles of geographical location, and firms find it increasingly necessary to create knowledge through linkages with distant firms and organisations (Ernst 2001).

But all this is only one side of the coin. In fact, location remains fundamental to competition, albeit in different ways, in the new techno-economic model dominated by ICTs (Cox 1997; Storper and Salais 1997). The relevant knowledge base involves *tacit as well as* increasingly codifiable and codified aspects. The former are related to a firm's specialised capabilities and require social interaction and co-location, while the latter refer to technological knowledge which is new, widely applicable and generic. So, even if technology can be licensed or sourced from other locations, and components and equipment can be out-sourced, other more complex dimensions of competitiveness remain geographically bounded and related to the Schumpeter Mark II Model. The enduring technological and competitive advantages in a global economy are often still significantly local.

In this perspective the spread of global production networks (GPN) may be understood as an organisational innovation which may enable a firm to gain quick access to higher quality and/or lower-cost foreign capabilities and knowledge, without losing access to local tacit knowledge and the complementary locally clustered capabilities (Ernst 2001).

To our present aims, these recent patterns impose drastic reorganisation demands on all enterprises. Such changes are sweeping and imply comprehensive industrial restructuring, new skills and intermediate inputs. In light of this evolution, two working hypotheses may be singled out:

1. A shift in the technological paradigm that applies across sectors and that requires a substantial industrial reorganisation is being observed worldwide. Firms traditionally operating within a cluster or a district need to learn to source their technological knowledge from the most advanced locations outside it, and reorganise their

knowledge linkages from a cluster-based approach to a wider and global approach such as the GPN model.

2. The prevailing form of the 'Marshallian' ID may not be the most adequate for the new technological areas promising faster and more sustained demand in world markets. The internal organisation of 'Marshallian' IDs, whose strength was based on local interactions within the cluster, may prove less capable of tackling the challenges posed by a new technological regime characterised by globalisation of production, and most notably of knowledge creation.

The comparative evidence on Italy and Taiwan presented in the following sections sheds some light on this issue.

Clusters and Networks in Taiwan's Electronics Industry

The comparison between the experience of industrial clustering in Italy and Taiwan may appear hazardous, but this is only apparent at first sight. In reality, in both economies, SMEs represent the bulk of industrial structures, and both countries are fully integrated into the current processes of internationalisation and globalisation. Taiwan has been one of the earliest developing countries to open to international economic flows, first targeting export markets, and then relying on the direct investments of foreign multinationals. More recently, Taiwanese companies have also started to invest overseas and to strike strategic linkages with transnational corporations.

Furthermore, what makes the comparison especially instructive are the countries' different patterns of industrial specialisation. Italy has been, and still is, mainly specialised in 'traditional' productions such as furniture, textiles and clothing, ceramics, and industrial machines, and this pattern has hardly changed over time (Pietrobelli 2002). In contrast, Taiwan has experienced a remarkable structural transformation and rapid diversification towards electronics and electrical machinery since the 1980s after an early phase of specialisation in labour-intensive clothing.

During the 1990s Taiwan achieved great success in the electronics industry, and especially in the information technology (IT) area. In 1998, the value of domestic and foreign production of the Taiwanese IT industry was over US$ 30 billion and ranked third in the world for the production of computers, following the US and Japan. In terms of export value,

Taiwan's electronics industry has overcome textiles and clothing—traditionally the core industry of the Taiwanese model—to become the leading exporter since 1994.[11] This outstanding success is all the more surprising for an economy with scarce resource endowments and which is dominated by SMEs.

Such remarkable restructuring has occurred during the last two decades in reaction to a combination of two main aspects: (*i*) a remarkable and mounting competitive pressure, and, (*ii*) active policies to foster firms' responses to such pressure, with interventions to remedy the drawbacks of small size and promote technology and innovation. This also implied initiatives such as support to the creation of science parks and inter-firm collaborations (for example, research consortia).

The increasing competitive pressure came from several strong market signals. The sharp appreciation of the New Taiwan dollar, the severe shortage of labour and the consequent escalation of wages, the loss of the Generalized System of Preference (GSP) status, the rise of real estate prices and the aggressive competition from the Korean *Chaebol* in the late 1980s, were all factors that have tremendously affected SMEs operating in traditional labour-intensive industries. Many of them were thus compelled to shift production abroad (mainly to South-east Asia and mainland China) to maintain competitiveness. The remaining enterprises had to redirect their business towards more skill-intensive, R&D-oriented products, searching for new product niches and new market areas to survive.

Indeed, the textile and clothing sector underwent a strong process of upgrading from a few traditional spinning and weaving products to capital and technology intensive man-made fibres and fashionable clothing. Currently, garment firms which continue to produce in Taiwan are all specialised in high-end products with strong design content. At the same time, the overall industrial structure has remarkably diversified towards higher-technology products and sectors.

The electronics industry in Taiwan has followed a totally different path of development. Differently from the textile and clothing industry, the electrical and electronics industry relied on a substantial flow of foreign direct investment (FDI), on which it initially depended for access to foreign technology and international markets. At the same time, however, the rapid expansion of the information industry provided many new opportunities for both existing and new SMEs.

