

The governance and evolution of local production networks in a cluster: the case of Taiwan's machine tool industry

Liang-Chih Chen

© Springer Science+Business Media B.V. 2009

Abstract The competitive advantages of spatially concentrated and networked production systems, in terms of flexibility and adaptivity, have been well documented. This paper contributes to this literature by improving our understanding regarding the underlying mechanisms behind the governance and evolution of such a production system. By using the case of Taiwan's machine tool (MT) industry, this paper demonstrates how lead firms depend on their relational capabilities or relation-building skills, nurtured greatly by cluster embeddedness, to effectively govern their suppliers in the production networks. While the production systems constantly evolve, this paper also discusses the ongoing reconfiguration of Taiwan's MT production networks stimulated by lead firms' efforts to tackle the cluster's emerging diseconomies so as to sustain their competitiveness. This paper concludes that a cure to deal with the cluster's diseconomies would be the reinforcement of industrial clustering.

Keywords Industrial clusters · Production networks · Governance · Evolution · Machine tool industry

As one of Taiwan's successful catching-up industries that has achieved a more than 400-fold growth from only US \$9 million in 1969 to US \$3.7 billion in 2006 and has evolved into the world's fourth largest exporter and sixth largest producer (Liu and Brookfield 2000; Gardner Publications 2007), Taiwan's machine tool (MT) industry has attracted many researchers who have sought to determine why this industry in Taiwan has been able to advance to its current global competitive position in the context of late industrialization. In the literature, scholars of industrial clusters have particularly emphasized that it is the presence of a spatially concentrated and networked production system in this industry that has contributed to its competitive advantages (see, for example, Liu 1999; Brookfield 2000; Chen 2007).

In Taiwan, the phenomenon of industrial clustering can be seen not only in the MT industry, but also in other well-known successful industries, such as the information technology (IT) (Hsu 1997), footwear (Cheng 2001), and bicycle industries (Chen 2002). The spatially concentrated and networked industrial system with dense inter-firm networks has been regarded as one of the most critical factors contributing to Taiwan's sustained competitiveness—that is, its ability to re-invent and re-engineer itself to respond to the changing demands of the domestic and international economy (Simon 1996; Hamilton 1997; Ernst 1998; Cheng 2001). In such a system, firms can hedge the risks of

L.-C. Chen (✉)
Graduate Institute of Building and Planning, National
Taiwan University, 1, Sec. 4, Roosevelt Rd., Taipei 106,
Taiwan
e-mail: liangchih@ntu.edu.tw

production bottlenecks or over-capacity by externalizing part of their production and having subcontractors share risks. Being able to subcontract allows firms to maintain low overheads while achieving high flexibility in both internal and external operations, and hence makes them more resilient to crisis.

Nevertheless, the formation of an efficient networked production system was not automatic. Studies carried out in the 1970s and 1980s in particular suggested that subcontracting in the production of capital goods, including machine tools, in developing countries was especially weak (Watanabe 1983; James 1991). In addition to the influence of the market (Amsden 1977, 1985), scholars like Pack (1981) contend that this shortcoming was because of the inability of actors in the capital goods industry in developing countries to fulfill two principal requisites for benefiting from subcontracting. First, the parent firms needed to be able to coordinate multiple sources of supply. Second, the subcontractors had to be efficient and reliable (p. 223). If this was the case, as a Taiwanese industry renowned for embedding its global competitiveness in localized subcontracting networks (Liu 1999), one might wonder how Taiwan's MT industry managed to escape the trap encountered by its other late industrializing counterparts. In this paper, I argue that the key lies in the issue of network governance. More specifically, I argue that for an efficient networked production system to be possible, and for its production advantages to be exploited, the governing efforts of lead firms that are able to cultivate, drive and act collectively with their partners in response to the ever-changing technologies and markets are in particular required. In the case of Taiwan's MT industry, the governance capacity of lead firms is enhanced through strategically utilizing the relational networks embedded within and nurtured by the cluster.

The aspect of cluster governance is often neglected in the cluster literature (De Propris and Wei 2007). However, as Sugden et al. suggest, it is crucial to study cluster governance if we are to understand the internal functioning and dynamics of clusters, as well as their impact on the locality (Sugden et al. 2006). Following this vein of thought, this paper aims to contribute to the discussions related to the governance of production networks in

the cluster.¹ Based on more than 60 in-depth interviews with decision-makers in MT firms, their suppliers, as well as related public and private agencies in Taiwan conducted between 2005 and 2006, this paper empirically investigates the strategies employed by Taiwanese MT firms to organize or coordinate economic transactions with their partners in the local production networks. On this basis, this paper improves our understanding of the factors contributing to, and the underlying mechanisms behind, the successful governance of a cluster's production systems. In addition, while much of the existing literature has cast doubt on the continued significance of traditional governance mechanisms exemplified in those dynamic clusters that rely on spatial proximity as well as social embeddedness in the current global economies, the ensuing discussions on the evolution of Taiwan's MT production networks will provide us with an empirical example that demonstrates how cluster actors adapt to evolving competitive conditions, in which spatial clustering should be still the key to facilitating the process.

The rest of this paper is organized as follows. “[Industrial clusters and network governance](#)” reviews the literature on industrial clusters and focuses on the issue of governance. “[Research method](#)” describes the research methods and how the research data was obtained. In “[The development of Taiwan's MT cluster](#)”, the history of the formation and development of Taiwan's MT cluster is introduced. In “[Governance of MT production networks](#)”, I then analyze the governance mechanisms of the production networks in Taiwan's MT cluster, followed by discussions concerning their ongoing evolution, in which local lead firms have started reconfiguring themselves and the production networks to tackle the emerging diseconomies of clustering. In the “[Conclusion](#)”, I conclude the research findings and discuss their implications for the future development of Taiwan's MT industry.

¹ Governance can refer to “any mode of coordination of interdependent activities” (Jessop 1998:29). In this paper, I focus mainly on activities related to production.

Industrial clusters and network governance

Since the early 1980s, the analysis of the territorial agglomeration of firms and economic activities, i.e., industrial clusters or districts, has been the subject of a large literature. Clusters of various forms have been identified in both industrialized and less industrialized countries and have been acknowledged to be able to exert push effects on national and regional economic development (Brusco 1982; Scott 1988; Sabel 1989; Amin and Thrift 1992; Harrison 1992; Humphrey 1995; Markusen 1996; Schmitz and Nadvi 1999; Porter 2000; Scott 2002).

Explanations of the advantages of clusters have their roots in the concept of agglomeration, which points to the phenomenon that similar or related firms and industries tend to concentrate in a particular locality. The classic advantages of agglomeration are laid out by Marshall (1920) who stresses the easy access to input suppliers and traders, the benefits of a pool of specialized workers, and knowledge spillovers (Krugman 1991). While acknowledging such traditional concepts of agglomeration economies, the new scholars of industrial clusters and districts have placed more emphasis on qualitative dimensions, such as trust, embeddedness, interdependence, the mix of cooperation and competition, and the role of institutions, to account for the successful development of certain regions, such as in the case of Third Italy (Brusco 1982; Pyke et al. 1990; Becattini 2003) and Silicon Valley (Saxenian 1994).

In the literature, scholars have found that the most prominent inter-organizational feature of industrial clusters is the prevalence of networked production, i.e., subcontracting arrangements, stemming from the manufacturers' dependence on other local firms for the production of components and semi-finished goods (Lazerson and Lorenzoni 1999). They also have produced numerous studies documenting the advantages of networked production systems in the clusters, including lowering labor costs, improving economies of scale and scope, enhancing learning, and offering higher quality and more rapid innovation, etc. (Brusco 1982; Saxenian 1994; Belussi and Arcangeli 1998; Porter 2000; Zeitlin 2008). To gain a deeper understanding of the dynamism of clusters in general, or networked production systems in particular, some scholars, however, have emphasized the need to address the issue of governance (De Propris

2001; Sugden et al. 2006), for studying cluster/network governance is crucial to understanding not only the internal functioning and dynamics of clusters, but also their impact on the locality (Sugden et al. 2006:69).

