



Stars, Rings and Tiers: Organisational Networks and Their Dynamics in Taiwan's Machine Tool Industry

Ren-Jye Liu and Jonathan Brookfield

Effective inter-firm networks are an important competitive advantage in manufacturing. Based on a series of in-depth interviews, three case studies are presented which reflect and are representative of the underlying structure and organisational dynamics of supplier networks in Taiwan's machine tool industry. Basic organisational patterns include lead firm networks shaped like stars, rings and tiers. Multi-centred networks of small firms also play an active role in the industry. Factors influencing network shape include the capabilities and values of member companies, business demand and industry competition. In particular, a combination of economies of scale due to increasing product volume and greater trust stemming from an accumulated history of successful business interaction seem fundamental to changes in network structure. © 2000 Published by Elsevier Science Ltd.

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Introduction

Despite Asia's recent economic difficulties, Taiwan's economy continues to grow at a rate of 6 per cent per annum. Compared to firms in Korea or Japan, Taiwanese companies are smaller and more dynamic. Taiwan's machine tool industry is typical in this regard. Although not as well-known as Taiwan's semiconductor or computer industries, the industry has been successful, making Taiwan the fifth largest exporter of machine tools in the world.

Taiwan's machine tool industry is peculiar for, if as Carlsson and Jacobsson argue,¹ domestic users are important to an industry's evolution, then by all rights the machine tool industry should not exist. The automobile and aerospace industries are both major users of machine tools, yet neither is particularly important in Taiwan. Nevertheless, not only has the industry survived, it has prospered.

In the early 1970s, Amsden visited the island and saw no future for the country's machine tool industry, figuring in the coming years most of the small producers would be lost in a shake-out.² In the 1980s, Jacobsson, concerned about the difficulty of integrating computer controllers with conventional machine tools, provided a similar eulogy.³ Yet for all the academic predictions, like the 'Energizer bunny', Taiwan's machine tool industry keeps on going.

What makes Taiwan's machine tool industry so difficult for outsiders to understand? Why is it that in the 1990s the industry survives, not just with a predicted two or three major producers of CNC (computer numerically controlled) machines, but with more like 50-plus manufacturers of increasingly sophisticated equipment? What accounts for the industry's success?

Effective subcontracting networks have long been noted as critical to the success of industrial firms, as witnessed by Deming's long standing interest in purchasing and procurement,⁴ Porter's inclusion of suppliers into his five forces model,⁵ and Chandler's integration concept.⁶ Studies from the automotive industry also provide good examples of effective manufacturing supply networks associated with complex assembly.⁷ A number of articles have underlined inter-firm networks as an important factor in contributing to the competitive advantage of Taiwanese industry,⁸ and according to Amsden, as the size of the market for Taiwanese machine tools has expanded, "a well articulated system of subcontracting and satellite shops has evolved similar to that in Japan".⁹ Unfortunately, little else is known about such networks.

The aim of this paper is to use Taiwan's machine tool industry to illustrate the network structure and dynamics of Taiwanese manufacturing and draw some lessons from that experience. In Taiwan's machine tool industry supplier network structures shaped like starbursts or rings are as common as companies sorted into tiers. Factors influencing network shape include the capabilities and values of member companies, business demand and industry competition. In particular, a combination of economies of scale, derived from increasing product volume and greater trust (stemming from an accumulated history of successful business interaction), seem fundamental to changes in network structure.

In the following sections we first provide a brief overview and history of Taiwan's machine tool industry and then look at previous literature on networks in order to provide an analytical framework for our research. Next, we focus on three representative cases in order to analyse the structure and dynamics

Taiwan's machine tool industry has a number of network structures

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of supplier networks in Taiwan. We end with a discussion of our findings, including some theoretical and managerial implications and a short conclusion.

Taiwan's machine tool industry

What is astonishing about the Taiwan machine tool industry is that it has managed to evolve organically even in the late twentieth century: from simple to technologically more demanding, in shops that have scrimped and saved to grow from small to large. (Alice Amsden¹⁰)

*Taiwan's machine tool
industry is a success
story*

Overview

Taiwan's machine tool industry is a success story. With a population of only 20 million, it is the fifth largest exporter and the sixth largest producer of machine tools in the world. How far has Taiwan's machine tool industry come? In 1969, total machine tool production was NT \$367 million (US \$9 million). In 1996, that figure was NT \$51.4 billion (US \$1.8 billion). Taiwan's machine tool trade figures are similar. While in 1969, Taiwan was a large net importer of machine tools, today it runs a machine tool trade surplus of about NT \$22 billion (about US \$700 million).