There has been an intense debate on how Taiwanese firms, most of them SMEs, have been able to compete successfully in the international

market. Strong networks, and notably information networks among local and overseas Chinese engineers, abundant human capital, flexible and specialised production systems and broadly based supporting industries are all commonly mentioned as distinctive characteristics of Taiwanese SMEs (Kuo 1998). In the summer and fall of 1999, we carried out fieldwork with interviews of a sample of enterprises in the textile and clothing and electronics sectors, and on the basis of EU-harmonised questionnaires.[12] The main objective of the survey was to provide a preliminary answer to the following questions: have networking and clustering played an important role in Taiwan's SMEs success? What are the specific forms of networking that have prevailed? The conclusion is that *networking has indeed played a key role*, and networks have taken different forms.[13]

The evidence collected is presented in greater detail by Kuo and Wang (2001) and reveals remarkable differences from the Italian cases, surveyed in the next section. Thus, many company founders (twelve out of twenty-three) had previously worked in large domestic or multinational companies, already suggesting an intense interaction between these groups of actors. Moreover, the interviews carried out support the view that Original Equipment Manufacturing (OEM) and Original Design Manufacturing (ODM) orders have helped manufacturers to acquire technological and product design capability from foreign companies, at the same time absorbing relevant experience in product management and shipping procedures. This valuable feedback effect has greatly enhanced the learning and innovative capacity of SMEs in Taiwan (Ernst 2001). At the same time, a high percentage of the equipment used by SMEs is purchased abroad, with crucial elements of technical know-how embodied into this equipment.

Most of these firms were also substantially helped by the numerous *government policies* to support SMEs in the electronics sector, whose role cannot be understated. These policies range from joint private and government R&D Consortia (for example, the 'Alliance for the Joint Development of Notebook Computers'), to subsidies for the development of leading new products (with 50 per cent of the development costs covered by government subsidies), active venture capital Funds, S&T Parks modelled on foreign, successful experiences such as Silicon Valley (for example, the Hsinchu Science-based Industrial Park, see ahead), to several government-sponsored research institutes for the generation and transfer of advanced technology (see Kuo and Wang 2001; Kuo 1998; San Gee 1995 for details).

A central policy area has been in the domain of building a remarkable array of inter-firm and inter-institutional linkages, often promoted by government policies to help exploit the opportunities offered by clustering and networking.

Still, the key explanation of the success of SMEs competing in globalised high-tech industries, supported by our survey evidence, is that clustering and networking have taken a peculiar form, and generated the co-evolution of domestic and international knowledge linkages. In other words, inter-firm and inter-institution linkages have been built to provide local SMEs with the necessary externalities to cope with the dual challenge of knowledge creation and internationalisation. Let us briefly explore how these networking linkages have developed for Taiwanese SMEs.

When Taiwan began to enter the computer industry during the late 1970s, domestic linkages did not exist. International linkages thus were of primary importance from the outset, and the domestic linkages gradually developed afterwards. Two main types of international linkages prevailed: inward FDI, that played an important catalytic role for knowledge creation during the early phase, and the participation of Taiwanese firms in GPN established by foreign electronics companies. The latter has represented a remarkable organisational innovation, and its main features have been aptly described by Ernst (2001) and summarised in Table 1.

Taiwanese SMEs, as well as the government, have pursued a *plurality* of approaches in parallel to build a variety of *domestic linkages.* Among these forms of linkage creation, the following have been considered especially important (ibid.: 101–7):

- Informal 'peer group' networks, whose focus has shifted from labour, capital and basic market information to technological knowledge and brand name recognition. Originally these networks were restricted to family and kinship relations. Now, they have evolved to professional 'peer group' networks, that are especially required in electronics and high-tech industries.
- Hierarchical centre-satellite systems to encourage closer, interdependent and long-term ties between larger 'centre' firms (upstream suppliers, final assemblers, large trading companies) and their 'satellites' (especially component suppliers). These links have often been favoured and subsidised through government policies.

TABLE 1
Features of Different Forms of Clusters and Models of Industrial Organisation

Features	*Marshallian ID (ITA = Italian variant)*	*Hub-and-spoke district*	*Satellite industrial platform*	*State-anchored industrial district*	*Global production network (GPN)*
Prevailing Market Structure	Local SMEs	One/several large firms and suppliers	Large firms external to the district	One/several government institutions providing infrastructures	Global oligopolies with networks of local SMEs
Extent of Geographical Agglomeration	High	Fair	Limited, extended beyond local cluster	High	Limited, extended beyond local cluster
Economies of Scale	Low	High	High	High	Highest (also for SMEs, often part of several GPNs)
Intra-district Trade	Highly developed	Between large enterprise and suppliers	Minimal	High between institution and suppliers	Limited
Key Investment Decisions	Local decision	Local decision, but globally dispersed	External decision	In local government or external to the ID	Foreign contractor
Regulation of Relationships	Long-term contracts	Long-term contracts	Short-term contracts	Short-term contracts	Contracts subject to instability
Cooperation with Firms Outside the ID	Low	High	High with parent company	High with parent-company (institution)	High with foreign contractor company

(*Table 1 Contd*)

(*Table 1 Contd*)

Features	*Marshallian ID (ITA = Italian variant)*	*Hub-and-spoke district*	*Satellite industrial platform*	*State-anchored industrial district*	*Global production network (GPN)*
Labour Market	Internal to the district, highly flexible	Internal to the district, flexible	External to the district, internal to the large enterprise	Internal (government), national from other institutions	Global (for high skills)/ local
Main Workers' Commitment	With the ID	With large firm	With large firm	With government institution, then with ID	With local SMEs
Local Cultural Identity	Developed	Developed	Virtually absent	Developed	Developed locally, not across the GPN
Sources of Knowledge and Innovation	Internal to the ID	Mainly in the hub	Mainly in parent company	Local Institution	Global
Sources of Financing and Technical Assistance	Internal to the ID	Large firm	External	External (national/local government, military base, State University or research Centre)	Foreign contractor improves local firms' access to finance
Patient Capital*	Exists	Scarce out of the large firm	Non-existent	Non-existent	
Local Trade Associations	Strong presence (ITA)	Virtually absent	Absent	Weak	Yes
Role of Local Government	Important (ITA)	Important	Important	Weak in regulation and industry promotion/ Important in infrastructure	Useful in promoting local participation to global networks

Source: Own elaboration inspired by Markusen 1996, Castellano 1999, Ernst 2001.