Among these scholars, one group has focused on analyzing various governance structures/forms within the clusters. By drawing on transaction cost economics, Hemmert (1999), for instance, compared different governance structures according to the nature of firm transactions in clusters and distinguished pure market relations from recurrent, interdependent, quasi-integrated and formally integrated relations. From a different perspective, De Propris (2001), based on the idea of power distribution, distinguished different types of governance in clusters' local systems that ranged from hierarchy, as in monopsonistic clusters, to heterarchy, as in Marshallian industrial districts. In a similar vein, Sacchetti and Sugden (2003) identified two extreme types of network governance, namely, networks of direction and networks of mutual dependence. By using the specific case of Taiwan's MT industry, Liu and Brookfield (2000) discovered that forms of governance in the cluster may be shaped like stars, rings and tiers, and influenced by factors including the capabilities and values of firms, production volume, trust and the level of competition among suppliers.²

While the foregoing research sought to develop and refine the taxonomy of governance structures in the clusters, other scholars attempted to study the underlying socio-economic institutions behind the clusters' various network governance mechanisms. It is argued that the governance mechanisms in those successful clusters appear to be a mixture of market and non-market forms (Powell 1990; Grandori 1997; Jones et al. 1997; Becattini 2003; Sugden et al. 2006). As opposed to the notion of transaction costs that emphasizes that firms might encounter greater transaction costs by employing subcontracting arrangements (Williamson 1981), much of the theoretical literature on industrial clusters has suggested that the costs of such decentralized transactions are contained by the spatial collocation and social embeddedness of

² Other studies concerning the typology of clusters' governance structures include Grandori (1997), Markusen (1997) and Guerrieri and Pietrobelli (2004), etc.

actors within clusters (Storper 1997a; Becattini 2003; Sugden et al. 2006; Zeitlin 2008). Because of the combined effect of social norms and economic incentives, the institutional environment of the clusters very much favors the development of relations of trust within the localities (Dei Ottati 1994). As a result, not only are the conflicts of opportunism in the inter-firm transactions more easily managed and resolved, but, more importantly, the inter-firm cooperation and learning are facilitated, thereby permitting firms and clusters to gain greater competitive advantages (Camagni 1991; Storper 1997a; Cooke and Morgan 1998; Morgan 2004; Malmberg and Maskell 2006). While acknowledging that trust, nurtured by the institutional and spatial proximity, represents an element governing network relationships in the clusters, the existing literature, however, also points out that the firms still need to develop relation-specific skills and capabilities for better network governance (Asanuma 1989; Sabel 1993; Dyer and Singh 1998; Lorenzoni and Lipparini 1999; Lechner and Dowling 2003).

The proposition that spatial proximity and local embeddedness promote the clusters' dynamism has, however, been challenged by critics who contend that the clusters' competitiveness can also be attained through organizational and relational networks between spatially distant actors (Amin and Cohendet 1999; Gertler 2001; MacKinnon et al. 2002). In the meantime, an increasing number of studies have begun to question whether the localized relational and production networks are still a sufficient factor enabling clusters to excel in the currently evolving global market characterized by intensified competition and rapid innovation (Oinas 1999; Gertler 2001; Bathelt et al. 2004; Whitford and Potter 2007). Some studies have further argued that clusters have to guard against the danger of negative "lock-in", since the effects of changing economic conditions can result in the local networks being "insidiously turned from ties that bind into ties that blind" (Grabher 1993:24; MacKinnon et al. 2002:304). In light of this, there has been a growing number of studies that have recently engaged in investigating the changes in the organizational structures and networks of clusters in industrialized countries, mostly in Italy, in response to the shifting competitive conditions (see for example, Belussi and Gottardi 2000; Paniccia 2002; Cainelli et al. 2006; Rabellotti et al. 2009). Furthermore, a

preliminary conclusion has been reached that there seems to be a general trend that clusters have, more or less, evolved toward greater internal differentiation and external openness (see Zeitlin 2008 for a recent review).

The strategic use of external resources through inter-firm relational networks embedded in the localities has been proven to provide an important growth mechanism for industrial clusters (Lechner and Dowling 2003). The existing literature has repeatedly emphasized that the inter-firm relationships in the clusters are bound not only by economic factors, but also by social and political ones, and are facilitated by factors such as spatial, cultural and mental proximity (Sugden et al. 2006). However, studies concerned with how the governance mechanisms of relational-based production networks in the clusters develop and, more importantly, adapt as well as evolve alongside changing environments do not only seem not to have received much attention, but have also been mostly concentrated in the clusters in industrialized country settings. In this paper, I seek to fill these gaps by studying the case of a cluster in an industrializing country, namely, Taiwan's MT cluster. As this paper's findings show, like their counterparts in industrialized economies, Taiwanese MT manufacturers were empowered to efficiently govern their production networks through exploiting the cluster's spatial proximity and social embeddedness. Yet, this paper also finds that, when facing increasing global competition, the Taiwanese MT latecomers appear to have started encountering certain sorts of clustering diseconomies resulting from their subcontracting arrangements. After investigating the ongoing reconfiguration of the production networks in Taiwan's MT industry, this paper suggests that tackling such cluster's diseconomies might call for the reinforcement of clustering.

Research method

To capture the nature of the growth and dynamics of Taiwan's MT cluster and its local production networks, this research primarily uses the qualitative research methods by conducting in-depth interviews among a broad cross-section of MT cluster participants and ethnographic accounts of the leading

firms.³ The key information needed was mostly provided by the firms in Taiwan's MT industry themselves, through their historical as well as current published or unpublished annual reports, brochures, firm websites and interviews with their key decision-makers. The sample was drawn from some 400 MT manufacturers who were the members of the Taiwan Machine Tool Foundation (TMTF). After reviewing archives of news, articles, research papers and reports, as well as analyzing statistical data on the historical development and restructuring of Taiwan's MT industry, I drew up an interview candidate list of MT firms that had gained a reputation in the above-mentioned secondary information sources for their extraordinary achievements in terms of sales growth, organizational restructuring, technological upgrading, or playing a leading role in this industry.⁴ I then sent out more than 70 interview invitations to MT firms on the list, of which 27 firms accepted my invitations. Through my fieldwork in Taiwan from February 2005 to January 2006, I was allowed to conduct 36 cases of interviews with CEOs or key managers of these MT firms. Their firms together accounted for more than 40% of the production value of Taiwan's MT industry.⁵ At the same time, I interviewed 15 suppliers who were identified by some MT firm interviewees as important suppliers or production partners of their firms. In addition to MT firms and their suppliers, I also conducted 12 interviews with officials, leaders, and researchers of other major institutions, such as government agencies, research institutes and industry associations, whose institutions had been critical participants in this industry. Typically, the in-depth interviews lasted one to three hours each. Besides asking interviewees to at first provide a historical description of their firms or

³ See, for example, MacKinnon et al. (2002) and Wolfe and Gertler (2004) for the discussions of the strengths of qualitative research methods on understanding the key process and dynamics that underpin a cluster's development.

⁴ Given the fact that firms willing to accept my interviews mostly are those current prosperous players, and the fact that many failed firms were already out of business and therefore not approachable, my sample was biased toward the more successful firms in Taiwan's MT industry. One might notice that such a sampling method might tend to give researchers, if anything, an overly optimistic view of their research targets (Breznitz 2005).

⁵ Author's calculation based on published data from various sources.

agencies, in the interviews I particularly addressed questions regarding how actors interacted with their partners and the development as well as changes in their relationships over time. With the permission of the interviewees, some of the interviews were followed by plant visits in which I was accompanied by the interviewees themselves or their assigned knowledgeable representatives.

The development of Taiwan's MT cluster

Although not as well-known as the IT industry, Taiwan had become the world's 4th largest exporter and 6th largest producer of machine tools by 2006 (Gardner Publications 2007). Moreover, in Taiwan's current economy, the MT industry not only plays a critical role in the machinery sector, which is estimated to be Taiwan's third largest sector, but it is also regarded as the key for sustaining the global competitiveness of Taiwan's IT industry by providing domestic IT firms with the necessary manufacturing equipment and services. According to the earliest available data, in 1969, the total production of machine tools in Taiwan was merely US \$9 million (Liu and Brookfield 2000). By 2006, however, that figure amounted to US \$3.7 billion (Gardner Publications 2007), signifying a more than 400-fold increase. As shown in Fig. 1, since the late 1970s, Taiwan's MT industry has continued to increase its share of the world's production and exports of machine tools. More surprisingly, it has managed to

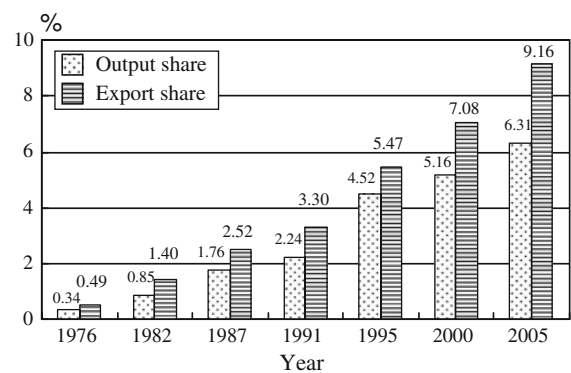


Fig. 1 Growth of Taiwan's MT industry in terms of its share in world outputs and exports. *Source:* MIRL (1995, 1999) and Taiwan Association of Machinery Industry (<http://www.tami.org.tw/statistics.php>)