Taiwan's machine tool makers operate in a global marketplace. The US, Europe, mainland China and South-east Asia are all important markets. Machine tool sales tend to be strongly cyclical, and Taiwan's production and export figures reflect this. However, whereas more mature economies might see these fluctuations as large changes in demand (both positive and negative) and adjust output accordingly, Taiwan's industry seems to operate at two speeds, steady and booming. Declines are rare. There has been a steady technological upgrading within the industry. In 1981, CNC machines comprised only 4 per cent of production, but by 1994 this had increased to 34 per cent.¹¹

History

According to the Republic of China's first census in 1954, there were only 19 machine tool manufacturers employing about 300 workers on the island. By 1988, the figures had increased impressively to 1068 and 17 520 respectively.¹² This may be attributed to success in following shifting patterns of machine tool demand, technological upgrading and inter-organisational restructuring.

Market demand

Markets for Taiwanese machine tools have changed several times over the years. Immediately following World War II, the industry was quite small and most sales were local. Demand

came mainly from small machine shops and metal working enterprises. In the 1960s and early 1970s, Taiwan began to find a foreign outlet for its machines in Hong Kong and South-east Asia. With its involvement in the Vietnam War, the US became a particularly attractive market. As the war wound down, Taiwan began to find even more sales opportunities in the US. In fact, Taiwan's exports to the US increased to such a degree that the Reagan administration insisted in 1987 that Japan and Taiwan implement voluntary export restrictions on machine tools bound for the US. Since that time, Taiwanese companies seem to have made a concerted effort to penetrate the European market. Most recently, energy has been concentrated on the mainland China market. Unsurprisingly, given that nation's strong economic growth, its share of Taiwan's exports has grown considerably.

Technological upgrading

Taiwan's first machine tools were basic and designs were often derived from foreign models (Japanese in most cases).¹³ Today, Taiwanese machine tools are held in much higher regard, but are still generally cheaper than Japanese or German machines. The majority of firms have specialised design departments, and funds for R&D are allocated on a project basis. While the machine tool industry may not be as research intensive as other sectors, the days when designers could succeed solely on the basis of 'on-the-job' experience are gone.

Industrial organisation

Sourcing has been an important issue. Amsden argues that initially most firms in the industry were highly integrated,¹⁴ with parts being similar since there was no electronic-mechanical divide. Owner-operators had a high degree of skill and energy, and filled their time through the production of a huge variety of machine parts and components. One advantage to the system was the way this helped keep production knowledge within the firm. A strong drawback was that because each plant produced its own parts, it had to maintain a great variety of equipment, and the so utilisation rate of much of it was low.

When Amsden first visited Taiwan in the 1970s, she saw little evidence of a division of labour among firms in the industry. Returning in 1981, however, Amsden found supplier networks to be well articulated, with some firms moving up the value chain to focus on certain components and all companies seeming to concentrate on fewer parts. We seek to update Amsden's observations with some more detailed information on the nature of those supplier networks today.

The role of government

Overall, Taiwan's government has been less intrusive in this industry than in many others. Direct intervention in support of individual companies has been rare (although it has occurred). Import duties have been imposed machine tools, but in general

*Today...it is held in
high regard*

Table 1. Six different approaches to networks and some examples

Approach	Examples	Type of evidence
Quantitative Sociology	Krackhardt, Ref. 19 Burt, Ref. 19	Pure theory Survey results
Strategic Management	Miles and Snow, Ref. 19 Johnston and Lawrence, Ref. 16 Snow, Miles and Coleman, Ref. 16 Lorenzoni and Baden-Fuller, Ref. 19	Illustrative examples Cases Illustrative examples Illustrative examples
Institutional Economics	Williamson (1985), Ref. 19 Thorelli, Ref. 15 Powell, Ref. 19 Williamson (1991), Ref. 19	Examples and cases Illustrative examples Illustrative examples Pure theory
Organisational Dynamics	Madhovan, Koka and Prescott, Ref. 19 Lorenzoni and Lipparini, Ref. 19	Data set Cases
Organisational Theory	Bradach and Eccles, Ref. 19 Grandori, Ref. 19	Illustrative examples Pure theory
Supply Chain Management	Helper, Ref. 7 Nishiguchi, Ref. 7 Dyer, Ref. 7	Survey results Survey and cases Survey results

the rates have been low (between 10 to 20%) and mitigated to some extent by similar duties on many imported components. Some countries have had certain categories of machine tool imports banned (e.g. S. Korea, Hong Kong and Japan), but Western nations have generally managed to avoid such restrictions.

Probably the most important state activity in this industry has been the founding of MIRC, Taiwan’s Machine Industrial Research Laboratory, now a part of the island’s Industrial Technology Research Institute (ITRI). Originally founded in 1969, MIRC was incorporated into ITRI in 1973. MIRC has offered technical and design support to a number of Taiwanese machine tool producers. MIRC has also undertaken national projects for the government, having worked on projects to develop better computer controls, robots and flexible manufacturing systems (FMS). (See Ref. 13.)