*Presence of financial institutions willing to take long-term risks, for the confidence and information they possess.

- Linkages with large domestic firms, often in the form of cross-sectoral business groups. The shift to business groups has been most pronounced in the electronics industry, due to the critical importance of economies of scale and scope, the necessary linkages with foreign customers through international subcontracting and OEM arrangements, and with international supply sources, especially for key components.
- Business groups centered around a holding company, and creating a federation of loosely connected companies united by four factors: access to common core technologies; access to the holding company's financial resources; access to its knowledge base, market intelligence and technology scanning capabilities; and a common brand name.[14]

Thus, contrary to the conventional view prevailing among Marshallian ID theorists, *large firms* have played a central role in the coordination and development of the Taiwanese computer industry; and have also acted as *important sources for knowledge creation in SMEs.*

One notable example of a policy directed to explicitly favour inter-firm linkages has been the creation and development of the Hsinchu Science-based Industrial Park (Saxenian and Hsu 2001; Wen-Hsiung Lee and Wei-Tzen Yang 2000). In a sense, the Hsinchu Park may be viewed as an industrial *cluster*, in which competition and vertical cooperation among local firms account for rising productivity, innovation, and new firm formation (Saxenian and Hsu 2001).

This Park was established in 1980, '…with the motivation being the creation of a base for the establishment and nurturing of hi-tech industries, and the creation of a high-quality environment for R&D, production, work, life and leisure' (Tsai and Wang 2005: 242). The Park was explicitly modelled on Silicon Valley, with land provided by the government and two of Taiwan's oldest universities—the National Tsing-Hua and National Chaio-Tung Universities—located nearby. Since its creation, the government invested over NT$ 18 billion (approximately US$ 600 million) in the Park, turning it into the main centre of Taiwan's industrial development. In 2000, companies located in the Park spent, on average, 5.94 per cent of their sales on R&D, employing almost 103,000 workers (8,000 in 1986) with a total turnover of US$ 29.8 billion (US$ 450 million in 1986; see ibid.). Their exports accounted for almost 10 per cent of Taiwan's total exports.

A remarkable feature of this Park has been its role in attracting large flows of technical experts and engineers of Chinese ancestry from abroad. This represented a powerful strategy to foster the transfer of advanced technology from developed countries, notably the US. The transnational ties developed between Silicon Valley and Hsinchu have been studied in detail, proving that they have dramatically accelerated the flows of skills, know-how and market information between Taiwan and the US (Saxenian and Hsu 2001). The trust and density of the mutually interacting social networks across the Pacific Ocean notably fostered the effective transfer of information and technology.

Moving to *international linkages*, a GPN may be taken as a paradigmatic example to describe the strategic complementarity of linkages with foreign networks of firms and institutions and localised external economies. The logistic complexity of a GPN is not simply a result of its geographic spread, but also a function of an increasingly complex division of labour. In fact, each GPN combines different hierarchically structured and closely interacting sub-networks.

A powerful policy to induce and favour international collaborative linkages has been the explicit promotion of R&D consortia by the Taiwanese government (Mathews 2002). Several alliances could be counted in Taiwan in the late 1990s, bringing together firms, public sector research institutes, trade associations, with catalytic financial assistance from the government. The target behind this policy was clearly the promotion of technological learning, upgrading and the creation of a catch-up industry. Although these consortia had varying results, their net contribution to effective network creation and technological upgrading of Taiwan's industry has been very positive.

What factors have induced large computer companies to increase their reliance on outsourcing and hence to establish GPNs, and local SMEs to participate in them? From the point of view of a large global competitor, concentrating on product development, while at the same time remaining a low-cost producer to stay competitive in international markets is vital.[15] Thus, large multinational firms tend to focus on R&D and on the production of some key components, and outsource most of the other activities, forcing potential suppliers to compete and reduce production costs.

From the point of view of small suppliers from a small country like Taiwan, participating in a GPN can provide various advantages, such as:

- Manufacturing on an OEM basis is a significant source of knowledge creation for affiliated firms. Knowledge is transmitted through the

supply of blueprints, the interaction of personnel and the transfer of tacit dimensions of technology.

- A supplier may then use the relevant technology and technical expertise acquired in manufacturing on an OEM basis for other multinationals. Thus, Taiwanese firms often participate in more than one GPN.
- This process allows local SMEs to achieve economies of scale, and in turn justifies the installation of capital equipment otherwise too large and costly.
- Letters of credit by the foreign purchaser allow local suppliers to borrow additional capital.
- Participation in a production network saves the expense of building distribution, sales and service networks. This reduces the costs of acquiring knowledge about foreign consumer preferences, and of setting up the distribution and service networks, a formidable challenge even to large multinationals.

Although, in principle, marketing products under the firm's own brand name (OBM) may allow higher profit margins, many Taiwanese companies have found that the costs incurred in setting up distribution, sales and service networks can outweigh their benefits. In several instances, OEM relationships and GPNs have rapidly moved beyond production to encompass an increasing variety of knowledge-intensive, high-end support services.

An important distinctive feature of the Taiwanese networks is that they *never implied a stable relationship* between input suppliers and users, which instead characterises the Japanese case. Probably due to the dominance of small sizes and to the unstable competitive environment, the 'centre' firms exerted a constant pressure to squeeze input suppliers and bargain hard to reduce costs. This has propelled the improvement of SMEs, although clearly not all of them could succeed (for examples see Kuo and Wang 2001: 71).[16]

In sum, inter-organisational knowledge creation is critical for small firms that compete in high-tech industries such as the computer industry, in years of changing technological regimes. If well organised and managed, such external knowledge linkages can effectively compensate for some of the original size-related disadvantages of small firms, and reproduce the advantages of local agglomeration. Such a model of industrial organisation has produced the *co-evolution of domestic and international knowledge linkages*, remarkably favouring the competitiveness of

Taiwanese SMEs. Local clustering and international reach have gone hand in hand and are mutually reinforcing.[17]

Italian Industrial Districts in the Textile and Clothing Industry

The Italian experience of clustering and organisation of industry is remarkably different from Taiwan's, and is centred on the notion of 'Marshallian Industrial Districts', that in the year 2000 accounted for 28.2 per cent of total manufacturing firms and 30.3 per cent of total employment in Italy (see Table 2).