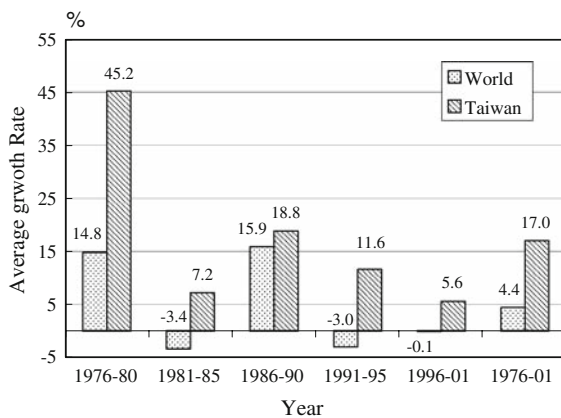


Fig. 2 Comparison of average annual growth rate of MT production between the world and Taiwan. *Source:* Kumar (2003) for the World, Brookfield (2000) and Taiwan Machine Tool Foundation (<http://www.tmtf.org.tw>) for Taiwan

maintain stable growth even during worldwide depressions such as in the first half of the 1980s and the 1990s (Fig. 2).

As for the explanations regarding the rapid growth of Taiwan's MT industry, it is argued that the key has been the existence of a well-articulated subcontracting-based production system composed of numerous small and medium-sized MT manufacturers and specialized suppliers agglomerated in central Taiwan that have contributed to the flexibility and adaptability of Taiwan's MT industry (Amsden 1985; Liu 1999; Brookfield 2000). In Taiwan, more than 60% of MT manufacturers are clustered in the central part of the island, including Taichung, Nantou and Chang-hwa (MIRL 1999: 3–107). In this region, MT builders can literally outsource each step of the production process of machine tools to capable local subcontractors (Liu 1999). Being able to subcontract allows firms to maintain low overheads while achieving high flexibility in both internal and external operations. At the same time, they are able to take advantage of the specialized ability of suppliers. The institutional environment of Taiwan's MT cluster also supports the creation of new ventures, either as MT manufacturers or suppliers (Brookfield 2000), which has helped develop various specialized competencies in each phase of MT production and has injected innovative ideas and vitality into the industry. Moreover, thanks to the industrial clustering, local MT firms have been able to experiment with numerous forms of production organization (Liu and

Brookfield 2000). All of these have contributed to the dynamism of Taiwan's MT industry.

The recognition of the significance of spatial clustering to the competitiveness of Taiwan's MT industry leads us to another question about why this industry became clustered. According to Gau (1999), the concentration of this sector in central Taiwan was actually not distinct until the 1970s. Before 1970, machinery firms were actually dispersed along the west coast of Taiwan island (Gau 1999:55). Nonetheless, due to the more appropriate climate conditions for machinery manufacturing in central Taiwan, where there is less humidity than in northern Taiwan and temperatures are lower than in southern Taiwan, machinery firms gradually moved there to avoid such problems as rusting and expansion in the manufacturing process, as well as to improve the quality of their machines (Hwang 2001).

The development of a MT cluster in central Taiwan, however, can be traced back to the 1940s when Taiwanese mechanics, who had learned the skills of metalworking after working in the sugar mills, military plants or local machinery firms during the Japanese colonial period, started establishing metalworking shops in the Taichung area to capitalize on the emerging local demand from the civilian industries, such as the woodworking, textile and agriculture industries (TAMI 2005). The most notable among these ventures that spurred the emergence of the MT industry in this region was the founding of the Yang Iron Works. Having been trained and supported by his father, a former mechanic of a sugar mill, Ru-Ming Yang, a central Taiwan native, established Yang Iron in Taichung in 1943. By providing repair services for broken machinery, Yang accumulated knowledge and experience related to the repair and manufacture of machinery and in the 1960s expanded his business to the manufacture of machine tools. From that time, Yang Iron was not only the seedbed for domestic MT machinists, but also became prominent as the pioneer of Taiwan's MT manufacturing, as it developed Taiwan's first high-speed lathe in 1967 and first NC lathe in 1974.

In the 1950s and 1960s, the increasing domestic demand and the prosperous international market due to the Vietnam War induced a group of mechanical entrepreneurs to join in the manufacture of machine tools. Most of Taiwan's major MT firms were founded in this period. For instance, Victor, currently

the largest MT firm in Taiwan, was founded in Taichung in 1954, while other ventures established in central Taiwan included Chin Fong (1948), Yeong Chin (1954) and Dah Lih (1960).

The growing demand for machine tools in the South-east Asian market in the late 1960s and mid-1970s continued to attract mechanical entrepreneurs to MT making (Sonobe et al. 2003). At the time when the production of machine tools in Taiwan was still predominantly integrated,⁶ the new entrants began to adopt subcontracting practices by taking advantage of the existence of subcontracting networks nurtured by the sewing machine industry in central Taiwan. Thanks to the development of Taiwan's sewing machine industry from the 1960s, which helped nurture a number of metalworking shops in central Taiwan that were capable of taking subcontracting orders for machine parts manufacturing or processing for other machinery-related industries, including the MT industry.⁷ In this context, for MT entrepreneurs who did not intend or could not afford to invest in manufacturing equipment in their plants as in the case of their predecessors, subcontracting became a feasible and economic option. While the leading MT firms with greater in-house manufacturing capability stressed the need for integrated production for quality control, the new start-ups earned their competitive edges on the manufacture of lower-end drilling machines and milling machines, whose production posed lower requirements on machine part quality. By being able to utilize subcontracting for low-cost and large-volume production, the quality disadvantage of products made by these new entrants was compensated for by their lower price and more rapid delivery, thereby allowing them to achieve as much success in the export market as their local integrated counterparts. The presence of capable subcontractors

had therefore lowered the threshold for establishing MT firms and led to more active entries of MT makers aiming to seize the business opportunities in the export market. From this time on, the concentration of MT firms in central Taiwan became distinct.

The further development of the MT cluster was stimulated by the growing sales of Taiwan-made CNC (Computer Numerically Controlled) machine tools in the 1980s. The success of Leadwell, a small start-up founded in Taichung in 1980 which, in less than ten years, became Taiwan's largest MT manufacturer in 1989, in the production of CNC machine tools through the aggressive exploitation of local subcontracting networks⁸ encouraged more MT entrepreneurs to start their ventures in central Taiwan. Later, not only were smaller-sized MT builders mushrooming in Taiwan in an attempt to imitate Leadwell and to profit from the production of CNC machine tools, but also existing integrated firms were being inspired to adopt subcontracting arrangements for greater production flexibility. Owing to the endeavors of these MT firms in cultivating and organizing local suppliers, specialized subcontracting networks for the manufacture of machine tools were formed in central Taiwan. Major MT firms founded in this region in this period included two current top-10 MT firms, Goodway (1975) and Fair Friend (1979), which represented a new generation of Taiwanese MT firms with their whole-hearted embrace of the possibilities of outsourcing at their founding (Brookfield 2000).

Acknowledging the concentration of MT firms as well as specialized suppliers in central Taiwan, in 1995 the state-founded research institute for Taiwan's machinery industry, the Mechanical Industrial Research Laboratories (MIRL) of the Industrial Technology Research Institute (ITRI), decided to move its machine tools division from its headquarter in Hsinchu to Taichung and established the Central Taiwan Service Center (CTSC). In actual fact, before

⁶ In the 1970s, Taiwan's leading MT firms produced roughly 90% of their parts by themselves (Amsden 1977).

⁷ From the 1960s to the 1990s, central Taiwan was the major production site of sewing machines, where manufacturing plants of leading foreign sewing machine firms, such as Singer from the US, and their suppliers were agglomerated. Since the manufacture of sewing machines was based on excessive subcontracting, i.e., where sewing machine firms focused on assembly and subcontracted all their production to specialized suppliers, these manufacturers helped cultivate and train a great deal of the metalworking labor force in central Taiwan, which was later utilized by nearby MT firms as subcontractors.

⁸ By employing subcontracting fully in the production of standardized CNC machine tools, Leadwell devised a mass production system of standardized NC machines, especially the machining centers, by further exploiting the capability of the local production system, in which subcontracting-based production networks for the manufacture of conventional milling machines, a product whose parts could also be used for machining centers, were already well-established (Sonobe et al. 2003).

Table 1 Taiwan's top ten MT manufacturers

Rank	Firms	Year of establishment	Location
1	Victor Taichung Machinery Works Co., Ltd	1954	Taichung ^a
2	Tong-Tai Machine and Tool Co., Ltd.	1969	Kaohsiung
3	Chin Fong Machine Industrial Co., Ltd.	1948	Changhwa ^a
4	Shieh Yih Machinery Industrial Co., Ltd.	1962	Taoyung
5	Goodway Machine Corp.	1975	Taichung ^a
6	Far East Machinery Co., Ltd.	1949	Chiayi
7	Yeong Chin Machinery Industries Co., Ltd.	1954	Taichung ^a
8	She Hong Industrial Co., Ltd.	1965	Taichung ^a
9	Fair Friend Enterprise Co., Ltd.	1979	Taichung ^a
10	Awea Mechantronic Co., Ltd.	1986	Hsinchu

Source: CommonWealth (2006), firm websites

^a In the central Taiwan region

the relocation of MIRL's machine tools division, another public research institute (PRI) for the MT industry co-founded by the Ministry of Economic Affairs and the Taiwan Association of Machinery Industry (TAMI), the Precision Machinery Research and Development Center (PMC), had already been established in Taichung in 1993. The joining together of these PRIs not only improved the public-private partnerships but also stimulated more inter-firm interaction and collaboration between participants both within and without the MT cluster (Chen 2007). Through the promotion of both private and public sectors, the central Taiwan region reinforced itself as the production center of Taiwan's machine tools by hosting the great majority of the domestic MT manufacturers, including six of Taiwan's top-10 firms in this industry (Table 1).

Governance of MT production networks

According to the latest available data in 1998, about 62% of the total manufacturing cost of Taiwan's MT firms was attributed to the expenses associated with subcontracting (MIRL 1999). In his study, Brookfield (2000) found that even as one of the most integrated MT firms in Taiwan, Victor outsourced 70% of the 700–800 parts involved in the manufacture of CNC lathes to subcontractors (p. 203). With their limited resources, how could Taiwanese MT SMEs manage to exercise effective governance over such a subcontracting-based production system? I would like to

answer this question by probing into the dynamics within the construction and operation of MT production networks, or more specifically, by discussing three sub-questions concerned with (1) how Taiwanese MT firms recruit or cultivate suppliers; (2) how they coordinate multiple suppliers to supply qualified products; and (3) how they maintain the effective operation of the production networks. In the following discussions, I particularly address issues related to leading firms' coordination capability and suppliers' reliability in terms of product quality and delivery, two major factors determining the effectiveness and efficiency of a subcontracting production system (Pack 1981).

Recruiting and cultivating suppliers

When it comes to the idea of subcontracting, the first issue facing MT manufacturers is to seek qualified suppliers who are capable of accommodating their demands for supplies in terms of quality, cost and delivery time. To minimize the costs associated with supply delivery and in acknowledging the need for frequent interaction with suppliers to discuss the outsourced tasks, they often start by searching for local partners through the following sources:

Supply firms established by former employees

The appearance of an abundance of specialized suppliers in the cluster has eased the supplier-matching tasks of MT firms. To Taiwanese MT

manufacturers, local supply firms established by their former employees are highly preferable, given the personal ties that help lubricate their business interactions. Having had the experience of working together, the coordination efforts, such as communicating the specifications, manufacturing methods or the quality needed between the two parties in the subcontracting process, are minimized. In addition, such MT firms will be allowed greater production flexibility, since they might expect to receive more favorable cooperation from their ex-colleagues in such a situation when they need the suppliers to adjust their manufacturing capacities along with the floating market demand.

Indeed, there seem to be numerous advantages for MT makers to work with their ex-colleagues. However, one needs to ask how such ex-colleague-established supply firms emerged and even proliferated in Taiwan's MT industry in the first place. The disagreement theory of spin-offs proposed by Klepper and his colleagues (Klepper and Thompson 2006; Klepper 2007) has provided a general answer to this question.⁹ In the specific case of Taiwan, however, as much of the existing literature suggests, the spin-offs could also be attributed to the strong motivation of Taiwanese entrepreneurs to start their own businesses in order to "be their own bosses" (Shieh 1992; Chen 1994; Hamilton 1997).¹⁰

In addition, in Taiwan's MT industry, many manufacturers would support their employees to set up their own businesses as subcontractors. According to Shieh (1992), this is a common practice for Taiwanese SMEs, because they can thereby avoid the expense of the retirement pension mandated by Taiwan's labor law. However, in the case of the MT industry, other strategic motives are also involved. For instance, when the outsourcing of certain manufacturing activities is both feasible and more economical, in addition to subcontracting them

to existing local suppliers, a MT firm might consider encouraging its employees specialized in the tasks destined to be outsourced to establish their own firms and become its suppliers. Being able to work with their acquainted suppliers would greatly help to reduce the risks and costs associated with the subcontracting arrangements.

Supporting their employees' start-ups is also a strategy that MT firms would employ so as to prevent them from weakening internal manufacturing capability due to the loss of manpower, given the fact that those who wish to leave are often the skilled and experienced workers. As the general manager of a thirty-year-old MT firm points out:

I know many of our employees enter this firm with the mindset of becoming their own bosses once they have accumulated enough skills and capital. I also acknowledge that my firm is too small to provide them with sufficient incentives to attract them to stay once the time arrives. Rather than devising measures to prevent my employees from leaving, which I think will eventually end up in vain, I would, on the contrary, support their ventures.¹¹...Compared with the risk of souring our friendships or even becoming enemies if we try to block their way out, playing a role in their start-ups would help to secure a beneficial relationship for possible future cooperation (Author interview, July 7, 2005).

In this way, the harm to MT firms caused by the departure of skilled workers is believed to be minimized. Moreover, some of my informants in MT firms even see it as the expansion of their firms for they can therefore gain more trustworthy suppliers.

Exploring capable local suppliers

Besides dealing with their familiar suppliers, MT firms also need to explore new and reliable partners. In the matter of screening suitable candidates, while the price is always a concern, the suppliers' reputation, such as

⁹ This theory depicts spinoffs as the result of strategic disagreements within firms. If an employee's is not adopted by his employer, then the employee is likely to leave and create where his(her) idea can be implemented.

¹⁰ Being influenced by Chinese entrepreneurial culture, in Taiwan many people's ultimate career goal appears to be entrepreneurship and becoming their own bosses. Taiwan was once labeled as "Boss Island", and is a particularly fertile ground in which dense subcontracting networks can take root (Shieh 1992).

¹¹ The support might range from providing loans of money and machinery for starting up and placing stable orders, to referring them to other prospective clients through personal connections.

their business styles, work ethic or technological capability, is a more crucial factor that MT firms need to take into account, considering the vast damage that would be caused by an incapable supplier to MT makers. In this regard, the MT firms' knowledge of capable local suppliers, often embodied in their high-ranking managers or procurement staff, is of critical importance. Thanks to their years of working experience in this industry, managers of MT firms might have accumulated some sort of local knowledge or informative sources, allowing them to find suitable suppliers more easily.

In addition to relying on their own knowledge, MT firms might also seek the assistance of industrial associations like TAMI to screen suitable suppliers from its member pool. However, due to the fact that the majority of local suppliers do not appear to have joined any machinery-related association, MT firms have to make the search through alternative informal channels, and mostly through their suppliers' own connections. Unlike the scarce interaction existing among rival Taiwanese MT firms, local suppliers have close formal and informal relationships with each other. In terms of business, they would help each other, for example, to reach the deadlines for delivery, tackle technological problems, and share orders or agent business opportunities. When they are off work, it is common to see the owners of various metalworking shops getting together to have tea and chitchat. These suppliers hence have built up tight connections, and such connections serve as useful information channels for MT firms' supplier hunting. This is a typical instance: if a MT manufacturer has no idea about where to find capable suppliers to take its subcontracting order, it inquires for information from a familiar supplier. In most cases, this supplier would be able to provide the firm with the candidate(s) right after learning of its needs. Yet, when this supplier has no suitable candidate(s) in mind, it can just consult his fellow workshops and then forward the feedback to the MT firm. Through such a mechanism, MT firms can easily find adequate local subcontractors.