TABLE 2
Italy, The Large Role of Industrial Districts, 1996–2000

	Total (1,000 and %)			
No. of firms	*1996*	*%*	*2000*	*%*
In districts	1.086	28,1	1.191	28,2
not in districts	2.785	72,0	3.027	71,8
Total Italy	3.870	100,0	4.218	100,0
Employment	1996		2000	
In districts	4.353	30,6	4.681	30,3
not in districts	9.887	69,4	10.769	69,7
Total Italy	14.240	100,0	15.450	100,0

Source: ISTAT—ASIA Database. Only non-agricultural firms.

The textiles and clothing industry has traditionally played a central role in the Italian pattern of trade specialisation since the Second World War with an average export propensity higher than that of total manufacturing. In addition, this sector has been the most representative of *local systems* in Italy for many years,[18] and already in 1995 only seven systems (ten provinces) accounted for the bulk of textile exports, and fifteen systems (twenty-three provinces) contributed to 83 per cent of Italian clothing exports (Conti and Menghinello 1996).

Most Italian textile and clothing clusters have undergone several rounds of restructuring since the 1980s. During the first one, which started during the 1980s, the Italian textiles and clothing IDs have shown a greater capacity of reaction and adaptation to the new market conditions than the average of SMEs (Guerrieri and Iammarino 2001: 39–42). This has had the characteristics of personalisation of products (from price competition to quality competition), diffusion of micro-electronics, growing

specialisation within the ID and in complementary sectors such as machinery and equipment for textiles and clothing, the rise of groups of firms referring to a leader (particularly in mature IDs, such as Prato, Como and Carpi) leading to more formal and long-term subcontracting linkages, and a much less pronounced hierarchisation of inter-firm relationships in 'younger' districts specialised in textiles and clothing (for example, in Teramo, Pesaro and Isernia).

In sum, since the 1980s most Italian IDs have shown a stronger propensity to upgrade their production into higher quality, abandoning upstream phases of production and relocation abroad, rather than to diversify their sectoral specialisation. The central question in this respect is whether such strategies are proving sufficient to stay ahead in the new technology environment, and combine external economies within the district, with increased openness of local networks and international links. In order to assess these issues, a fieldwork analysis was carried out in selected districts with the same questionnaire and methodology used in Taiwan and in other countries (Guerrieri et al. 2001).

As it is well known, the geographical identification of IDs is not straightforward, as Italian IDs are often an intermediate area between the commune and the province. Aware of such difficulties, and making use also of secondary sources, we chose the province as a unit of analysis to represent a good approximation of an ID. The analysis of some structural characters of production and export specialisation of Italian provinces allowed us to select three case-studies.[19] Thus, Prato and Carpi were chosen as representative of 'older' IDs, whilst Teramo was selected as an example of a 'younger' ID. The fieldwork was carried out in the summer and autumn of 1998 with interviews and questionnaires to 48 SMEs overall.

Firms on average turned out to be older and smaller in Prato and Carpi, and younger (late 1970s) but larger in the newer district of Teramo. The recent sales performance has been better in Prato, with an improving trend over time, relative to an almost stable pattern in Teramo and a sudden decline in Carpi in 1997, after years of increasing sales. Enterprises in Prato and Carpi appear more export-oriented, with respectively 54 and 33 per cent of total sales going to foreign markets, than in Teramo, where exports account for only 17 per cent of sales. Most of these exports go to EU markets (54.2 per cent).

Furthermore, data on the share of output sold to the top three customers in 1997 show that Prato and Carpi seem to rely much less on top customers (31 and 22 per cent respectively), while Teramo's firms on average

sell 63 per cent of their output to the main three clients. This suggests a stronger concentration of subcontracting relationships in Teramo than in the other two more mature districts, and is confirmed by qualitative evidence.[20]

One central target of the survey was to assess and measure the 'cluster effect'—that is the extent to which the location in the ID is perceived as important (strategic) by the firm—and its impact on enterprise performance. The main results may be described as follows:

- The background of the entrepreneur/founder, is often a family business (46 per cent of all firms) or another SMEs (33 per cent), both located in the same cluster. This confirms the traditional result on the importance of family ties, traditions, and a sort of 'path-dependence' in Italian districts, differently from what the Taiwanese survey reveals, with many entrepreneurs as spin-offs of larger companies.
- Product innovation has been limited. However, 50 per cent of all surveyed firms undertook improvements in production processes, with new specialised machinery, equipment and computer-assisted technologies. This confirms once more the central role played by the machinery and equipment sector for innovation in SMEs in traditional manufactures.[21]
- Turning to the *external sources of technology*, customers and equipment suppliers were assessed as crucial by our respondents. In Prato, local *together with* national and international customers were ranked as the leading channels of technology sourcing. Only in the case of Teramo no international linkages turned out to be important. Moreover, local and national equipment suppliers emerge as the main external source of technology in all cases.
- The geographical features of relevant linkages are especially noteworthy in our sample. In Prato, local technological linkages are rather strong (with ten firms indicating the local environment as the origin of the main source of technology), as well as for Teramo (with nine firms). But while in Prato and Carpi firms *also* show a notable international openness, the respondents in Teramo do *not* have any major technological channel with sources outside the country.
- Overall, the intensity of local linkages, and therefore the strength of an 'ID atmosphere', is far more perceived in the two 'older' districts of Prato and Carpi than in the 'younger' ID of Teramo, which

attached a lower rating to local connections as a whole. Moreover, linkages with service providers were deemed important in Prato, whilst linkages with private financial institutions were considered important in Carpi.