Exploring suppliers outside the locality and industry

It may also frequently be the case that local suppliers are unavailable, if, for example, the tasks subcontracted by the MT firms are beyond the technical

capability or willingness of local suppliers.¹² While they might therefore consider investing in equipment to manufacture in-house by themselves, MT firms would also seek the possibility of exploring suppliers outside the locality or even the industry. In this situation, their local suppliers again serve as valuable informative agents. Besides the MT industry, in Taiwan metalworking shops would also work for other industries, such as the woodworking machinery, plastic machinery or the electronic machinery industries. Their connections with metalworking shops in those industries could help MT firms to dig out potential suppliers who might be unfamiliar to this industry but possess special skills or technologies useful to the manufacture of machine tools. A Taichung-based MT firm, for instance, once experienced difficulties finding capable suppliers in the cluster. Through the reference of its supplier, however, this firm eventually found a spray workshop in Hsinchu that specialized in painting the electronic machinery of the electronics industry to do the work for its newly-developed machine tool which required that a special coating be sprayed onto the sheet metal of its body.¹³

Interactions within the production networks

The specialized and professional services provided by suppliers in Taiwan's MT cluster have been highly complimented by local MT firms. Even so, to these MT manufacturers, getting what they order, however, is not as easy as just placing orders and expecting the delivery. In Taiwan's MT industry, the great majority of suppliers are working for multiple clients. They have to deal with a variety of orders simultaneously, and should be able to manage to deliver qualified supplies to their respective clients on time. However, in practice, it is quite often the case that these suppliers fail to fulfill their clients' orders in terms of delivery time or the quality of supplies, either due to

¹² For instance, if the tasks MT firms are subcontracting are small batches and require distinct and complicated manufacturing procedures to complete, suppliers might be reluctant to take such orders since they are not short of orders from other clients which are easier to deal with.

¹³ This example is provided by a MT firm during the author's interview.

over-capacity, especially in the peak season, or to miscommunication. As a result, diligent efforts are required by MT makers so as to safeguard the delivery of quality supplies.

As for the matter of delivery time, instead of doing nothing and just wishing for the best outcome, MT firms frequently send staff to visit their suppliers to monitor whether their orders have been properly taken care of. During peak seasons when suppliers might have a pile of orders, MT makers would even ask their staff to visit suppliers on an hourly basis. As for the issue of ensuring the quality of the supplies, they need to do more than just show up. Sometimes the failure of supplies might be attributed to the suppliers' incompetence resulting from poorer manufacturing knowledge or equipment. To tackle the former issue, MT manufacturers would hold fixed and floating meetings with suppliers in which their technical or quality control staff help suppliers to inspect and solve problems in the manufacturing processes. They might also urge their affiliated suppliers to adopt specific manufacturing technologies and quality control systems. Regarding the issue of poor equipment, MT firms might sometimes provide loans to their critical suppliers to upgrade their machinery.

Maintenance of production networks

Although it is seldom a problem for Taiwanese MT manufacturers to find replacements in the cluster when their current suppliers seem incapable of meeting their changing demands, in my interviews informants have still stressed the necessity of developing and maintaining long-term and stable relationships with existing suppliers. Given there is often no written protocol to regulate their business transactions, MT firms need to frequently communicate with suppliers to ensure their outsourced works can be completed correctly. Nevertheless, most Taiwanese MT SMEs just cannot afford to allocate too many resources to such coordinating efforts, not to mention that they wish to minimize the coordination with suppliers to enhance the manufacturing speed. In this context, they are more willing to work with suppliers with whom they have had previous experience of collaboration and have developed a mutual tacit understanding. One MT firm manager emphasizes:

Most of our suppliers have been doing business with us for many years. We can just place the orders and present them with the drawings. They are professional and specialized and know exactly what to do without many instructions needed. Besides, having been working with us for so long, they know our specific requirements for supplies and know how to fulfill those requirements. Even if sometimes there are disagreements or misunderstandings within our transactions, we can always easily resolve the issues based on our past experiences. We often cannot enjoy such smooth cooperation with newly-recruited subcontractors (Author interview, August 4, 2005).

To MT firms and their suppliers, the long-term business transactions also help with the development of friendships. Becoming friends with their suppliers means that MT firms might expect some possible favors from suppliers before, between and after the transactions, ranging from agreeing to supply parts with certain special specifications in small batches, working extra time to refine the parts, or to accepting late payment, which allows these MT makers greater flexibility in their business operations.

Thanks to the firm-specific knowledge and relationships they develop and share with suppliers, the coordination required by Taiwanese MT firms in their excessive subcontracting arrangements is greatly reduced. Given the fact that such firm-specific knowledge and relationships are hard to transfer and take time to be built with new suppliers, maintaining stable relationships with their existing capable suppliers is critical for the effective governance of Taiwanese MT firms. If this is the case, how then can they manage to achieve it?

Placing large orders is the most direct and effective way for MT firms wishing to increase their leverage over suppliers and to secure their relationships. In some cases, they might even negotiate with a few critical suppliers to work for them exclusively by providing sufficient orders over the long term. Under such an arrangement, on the one hand, MT firms no longer have to compete for supplies in the market and are able to work more closely with suppliers without concerning themselves with leakages of technological secrets to their competitors. On the other hand, suppliers are also willing to exchange

their loyalty for stable orders and other expected assistance from their parent firms. Nevertheless, with their limited resources and production volume, local MT manufacturers can only afford to maintain a handful of exclusive suppliers. In Taiwan, it is common for a MT firm to have only two to three exclusive suppliers, while there could be more than 60 suppliers involved in its subcontracting networks. Some firms might even have no suppliers working exclusively for them.

As for the majority of suppliers with whom they are not able to place large orders, MT firms employ other strategies to stabilize their relationships. Frequent on-site visits is a widely-used means. In addition, MT makers particularly require specific knowledge and social skills to deal with local suppliers effectively. According to the general manager of a MT firm:

To these black-hand bosses,¹⁴ making money, of course, is the major motive for them to do business with us. Nevertheless, they are confident of their skills and believe that equipped with such skills they can survive anywhere, even without our orders. We should be careful not to treat them like we are giving them a favor as their clients in the transaction process. If they trust you and see you as a friend, these black-hands will do their best to accommodate your requests. But once you are careless toward them, such as making them feel they are not being respected, they would not hesitate to reject your orders (Author interview, October 19, 2005).

Some of my interviewees especially claimed that one distinct characteristic of the machinery workers is their pride of craftsmanship, which makes them believe that the fulfillment of their skills is of similar, if not more, importance to monetary benefit in their business transactions. Due to the share of the recognition of craftsmanship, managers of MT firms are able to understand why acknowledging the skills of and becoming friends with suppliers are the keys to their sustained and smooth collaborative relationships. Also because of such reasons, MT firms still rely largely on direct on-site visits and face-to-face

discussions with suppliers during their transactions. In addition to the need to better tackle tacit technological issues, the dense face-to-face interactions with suppliers also serves a socialization purpose that is crucial for Taiwanese MT manufacturers to maintain stable production networks.

In this section, I investigate the governing efforts of Taiwanese MT firms within the production networks. The easy access to a wide variety of specialized suppliers has been eulogized by almost all my interviewees in the MT firms as the major advantages for setting up their businesses in the cluster. While spatial proximity facilitates the logistics of physical manufacturing supplies, we learn that being close to their suppliers is also of particular importance for MT firms to effectively utilize their various relational governing instruments to allow the operation of efficient production networks to materialize.

However, one should note that there are emerging concerns regarding the diseconomies brought about by such industrial agglomeration that may serve as obstacles to the upgrading of Taiwan's MT industry. In the next section I will discuss such issues and how Taiwan's MT firms are dealing with them.

Evolving production networks: tackling cluster's diseconomies

In Taiwan, the agglomeration of the MT industry has been reinforced through the continuing entry of entrepreneurs and labor into central Taiwan, and by the recent establishment of two industrial parks in Taichung, namely, the Central Taiwan Science Park and the Taichung Precision Machinery Technology Innovation Park, designed to host the government's target industries, including the MT industry (Chen 2007:159). While continuing to exploit the advantages of industrial clustering, local MT manufacturers are aware that the agglomeration has also had adverse effects hampering the further development of this industry.

The excessive subcontracting arrangements adopted by Taiwanese MT firms have contributed to their global competitiveness in low-cost and flexible manufacturing. The heavy dependence on subcontracting, however, is also creating problems for them. Outsourcing to the same pool of suppliers has caused

¹⁴ In Taiwan, people in the machinery industry refer to themselves as "black-hands".

Taiwan's MT industry to be criticized for lacking product differentiation, leading to cut-throat competition among Taiwanese MT makers in the global market. Furthermore, owing to the active entry of new MT entrepreneurs in the cluster, the local competition for suppliers has been severe, resulting in the destabilization of established production networks. The rapid technological changes and sophistication of new machine tools also demands not only the upgrading capabilities of MT firms but also of suppliers. To respond to these emerging issues and competition requirements, Taiwanese MT firms have started reconfiguring their subcontracting arrangements. Two concurrent endeavors have been observed within the cluster.

Diversification of supply sources

Except when their orders exceed the manufacturing capacity of subcontractors, for a given part or activity, MT firms might wish to subcontract to as few suppliers as possible. In the cluster, it is reported that less than 25% of Taiwanese MT firms use more than three suppliers for a given part (Brookfield 2000). Even in cases when they have to use more than two suppliers for a given part, MT firms would often have one entrusted supplier receive the major portion of the order, while having other suppliers share the rest of the work. It is not only for the sake of reducing the work of coordination, but is also a way for MT firms to show their trust to principal suppliers so as to nurture better partnerships. However, some incidents happening in recent years have alerted clustered MT manufacturers to the risk of over-dependence on a single main supplier and the need to diversify supply sources to reduce their vulnerability in existing arrangements. For instance, according to the experience of the CEO of a MT firm:

To compete for suppliers, a new MT firm was willing to pay a subcontracting price 30% higher than my firm's to seduce some of our main and long-term suppliers to prioritize its orders. And it succeeded. Our supplies from these subcontractors were therefore delayed or even cancelled. As a result, in the booming market of 2004, that firm grew at a rate of 200% in comparison with only 25% for my firm. I never expected such a thing would happen. I

thought I could trust these suppliers with whom I had been doing business for many years. Learning from this lesson, I started subcontracting the same work to more suppliers (Author interview, June 30, 2005).

In the literature, there have been debates regarding whether lead firms should increase or decrease the number of their suppliers in order to maximize business profits and competitiveness. While scholars, like Porter (1980), stress that firms should purchase an item from alternative suppliers so as to improve their bargaining power, others, like those relational perspective proponents such as Bakos and Brynjolfsson (1993), contend that firms can increase profits by increasing their dependence on a smaller number of suppliers so as to develop relationship-specific assets for better cooperation between both parties (Dyer and Singh 1998:675). However, in the case of Taiwan's MT industry, thanks to industrial clustering, this does not seem to be an issue to MT makers for they have been allowed to employ both strategies flexibly in response to the changing manufacturer-supplier dynamics within the localized production networks.

Increasing in-house manufacturing investments

The incapability and unwillingness of local suppliers to improve their own manufacturing capability has emerged as another major obstacle to the upgrading of Taiwanese MT firms. In Taiwan these local metalworking shops may work not only for the MT industry but also other industrial machinery sectors. Given that they are able to secure orders from other clients without the need for additional investments, these metalworking shops have less incentive to improve along with the more demanding MT firms, whose requirements have been known for being the most restricted within the manufacturing sector. To Taiwanese MT makers, relying on the same pool of suppliers has made their products become alike, not only in machinery designs and appearances, but also in performance. They therefore have to compete with each other on price in the world market.

To overcome the above-mentioned unwanted development and competition situation, it is recognized that Taiwanese MT makers need to pursue

product differentiation.¹⁵ However, the existing MT production system in Taiwan does not appear to be favorable to firms wishing to produce machines with unique designs. On the one hand, local suppliers prefer manufacturing standardized parts and components which can be supplied to as many clients as possible. On the other hand, Taiwanese MT makers, which are mostly smaller in size, will not be able to enjoy economies of scale once their new machines require too many customized supplies. Furthermore, even if a MT firm has developed a product with distinctive designs and has had capable suppliers to take care of its outsourced work, since it might be sharing some of its suppliers with other local MT makers, the technological secrets embodied in the new product might leak out to its competitors through their shared suppliers. Later, similar products from other domestic firms might appear in the market. Consequently, the MT firm's accomplishment of product differentiation would be accordingly compromised. Simply put, in the current open subcontracting system of Taiwan's MT cluster, MT firms' unique product designs, if they had any, would easily and quickly lose their uniqueness (Chen 2009). All these problems point to the need for them to reconfigure their subcontracting arrangements and networks.

The successful development of Taiwan's MT industry has allowed many once small MT firms to grow larger and reach the economic scale to perform a certain level of internal manufacturing. While acknowledging the fact that subcontracting is still inevitable for their sustained adaptability and flexibility, it is observed that major Taiwanese MT firms have undertaken projects aimed at reducing their dependence on subcontracting by investing in sophisticated equipment for in-house manufacturing. For instance, the vice president of a leading MT firm, whose firm was actually a pioneer in outsourcing the manufacturing of CNC machine tools

in Taiwan, describes his firm's ongoing plan as follows:

Putting out all the manufacturing work makes it hard for us to develop and retain core technology.... To upgrade our products and manufacturing capability, we are planning to increase our equipment investment. Instead of outsourcing all the manufacturing activities, supplies which are critical to machine performance and which embody specific confidential know-how will be manufactured in-house. While some crucial supplies might still be purchased from outside, they will, however, be further processed by using our special equipment, and will be readjusted by our engineers. This final processing and related adjustments especially embody our valuable know-how (Author interview, October 19, 2005).

Such arrangements are becoming popular for MT firms endeavoring to upgrade and add value to their products. By strategically performing a certain portion of manufacturing in-house through investing in sophisticated equipment, these manufacturers can retain and materialize their core competencies as well as upgrade their products without being subject to the suppliers' technological capability, while at the same time being able to continue enjoying the benefits of subcontracting.

The increase in internal manufacturing is also part of the MT firms' deliberate efforts to restrict the entry of new competitors. Many interviewees complain that the cluster is crowded with new competitors, which has negative effects not only on existing MT firms (such as the competition for suppliers as mentioned in the previous section), but also on the industry as a whole. The reduction in the profit of each firm owing to their excessive price competition in the market has been an obvious outcome. The relative ease in becoming a MT maker and the aggressive recruitment strategies employed by new entrants has increased the labor mobility within the cluster, which would be harmful to the technological advancement of the MT firms. The departure of workers would also make it harder for MT firms to establish their technological bases. They would consequently become unwilling to invest in manpower training since they might not benefit from such investment. As a result, the

¹⁵ Almost all interviewees of MT firms stressed in my interviews that their firms have to some extent started engaging in the projects of product differentiation. While in this section I focus on their efforts in improving the products, I was also informed that MT firms would manage to differentiate their products from others through improved services.

industry as a whole might not have sufficient energy for further development.

The excessive outsourcing of Taiwanese MT firms has helped nurture the growth of local specialized suppliers in almost every phase of MT manufacturing, inducing the influx of MT entrepreneurs due to the lower establishment threshold in the cluster. In this context, if incumbent MT firms become conservative in terms of outsourcing the manufacture of their critical machine parts, it is believed that the future business and technological development of local subcontractors will be constrained. Once there are not many local advanced specialized suppliers available, establishing a competitive MT firm in the cluster will become harder. This will then discourage some would-be-boss entrepreneurs from becoming MT makers. When the entry of competitors decreases, the pressure brought about by price competition among Taiwanese MT firms might be expected to decline.

Conclusion

Taiwan's MT cluster has continued evolving along with the changing competitive situation. This evolutionary process can be best observed by looking into the changes in the production systems. Before the 1980s, the production of machine tools in Taiwan was highly integrated, while subcontracting has become dominant since the late 1980s. The spatial clustering has allowed for a range of productive organizations and fluidity between organizational forms (Enright 2003:112). Within the cluster, MT firms have been able to experiment with different degrees of specialization, i.e., to make choices between what they manufacture internally and what they buy externally (Storper 1997b), while avoiding fixed hierarchical structures (Lazerson and Lorenzoni 1999). Furthermore, such effective and supportive infrastructures have continued to nurture the vitality of Taiwan's MT cluster, as we can see in the ongoing reconfiguration of local MT manufacturers and the production networks in response to the changing competitive environment.

Nevertheless, the spatial clustering itself does not determine the coordination mechanism (Enright 2003). Due to their small sizes, most Taiwanese MT firms have limited resources to exercise direct

and strong governing power over suppliers. They, however, manage to succeed in this by strategically exploiting their relational capabilities, defined as a lead firm's ability to select right partners, and to establish and maintain relationships with other firms (Lorenzoni and Lipparini 1999; Lechner and Dowling 2003:4), or relational-building skills. In initiating the subcontracting, for instance, MT makers need knowledge and informal connections that enable them to cultivate and find capable suppliers. They also need social skills to smoothly interact with suppliers and maintain deeper and enduring relationships so as to reduce the uncertainties involved in their transactions, and to allow them to get the most out of the subcontracting arrangements. While such relational capabilities and skills are mostly industry- or firm-specific and even localized, in order to build and accumulate them, "being there" to expose themselves to the industrial atmosphere as well as to improve their embeddedness in the cluster is hence of critical importance for Taiwanese MT makers. In other words, in Taiwan's MT industry, spatial clustering not only facilitates the logistics of physical manufacturing supplies, but also enhances the local MT makers' capacity to strategically utilize their various relational governing instruments so as to overcome the difficulties inherent in exercising effective subcontracting, a task, according to Pack, that most capital goods manufacturers in less industrialized countries have not been able to tackle well.