In sum, there is evidence to argue that the well-established system of networking detected in Carpi and Prato by this and many other studies, may not only encourage interdependence and collective learning but also facilitate the future integration in global networks and the response to the challenge of the ICT revolution.[22] On the other hand, the relative lack of internationalisation and perception as being part of a local system detected in Teramo may turn out to be a critical drawback in the complex path to stay ahead in global markets.

The evidence presented confirms the importance of the *industrial atmosphere* and the strength of the Marshallian model in traditional IDs like Prato and Carpi. This appears to occur to a lesser extent in younger IDs such as Teramo.

Thus, *proximity matters and will continue to matter*. However, the necessary attitude of IDs to open and reach out to distant markets and partners, and become part of international integrated systems is still incipient, and only observed in 'older' and more mature districts. Yet, the limited knowledge of new global technological languages, as well as the lack of substantial organisational changes required by the new technologies to be effective, may progressively cut out geographical clusters and, as a result, 'industrial atmosphere' might not be sufficient any more.

Indeed, the global challenge implies not only relocation of production in search of low labour costs, but even more a variety of forms of industrial organisation. Most firms, both small and large, are learning to acknowledge the crucial importance of participating in global innovation networks which entail relationships with suppliers, distributors, financial systems and customers, each of them contributing differently to the innovation of products and processes, and boosting the productivity and creativity of everyone in the network. So far, in the Italian IDs specialised in traditional sectors, the exploitation of the potential offered by global networks to strengthen communication and information has been rather weak, and different case by case. This remarkably differs from what is occurring in other emerging parts of the world, as the evidence on Taiwan suggests. In addition, *the role of policies* to lead and direct such trend has been *minimal*, in contrast with what happened in Taiwan.

Conclusion

The selected evidence discussed in this article suggests three interrelated propositions. First, there is no one best model for organising an ID or an industrial cluster, since a diversity of institutional arrangements is possible and each has proved successful in different circumstances. Second, clusters are not cast in iron, but they evolve over time. Third, globalisation reshapes the upgrading options for SME-based clusters, by providing a variety of international knowledge linkages. In a nutshell, globalisation changes both the concept of proximity and the scope of competition: a necessary prerequisite for competitive survival is the capacity to foster the co-evolution of local and global linkages and networks, and to develop new interactive modes of knowledge creation.

The first two propositions are fully confirmed by the reorganisation of both the Taiwanese and Italian SME-based clusters, particularly over the past decade. Industry and firm-specific differences provide one possible explanation for the diversity of cluster development trajectories in the two countries. However, the industry-level explanation is not sufficient by itself, and some new features of the technological regimes challenge all industries, though in different ways. The consequences of globalisation on industrial restructuring and reorganisation are going to be felt more and more across sectors in the future, and so the industry level could not be the relevant unit of analysis of such changes.

Geographical dispersion is occurring on a massive scale. However, geographic dispersion does not lead to the wonderland of a 'borderless world' (Ohmae 1991), and the *gravitational forces of geography are not rescinded by globalisation*. A breathtaking speed of geographical dispersion has been combined with spatial concentration, and much of the recent cross-border extension of manufacturing and services has been concentrated on a handful of specialised local clusters. Thus, rapid cross-border dispersion coexists with agglomeration, and agglomeration economies continue to matter, as well as the path-dependent nature of the cluster evolution. Moreover, dispersion is no longer restricted to lower-end activities, and notably applies also to more traditional sectors such as textiles and clothing (Ernst et al. 2001).

Systemic forms of integration are emerging *to combine geographic dispersion with localised concentration*. Global production networks represent a remarkable example of such evolution, especially noteworthy in Taiwan. Systemic integration implies that international linkages are no longer secondary, quasi-optional to domestic linkages. Instead, existing

clusters in any two countries supplement each other and may experience mutual inter-penetration. Under such conditions international linkages are essential for the continuous growth of an industrial cluster.

This is self-evident for network suppliers, especially lower tier ones, whose growth and strategic direction is heavily determined by the network or cluster leaders. But it has important implications also for the experience of the Marshallian IDs and the high locally concentrated innovation capability that has been characterising their evolution up to now. In fact, such international linkages can recharge local linkages. They provide important opportunities for international knowledge sourcing (a possible explanation for Silicon Valley's apparently inexhaustible upgrading capacity).[23]

In this perspective we argue that the 'Marshallian' form of ID, prevailing in several Italian cases, may not be the most adequate for exploiting the new technological opportunities, and the organisation of economic activities in IDs will need be less locally confined and less vertically disintegrated.

The integration into the global economy, through international networks and markets, corporate hierarchies, global production and technological organisation, is boosting the importance of *functional integration* vis-à-vis *geographical integration*. The latter was one of the fundamental conditions for the emergence of IDs and will continue to be an essential factor, provided that the necessary organisational changes connected with complex technologies are introduced.

The current shift in the technological regime that applies to all sectors and requires a substantial industrial reorganisation, poses formidable challenges to the industrial organisation of SME clusters. New technologies, and particularly the ICT paradigm, have permitted the intimacy that used to be possible only within a cluster to take place over long distances. Firms traditionally operating within the ID mould need to learn to source their technological knowledge from the most convenient locations outside the ID, and to reorganise their knowledge linkages from a cluster-based approach to a global approach. The experiences of Taiwan and Italy are remarkably insightful in this respect.

NOTES

The research leading to this paper has been supported by the European Commission through the DGXII TSER Project «SMEs in Europe and East Asia: Competition, Collaboration and Lessons for Policy Support» (Contract No. SOE1CT97-1065). Preliminary drafts

were presented at Conferences at Kennedy School of Government, Harvard University, Oslo University, Aalborg University (DRUID 2000), Denmark, at the *Universidad Nacional del Sur*, Bahía Blanca, Argentina, at the University of Molise 2001 EADI Workshop, at the EAEPE Annual Conference (Siena 2001), and at the University of Malaya, Malaysia. We wish to thank Simona Iammarino, Dieter Ernst, Wen-Jeng Kuo, Jiann-Chyuan Wang, Chaw-Hsia Tu, Bjorn Asheim and Thomas Brenner for their useful comments and discussions, and Federico Castellano for his skilful research assistance. We also wish to thank Jan Vang Lauridsen and Intarakumnerd Patarapong and two anonymous referees. The usual disclaimer applies.

1. On this evidence, see the studies in Pyke et al. (1991), Guerrieri, Iammarino, Pietrobelli (1998), and Becattini (1987), Nadvi and Schmitz (1999).
2. An interesting exception is Castellano 1999.
3. This article draws on the empirical findings of Guerrieri et al. 2001.
4. Her definition of ID is clearly different from the definition proposed and utilised by the Italian (mainly Florentine) school (Becattini, Bellandi, Dei Ottati, Sforzi and others) as she acknowledges several different institutional set-ups as having the essential features of a 'district'. In fact, her typology gathers together several different forms of organisation of production where a common geographical localisation plays a central role. As a consequence of this very broad approach the 'Italian' version of ID ends up being only one possible form of inter-firm organisation, very close to the original Marshallian idea.
5. See Pietrobelli 1998, for an empirical test of the concept of 'industrial atmosphere' in a sample of Italian IDs.
6. See Guerrieri et al. 1998 for a survey.
7. An example may be provided by the local skilled labour pool (or cadre of business services) built up by a large firm that facilitates the start up and growth of SMEs in the shadow of the major firm (Markusen 1996).
8. For instance, Silicon Valley hosts an industrial district in electronics (Saxenian 1994), some important hubs (Lockheed, Hewlett Packard, Stanford University), and platforms branches of large corporations (IBM, Oki, Hyundai, Samsung, NTK Ceramics), but it is also the fourth largest recipient of military spending in the US.
9. However systematic differences in patterns of technological change across countries in all sectors have also been observed (Guerrieri and Tylecote, 1997).
10. Baptista and Swann (1998) find evidence of a positive relationship between firms clustering and their probability to innovate for the electronics sector.
11. Machinery, electrical and electronic equipment accounted for 22 per cent of Taiwan's total exports in 1981 and 50 per cent in 1998 (with information and communication products—the highest technology sub-set—growing from 0.7 to 12.4 per cent of total exports during the same period).
12. The research leading to this paper was carried out within an international project comparing clusters' evolution in Europe and Asia, and including case studies in Greece, Israel, England, Scotland, South Korea and Japan, in addition to Italy and Taiwan (European Commission DGXII TSER Project 'SMEs' in Europe and East Asia: Competition, Collaboration and Lessons for Policy Support).
13. All 23 SMEs surveyed in electronics were located in northern Taiwan, reflecting cluster effects in Hsinchu County and in Taoyuan County.
14. This has been named the 'client-server' model.

15. The cost of components, software and services purchased from outside has increased to more than 80 per cent of total (ex-factory) production costs (Ernst and O'Connor, 1992), thereby raising coordination costs substantially. As a result, the *reduction of the cost of external sourcing* through rationalisation and internationalisation represents a central strategic concern.
16. A different and complementary reading of Taiwan's experience in electronics is presented by Kishimoto (2003), who stresses the central role played by clusters and networks, and proposes the thesis that the importance of (geographical) clustering has diminished in the 'production system' but remained high in the 'knowledge system'. He argues that in the production system we observe the increasing relocation of manufacturing mature products to neighbouring low wage countries. In contrast, with respect to the knowledge system, the manufacture of the more innovative products and innovation activities themselves remain concentrated in the geographical cluster. Something similar has been recently observed in Italian clusters.
17. Poon (2005) offers additional evidence in support to our reading of the Taiwanese evidence.
18. Italy has almost 200 local systems of SMEs, of which nearly half can be strictly defined as IDs, while the others are either IDs in the birth phase, or remains of declined IDs, or polarised industrial areas. However, in the sector here analysed, the majority of local systems correspond to real IDs (Becattini 1987).
19. The analysis of textiles and clothing exports was carried out at a detailed level of sectoral breakdown (i.e., Twenty-seven groups of products for textiles and fifteen for clothing, numbered from 99 to 140 according to the Istat classification, which includes 236 product groups, with reference to the province unit. In spite of the presence of more than one local system in the same province, by considering detailed classes of products it was possible to obtain a rather accurate picture of the contribution of the 'dominant industry' given by geographical systems to national exports.
20. The results of this survey can by no means be generalised. However, this result is confirmed also by the recent survey on Italian IDs carried out by the Bank of Italy (Pizzi 1998).
21. As expected, R&D is not at all the principal source of innovation for SMEs operating in traditional sectors. Indeed, the expenditure on design, development and engineering amounted to very small values in all districts. Overall 13 firms out of 48 declared to perform 'some' R&D.
22. It has been pointed out, with reference to the Italian cotton industry, that the adoption of ICTs may display its economic effects in terms of overall productivity levels '… only when associated with systematic changes in the organization based upon systemic networking among different firms and different units within the firms'. Furthermore, the efficiency brought about by the adoption of ICTs can be effective only with the introduction of '… parallel changes in [firms'] organization in terms of closer interaction among internal functions such as production, marketing, finance and strategic decision-making, higher levels of vertical integration and product diversification, closer interaction with customers and providers of intermediate goods and services' (Antonelli and Marchionatti 1998: 13).
23. The critical importance of international linkages is also reflected in the dense links between the Valley and Taiwan, India and China, through transnational technical communities, especially circuit designers and computer engineers.