Such findings regarding the importance of spatial closeness to the relation-based governance mechanisms echo the notion of territorial and social embeddedness engendering the growth of industrial clusters. Yet, without over-stating the advantages of clustering, in this paper I also address the issue of the cluster's diseconomies that seems to have been rarely discussed in the existing cluster literature. Unlike their counterparts in industrialized economies that are equipped with greater technological and innovative capabilities, clusters in less industrialized countries have been known for deriving their strength mainly from the rapid learning (or copying) and scale manufacturing of technologies and goods that have matured and have been standardized (Viotti 2002; Amsden and Chu 2003). Although spatial clustering has allowed these less industrialized firms to exploit the advantages of flexible and efficient manufacturing,

it might also have given rise to certain diseconomies that they especially have to bear. As this paper shows, in Taiwan's MT industry the spatially concentrated production system has created its own problems. The over-dependence on subcontracting has made Taiwanese MT firms suffer from a loss of autonomy not only in production, but also in their upcoming pursuit of upgrading. Sourcing supplies from the same pool of local suppliers, whose technological competence seems problematic to meet the demands of more sophisticated manufacturing, has resulted in a lack of differentiation and has led to stagnation in the upgrading of Taiwan-made machine tools.

To tackle the above issues and survive in the midst of the apparently intensified global competition, Taiwan's MT industry might need to reconfigure its territorial networks and governance. This paper has observed that there seems to be a further elaboration of the division of labor within Taiwan's MT cluster, in which some lead firms have started increasing their internal manufacturing while diversifying, as well as intensifying their cooperation with local specialized suppliers. To be able to succeed in such endeavors, however, would call for improved administrative and governing capability of the part of these manufacturers. In addition to foreseeing more complex business management resulting from their expanded internal capital investments, these MT makers also face challenges regarding sustaining the effective governance of the evolving and uncertain production networks characterized by unstable parent firms/suppliers relationships and the changing mix of in-house/subcontracting manufacturing arrangements. In this situation, one might question whether their accumulated relational capabilities and skills emphasized in this paper are sufficient to enable Taiwan's MT firms to continue to drive the production networks. Nevertheless, after learning the governance mechanisms of Taiwan's MT production networks, this paper would like to suggest that reinforcing agglomeration would be required, for the enhanced physical and institutional proximity could help local firms to manage more complex and unfamiliar coordination activities (Leamer and Storper 2001). In short, to Taiwan's MT industry, a cure to deal with the cluster's diseconomies would be the reinforcement of industrial clustering.

References

- Amin, A., & Cohendet, P. (1999). Learning and adaptation in decentralised business networks. *Environment & Planning D*, 17(1), 87–104.
- Amin, A., & Thrift, N. (1992). Neo-Marshallian nodes in global networks. *International Journal of Urban and Regional Research*, 16(4), 571–587.
- Amsden, A. (1977). The division of labour is limited by the type of market: The case of the Taiwanese machine tool industry. *World Development*, 5(3), 217–233.
- Amsden, A. (1985). The division of labour is limited by the rate of growth of the market: The Taiwan machine tool industry in the 1970s. *Cambridge Journal of Economics*, 9(3), 271–284.
- Amsden, A., & Chu, W.-W. (2003). *Beyond late development: Taiwan's upgrading policies*. Cambridge: MIT.
- Asanuma, B. (1989). Manufacturer-supplier relationships in Japan and the concept of relation-specific skill. *Journal of the Japanese and International Economies*, 3(1), 1–30.
- Bakos, Y., & Brynjolfsson, E. (1993). Information technology, incentives, and the optimal number of suppliers. *Journal of Management Information Systems*, 10(2), 37–54.
- Bathelt, H., Malmberg, A., & Maskell, P. (2004). Clusters and knowledge: Local buzz, global pipelines and the process of knowledge creation. *Progress in Human Geography*, 28(1), 31–56.
- Becattini, G. (2003). *From industrial districts to local development: An itinerary of research*. Cheltenham: Edward Elgar.
- Belussi, F., & Arcangeli, F. (1998). A typology of networks: Flexible and evolutionary firms. *Research Policy*, 27(4), 415–428.
- Belussi, F., & Gottardi, G. (2000). *Evolutionary patterns of local industrial systems: Towards a cognitive approach to the industrial district*. Brookfield: Ashgate.
- Breznitz, D. (2005). Development, flexibility and R&D performance in the Taiwanese IT industry: Capability creation and the effects of state-industry coevolution. *Industrial and Corporate Change*, 14(1), 153–187.
- Brookfield, J. (2000). *Localization, outsourcing, and supplier networks in Taiwan's machine tool industry*. Doctoral dissertation, University of Pennsylvania.
- Brusco, S. (1982). The Emilian model: Productive decentralization and social integration. *Cambridge Journal of Economics*, 6(2), 167–184.
- Cainelli, G., Iacobucci, D., & Morganti, E. (2006). Spatial agglomeration and business groups: New evidence from Italian industrial districts. *Regional Studies*, 40(5), 507–518.
- Camagni, R. (Ed.). (1991). *Innovation networks: Spatial perspectives*. New York: Belhaven.
- Chen, C.-H. (1994). *Subcontracting networks and living structure: The socioeconomic analysis of Taiwan's small and medium sized enterprises*. Linking: Taipei (in Chinese).
- Chen, M.-C. (2002). *Industrial district and social capital in Taiwan's economic development: An economic sociological study on Taiwan's bicycle industry*. Doctoral dissertation, Yale University.