REFERENCES

Antonelli, C. and R. Marchionatti (1998), 'Technological and Organisational Change in a Process of Industrial Rejuvenation: The Case of the Italian Cotton Textile Industry', *Cambridge Journal of Economics*, 22(1), pp. 1–18.

Archibugi, D. and C. Pietrobelli (2003), 'The Globalisation of Technology and its Implications for Developing Countries: Windows of Opportunity or Further Burden?', *Technological Forecasting and Social Change*, 70(9), pp. 861–83.

Archibugi, D. and J. Michie, eds (1998), *Technology, Globalisation and Economic Performance*, Cambridge: Cambridge University Press.

Baptista, R. and P. Swann (1998), 'Do Firms in Clusters Innovate More?', *Research Policy*, 27(5), pp. 525–40.

Becattini, G., ed. (1987), *Mercato e forze locali: il distretto industriale*. Bologna: Il Mulino.

Cantwell, J.A. and S. Iammarino (2001), 'EU Regions and Multinational Corporations: Change, Stability and Strengthening of Technological Comparative Advantages', *Industrial and Corporate Change*, 10(4), pp. 1007–37.

Castellano, F. (1999), Distritos Industriales y Modelos Organizativos de Pymes, Masters Thesis, EU-ALFA Programme, Università di Roma Tor Vergata.

Conti, G. and S. Menghinello (1996), 'L'internazionalizzazione Produttiva dei Sistemi Locali', *Rapporto ICE*, Rome: Instituto per il Commercio Estero, Chapter 7.

Cox, K.R., ed. (1997), *Spaces and Globalization: Reasserting the Power of the Local*. New York: Guilford.

Ernst, D. (2001), 'Small Firms Competing in Globalized High-Tech Industries: The Co-Evolution of Domestic and International Knowledge Linkages in Taiwan's Computer Industry', in P. Guerrieri, S. Iammarino and C. Pietrobelli, eds, *The Global Challenge to Industrial Districts: SMEs in Italy and Taiwan*. Cheltenham and Lyme: Edward Elgar, pp. 95–130.

Ernst, D. and P. Guerrieri (1998), 'International Production Networks and Changing Trade Patterns in East Asia: The Case of the Electronics Industry', *Oxford Development Studies*, 26(2), pp. 103–21.

Ernst, D., P. Guerrieri, S. Iammarino and C. Pietrobelli (2001), 'New Challenges for Industrial Clusters and Districts: Global Production Networks and Knowledge Diffusion', in P. Guerrieri, S. Iammarino and C. Pietrobelli, eds, *The Global Challenge to Industrial Districts: SMEs in Italy and Taiwan*. Cheltenham and Lyme: Edward Elgar, (2003 paperback edition) pp. 131–44.

Ernst, D. (1997), *From Partial to Systemic Globalization: International Production Networks in the Electronics Industry*, *BRIE Working Paper # 98*, the Berkeley Roundtable on the International Economy (BRIE), University of California at Berkeley, April.

Ernst, D. and D. O'Connor (1992), *Competing in the Electronics Industry: The Experience of Newly Industrialising Economies*. Development Centre Studies, Paris: OECD.

Ernst, D., T. Ganiatsos and L. Mytelka, eds (1998), *Technological Capabilities and Export Success: Lessons from East Asia*. London: Routledge.

Garofoli, G. (1991), *Modelli Locali di Sviluppo*. Milano: Franco Angeli.

Giuliani, E., C. Pietrobelli and R. Rabellotti (2005), 'Upgrading In Global Value Chains: Lessons from Latin American Clusters', *World Development*, 33(4), pp. 549–73.

Guerrieri, P. and S. Iammarino (2001), 'The Dynamics of Italian Industrial Districts: Towards a Renewal of Competitiveness?', in P. Guerrieri, S. Iammarino and C. Pietrobelli, eds, *The Global Challenge to Industrial Districts: SMEs in Italy and Taiwan*. Cheltenham and Lyme: Edward Elgar, (2003 paperback edition), pp. 35–62.

Guerrieri, P. and C. Pietrobelli (2004), 'Industrial Districts' Evolution and Technological Regimes: Italy and Taiwan', *Technovation*, 24(11), pp. 899–914.

Guerrieri, P. and Tylecote (1997), 'Inter-industry Differences in Technological Change and National Patterns of Technological Accumulation', in C. Edquist, ed., *Systems of Innovation*. London and Washington D.C.: Pinter Publishers.

Guerrieri, P., S. Iammarino and C. Pietrobelli (1998), 'Agglomeration Economies, Cluster Effects and Industrial Districts: A Survey of the Literature', mimeo, TSER Project, Rome: Institute of International Affairs.

——— eds (2001), *The Global Challenge to Industrial Districts: SMEs in Italy and Taiwan*, Cheltenham, UK and Lyme, US: Edward Elgar.

Humphrey, J. (1995), 'Industrial Reorganization in Developing Countries: From Models to Trajectories', *World Development*, 23(1), pp. 149–62.

Kishimoto, C. (2003), 'Upgrading in the Taiwanese Computer Cluster: Transformation of its Production and Knowledge Systems', IDS Working Paper No. 186, Institute of Development Studies, Sussex.

Kuo, W.J. and J.C. Wang (2001), 'The Dynamics of Taiwan's SMEs: The Case of Electronics', in P. Guerrieri, S. Iammarino and C. Pietrobelli, eds, *The Global Challenge to Industrial Districts: SMEs in Italy and Taiwan*. Cheltenham and Lyme: Edward Elgar, (2003 paperback edition), pp. 63–94.

Kuo, W.J. (1998), *White Paper on Small and Medium Enterprises*, Taipei: Small Business Administration, Ministry of Economic Affairs.

Lorenzoni, G. (1990), *L'architettura di sviluppo delle imprese minori*. Bologna: Il Mulino.

Lundvall, B.Å. (1988), 'Innovation as an Interactive Process: From User-Producer Interaction to the National System of Innovation', in G. Dosi, C. Freeman, R.R. Nelson, G. Silverberg and L. Soete, eds, Technical Change and Economic Theory, London: Pinter Publishers.

Malerba, F. and L. Orsenigo (1995), 'Schumpeterian Patterns of Innovation', *Cambridge Journal of Economics*, 19(1), pp. 47–65.

——— (1996a), 'The Dynamics and Evolution of Firms', *Industrial and Corporate Change*, 5(1).

——— (1996b), 'Schumpeterian Patterns of Innovation are Technology-specific', *Research Policy*, 25(3), pp. 451–78.

——— (1997), 'Technological Regimes and Sectoral Patterns of Innovative Activities', *Industrial and Corporate Change*, 6, pp. 83–117.

Markusen, A. (1996), 'Sticky Places in Slippery Space: A Typology of Industrial Districts', *Economic Geography*, 72, pp. 293–313.

Marshall, A. (1896), *Principles of Economics*. London: Macmillan.

Mathews, J. (2002), 'The Origins and Dynamics of Taiwan's R&D Consortia', *Research Policy*, 31(4), pp. 633–51.

Nadvi, K. and H. Schmitz (eds) (1999), 'Industrial Clusters in Developing Countries', *World Development*, 27(9), pp. 1503–14, Special Issue.

Nelson, R.R. and S. Winter (1982), *An Evolutionary Theory of Economic Change*. Cambridge MA: Harvard University Press.

OECD (1992), *Technology and the Economy: The Key Relationship*. Paris: OECD.

Ohmae, K. (1991), The Borderless World: Power and Strategy in the Interlinked Economy, New York: Harper and Row.

Park, S. and A. Markusen (1994), 'Generalizing New Industrial Districts: A Theoretical Agenda and an Application from a Non-Western Economy', *Environment and Planning*, A(27), pp. 213–24.

Pietrobelli C. (1996), *Emerging Forms of Technological Cooperation: The Case for Technology Partnerships—Inner Logic, Examples and Enabling Environment*. Science and Technology Issues, Geneva: UNCTAD.

——— (1998), 'The Socio-economic Foundations of Competitiveness: An Econometric Analysis of Italian Industrial Districts', *Industry and Innovation*, 5(2), pp. 139–55.

——— (2002), 'La competitività dell'Italia nei Confronti dei Paesi Industrializzati. Dinamiche Settoriali e di Mercato', in G.P. Galli and L. Paganetto, eds, *La Competitività dell'Italia: Le Imprese*. Milan: Il Sole 24 Ore.

Pizzi, P. (1998), 'Il Distrtto Tessile di Teramo', *Economia Marche*, XVII(3), pp. 101–12.

Poon, T.S.C. (2005), 'Beyond the Global Production Networks: A Case of Further Upgrading of Taiwan's Information Technology Industry', *International Journal of Technology and Globalization*, 1(1), pp. 130–44.

Pyke, R., G. Becattini and W. Sengenberger, eds (1991), *Industrial Districts and Inter-firm Cooperation in Italy*. Geneva: ILO.

San, Gee (1995), 'An Overview of Policy', *Journal of Industry Studies*, 2(1), pp. 30–42.

San Gee and Wen-jeng Kuo (1998), 'Export Success and Technological Capability: Textiles and Electronics in Taiwan', in D. Ernst, T. Ganiatsos and L. Mytelka, eds, *Technological Capabilities and Export Success—Lessons from East Asia*. London: Routledge.

Saxenian, A. (1994), *Regional Networks: Industrial Adaptation in Silicon Valley and Route 128*. Cambridge: Harvard University Press.

Saxenian, A. and J.Y. Hsu (2001), 'The Silicon Valley-Hsinchu Connection: Technical Communities and Industrial Upgrading', *Industrial and Corporate Change*, 10(4), pp. 893–920.

Schmitz, H. (1995), 'Collective Efficiency: Growth Path for Small-scale Industry', *Journal of Development Studies*, 31(4), pp. 529–66.

Schumpeter, J.A. (1934), *The Theory of Economic Development*. Cambridge, MA:Harvard Economic Studies.

——— (1942), *Capitalism, Socialism, and Democracy*, New York: Harper.

Shih-Chang Hung (2000), 'Social Construction of Industrial Advantage', *Technovation*, 20(4), pp. 197–203.

Storper, M. and Salais (1997), *The Regional World: Territorial Development in the Global Economy*. New York: Guilford Press.

Tsai, K.H. and J.C. Wang (2005), 'An Examination of Taiwan's Innovation Policy Measures and their Effects', *International Journal of Technology and Globalisation*, 1(2), pp. 239–57.

UNCTAD (1995), 'New Technologies and Issues in Technology Capacity Building for Enterprise', Mimeograph, Division for Science and Technology, Geneva.

UNDP (2001), *Human Development Report: Making New Technologies Work for Human Development*. New York: Oxford University Press.

UN (1995), *World Economic and Social Survey 1995*. New York: United Nations.

Wang, J.C. and Chao-Cheng Mai (1999), 'The Transformation of Industrial Structure and Industrial Development Strategy', *The Economic Development of Taiwan since the 1980s*. Taipei, Taiwan: Chung-Hua Institution for Economic Research.

Wen-Hsiung Lee and Wei-Tzen Yang (2000), 'The Cradle of Taiwan High-technology Industry Development—Hsinchu Science Park', *Technovation*, 20(1), pp. 55–59.