- Chen, L.-C. (2007). *Industrial upgrading of newly industrializing countries: The case of machine tool industry in Taiwan*. Doctoral dissertation, University of California at Berkeley.
- Chen, L.-C. (2009). Learning through informal local and global linkages: The case of Taiwan's machine tool industry. *Research Policy*, 38(3), 527–535.
- Cheng, L.-L. (2001). Sources of success in uncertain markets: The Taiwanese footwear industry. In F. Deyo, R. Doner, & E. Hershberg (Eds.), *Economic governance and the challenge of flexibility in East Asia* (pp. 33–53). Lanham: Rowman & Littlefield.
- Cooke, P., & Morgan, K. (1998). *The associational economy: Firms, regions, and innovation*. New York: Oxford University Press.
- De Propriis, L. (2001). Systemic flexibility, production fragmentation and cluster governance. *European Planning Studies*, 9(6), 739–753.
- De Propriis, L., & Wei, P. (2007). Governance and competitiveness in the Birmingham jewellery district. *Urban Studies*, 44(12), 2465–2486.
- Dei Ottati, G. (1994). Trust, interlinking transactions and credit in the industrial district. *Cambridge Journal of Economics*, 18(6), 529–546.
- Dyer, J. H., & Singh, H. (1998). The relational view: Cooperative strategy and sources of interorganizational competitive advantage. *Academy of Management Review*, 23(4), 660–679.
- Enright, M. (2003). Regional clusters: What we know and what we should know. In J. Broucker, D. Dohse, & R. Soltwedel (Eds.), *Innovation clusters and interregional competition* (pp. 99–129). New York: Springer.
- Ernst, D. (1998). *What permits small firms to compete in high-tech industries? Inter-organizational knowledge creation in the Taiwanese computer industry*. DRUID Working Paper No.98-3.
- Gardner Publications. (2007). *2007 World machine tool output and consumption survey*. <http://www.gardnerweb.com/consump/survey.html>, accessed February 5, 2009.
- Gau, S.-C. (1999). *Production network and learning region: The production of machine tools in Taichung*. Doctoral dissertation, Tunghai University (in Chinese).
- Gertler, M. (2001). Best practice? Geography, learning and the institutional limits to strong convergence. *Journal of Economic Geography*, 1(1), 5–26.
- Grabher, G. (1993). *The embedded firm: On the socioeconomics of industrial networks*. New York: Routledge.
- Grandori, A. (1997). An organizational assessment of interfirm coordination modes. *Organization Studies*, 18(6), 897–925.
- Guerrieri, P., & Pietrobelli, C. (2004). Industrial districts' evolution and technological regimes: Italy and Taiwan. *Technovation*, 24(11), 899–914.
- Hamilton, G. (1997). Organization and market processes in Taiwan's capitalist economy. In M. Orru, N. W. Biggart, & G. Hamilton (Eds.), *The economic organization of East Asian capitalism* (pp. 237–293). Thousand Oaks: Sage.
- Harrison, B. (1992). Industrial districts: Old wine in new bottles? *Regional Studies*, 26(5), 469–483.
- Hemmert, M. (1999). 'Intermediate organization' revisited: A framework for the vertical division of labor in manufacturing and the case of the Japanese assembly industries. *Industrial and Corporate Change*, 8(3), 487–517.
- Hsu, J.-Y. (1997). *A late industrial district? Learning networks in the Hsinchu science-based industrial park*. Doctoral dissertation, University of California at Berkeley.
- Humphrey, J. (1995). Industrial reorganization in developing countries: From models to trajectories. *World Development*, 23(1), 149–162.
- Hwang, Y.-J. (2001). *Revolution of black-hands: The legendary black hawk*. Linking: Taipei (in Chinese).
- James, D. (1991). Capital goods production and technological learning: The case of Mexico. *Journal of Economic Issues*, 25(4), 977–991.
- Jessop, B. (1998). The rise of governance and the risks of failure: The case of economic development. *International Social Science Journal*, 50(1), 29–45.
- Jones, C., Hesterly, W. S., & Borgatti, S. P. (1997). A general theory of network governance: Exchange conditions and social mechanisms. *The Academy of Management Review*, 22(4), 911–945.
- Klepper, S. (2007). Disagreements, spinoffs, and the evolution of Detroit as the capital of the US automobile industry. *Management Science*, 53(4), 616–631.
- Klepper, S., Thompson, P. (2006). *Intra-industry spinoffs. Miami, Florida*. Working paper, Department of Economics, Florida International University.
- Krugman, P. (1991). *Geography and trade*. Cambridge: MIT.
- Kumar, A. (2003). *The impact of policy on firm's performance: The case of CNC machine tool industry in India*. Doctoral dissertation, Wageningen University.
- Lazerson, M., & Lorenzoni, G. (1999). The firms that feed industrial districts: A return to the Italian source. *Industrial and Corporate Change*, 8(2), 235–266.
- Leamer, E., & Storper, M. (2001). The economic geography of the internet age. *Journal of International Business Studies*, 32(4), 641.
- Lechner, C., & Dowling, M. (2003). Firm networks: External relationships as sources for the growth and competitiveness of entrepreneurial firms. *Entrepreneurship and Regional Development*, 15(1), 1–26.
- Liu, R.-J. (1999). *Networking division of labor: Examining the competitiveness of Taiwan's machine tool industry*. Linking: Taipei (in Chinese).
- Liu, R.-J., & Brookfield, J. (2000). Stars, rings and tiers: Organisational networks and their dynamics in Taiwan's machine tool industry. *Long Range Planning*, 33(3), 322–348.
- Lorenzoni, G., & Lipparini, A. (1999). The leveraging of interfirm relationships as a distinctive organizational capability: A longitudinal study. *Strategic Management Journal*, 20(4), 317–338.
- MacKinnon, D., Cumbers, A., & Chapman, K. (2002). Learning, innovation and regional development: A critical appraisal of recent debates. *Progress in Human Geography*, 26(3), 293–311.
- Malmberg, A., & Maskell, P. (2006). Localized learning revisited. *Growth and Change*, 37(1), 1–18.
- Markusen, A. (1996). Sticky places in slippery space: A typology of industrial districts. *Economic Geography*, 72(3), 293–313.

- Marshall, A. (1920). *Principles of economics*. New York: Macmillan for the Royal Economic Society.
- MIRL. (1995). *1995 machine tools yearbook*. MIRL: Hsinchu (in Chinese).
- MIRL. (1999). *1999 machine tools yearbook*. MIRL: Hsinchu (in Chinese).
- Morgan, K. (2004). The exaggerated death of geography: Learning, proximity and territorial innovation systems. *Journal of Economic Geography*, 4(1), 3–21.
- Oinas, P. (1999). Activity-specificity in organizational learning: Implications for analysing the role of proximity. *GeoJournal*, 49(4), 363–372.
- Pack, H. (1981). Fostering the capital-goods sector in LDCs. *World Development*, 9(3), 227–250.
- Paniccia, I. (2002). *Industrial districts: Evolution and competitiveness in Italian firms*. Cheltenham: Edward Elgar.
- Porter, M. (1980). *Competitive strategy: Techniques for analyzing industries and competitors*. New York: Free.
- Porter, M. (2000). Location, competition, and economic development: Local cluster in a global economy. *Economic Development Quarterly*, 14(1), 15–34.
- Powell, W. (1990). Neither market nor hierarchy: Network forms of organization. *Research in Organizational Behavior*, 12, 295–336.
- Pyke, F., Becattin, G., & Sengenberger, W. (Eds.). (1990). *Industrial districts and inter-firm co-operation in Italy*. Geneva: International Institute for Labour Studies.
- Rabellotti, R., Carabelli, A., & Hirsch, G. (2009). Italian industrial districts on the move: Where are they going? *European Planning Studies*, 17(1), 19–41.
- Sabel, C. (1989). Flexible specialization and the re-emergence of regional economies. In J. Zeitlin & P. Q. Hirst (Eds.), *Reversing industrial decline? Industrial structure and policy in Britain and her competitors* (pp. 17–70). New York: St. Martin's.
- Sabel, C. (1993). Studied trust: Building new forms of cooperation in a volatile economy. *Human Relations*, 46(9), 1133–1170.
- Sacchetti, S., & Sugden, R. (2003). The governance of networks and economic power: The nature and impact of subcontracting relationships. *Journal of Economic Surveys*, 17(5), 669–691.
- Saxenian, A. (1994). *Regional advantage: Culture and competition in silicon valley and route 128*. Cambridge: Harvard University Press.
- Schmitz, H., & Nadvi, K. (1999). Clustering and industrialization: Introduction. *World Development*, 27(9), 1503–1514.
- Scott, A. (1988). *New industrial spaces: Flexible production organization and regional development in North America and Western Europe*. London: Pion.
- Scott, A. (2002). Regional push: Towards a geography of development and growth in low- and middle-income countries. *Third World Quarterly*, 23(1), 137–161.
- Shieh, K.-H. (1992). “Boss” island: *The subcontracting network and micro-entrepreneurship in Taiwan's development*. New York: P. Lang.
- Simon, D. F. (1996). Charting Taiwan's technological future: The impact of globalization and regionalization. *China Quarterly*, 148, 1196–1223.
- Sonobe, T., Kawakami, M., & Otsuka, K. (2003). Changing roles of innovation and imitation in industrial development: The case of the machine tool industry in Taiwan. *Economic Development and Cultural Change*, 52(1), 103–128.
- Storper, M. (1997a). *The regional world: Territorial development in a global economy*. New York: Guilford.
- Storper, M. (1997b). Regional economies as relational assets. In R. Lee & J. Wills (Eds.), *Geographies of economies* (pp. 248–258). New York: Arnold.
- Sugden, R., Wei, P., & Wilson, J. (2006). Clusters, governance and the development of local economies: A framework for case studies. In C. Pitelis, R. Sugden, & J. Wilson (Eds.), *Clusters and globalisation: The development of urban and regional economies* (pp. 61–81). Cheltenham: Edward Elgar.
- TAMI. (2005). *Sixty years of machinery industry in Taiwan*. Taipei: TAMI (in Chinese).
- Viotti, E. (2002). National learning systems: A new approach on technological change in late industrializing economies and evidences from the cases of Brazil and south Korea. *Technological Forecasting and Social Change*, 69(7), 653–680.
- Watanabe, S. (1983). Technological linkages through subcontracting in Mexican industries. In S. Watanabe (Ed.), *Technology, marketing and industrialisation: Linkages between large and small enterprises* (pp. 169–192). New Delhi: Macmillan India.
- Wealth, Common. (2006). *Top 1000 Taiwanese manufacturing firm survey*. Common Wealth: Taipei (in Chinese).
- Whitford, J., & Potter, C. (2007). Regional economies, open networks and the spatial fragmentation of production. *Socio-Economic Review*, 5(3), 497–526.
- Williamson, O. (1981). The economics of organization: The transaction cost approach. *The American Journal of Sociology*, 87(3), 548–577.
- Wolfe, D., & Gertler, M. (2004). Clusters from the inside and out: Local dynamics and global linkages. *Urban Studies*, 41(5/6), 1071–1093.
- Zeitlin, J. (2008). Industrial districts and regional clusters. In G. Jones & J. Zeitlin (Eds.), *The oxford handbook of business history* (pp. 219–243). Oxford: Oxford University Press.