Theory

In the mid-1980s, Thorelli wrote: “clearly ... there is a great need for academic research on networks”.¹⁵ Since then, the academic community has responded with a proliferation of articles.¹⁶ What is a network? Thorelli provides a very serviceable general definition: “Generically, a network may be viewed as consisting of ‘nodes’ or *positions* and *links* manifested by interaction between the positions.”¹⁷ Tailoring a definition more specifically to inter-organisational networks, Thorelli begins his paper as follows: “the term network in this article refers to two or more organizations involved in long-term relationships”.¹⁸

We find this definition a bit broad, since when only two organisations are involved, this would seem to be better characterized as a transaction or relationship as opposed to a network.

In considering organisational networks, we observe at least six different approaches (see Table 1).¹⁹

Of those approaches to networks, quantitative sociology has perhaps the longest pedigree and includes classic works by White and Burt among others.²⁰ While quantitative sociology is eminently suitable for the analysis of inter-firm relations, much of the research has focused on ties within individual firms and because of the demands that quantitative methods place on data collection, longitudinal studies of network dynamics are rare.

More recent are the approaches of strategic management and institutional economics that have arisen in an attempt to address new organisational patterns not easily incorporated into earlier analyses. Understanding differences in the two approaches depends to a large extent on distinguishing between transactions and organisational forms. Where the approach of institutional economists has tended to focus on transactions (e.g. Williamson takes great care in classifying transactions into firms, markets and relational contracts), researchers like Miles and Snow have been more concerned with organisational forms. Unfortunately, Williamson's choice of transactional labels can be confusing for what he terms 'firms' might be better described as 'employment relations' and 'markets' as 'classical contracts'. Ultimately, the bulk of Williamson's work concerns dyads and hypotheses regarding the appropriate type of mediating relationship. From a strategic management perspective, however, network organisations are seen as a new type of organisational form, not just a transactional type. Price, trust and authority may all be present in a network organisation—what really matters is how they are linked.

Considering organisational variety helps to distinguish the strategic management perspective from that of organisational theory. Where those entertaining a strategy perspective tend to treat network organisations as a single new form, organisational theorists see a family of forms, distinct not just from firms and markets, but also from each other.

While all of the above approaches are structural, none need be static. Unfortunately, because of the difficulty of collecting good network data, longitudinal studies have been rare. Organisational dynamics, the fifth approach identified in this paper, has attempted to tackle this problem head on. The sixth category, supply chain management, includes a combination of approaches and is really more heterogeneous than its label might indicate. It is meant to represent research initiated according to a topic area. A number of articles could have been cited in Table 1 (e.g. those on strategic alliances, multinational enterprises and/or sales networks), but given the topic at hand the choice of articles does not seem unreasonable.

Whether one sympathises with Williamson in his reluctance

*there are six
approaches to
networks*

to acknowledge much of a centre-ground between markets and hierarchies,²¹ Thorelli's view that networks lie on a continuum between the two, or Powell's position that they are an organisational form in their own right,²² it seems clear that there are a variety of ways to co-ordinate economic activity. We prefer the network paradigm to other organising frameworks because of the degree to which it emphasises a firm's efforts to control its environment. Moreover, as an effort to underscore the variety of organisational forms observable in the real world,²³ a notion of networks as separate from markets and hierarchies²⁴ is helpful.

Because of our background in supply chain management, we tend to sympathise with an organisational approach and an aspiration to develop an understanding of the dynamics of inter-firm networks. We see this paper as (1) providing useful information on generally unreported organisational patterns from a part of the world where systematic research on business issues is thin and (2) helping to fill a real gap in the literature by considering issues of network dynamics and evolution. By reporting on a number of network patterns existing in manufacturing, we reveal structures previously unknown, if not wholly unfamiliar. As Taiwanese manufacturing—ably represented by its machine tool industry—has been quite successful, these observations are particularly relevant. Furthermore, by comparing the networks with those found elsewhere, this paper attempts to include Taiwanese production networks within what is an already rich stream of organisational literature.

Although the literature is thin, network dynamics has been recognised as important topic for many years. In his 1986 article, Thorelli does devote a whole section to the subject, considering network evolution in terms of membership—the entry and exit of firms combined with the positioning and repositioning that surround such events—and the overall growth. Six years later, however, Nohria²⁵ is still calling for “better theories on network evolution and change”.

Lorenzoni and Lipparini and Madhavan, Koka and Prescott have helped enrich our understanding of network dynamics. According to Lorenzoni and Lipparini, too much emphasis has been placed on dyadic ties rather than on understanding the network as a whole. By focusing on changing patterns of outsourcing, both in terms of manufacturing and new product development, Lorenzoni and Lipparini have worked to redress the balance. Madhavan, Koka and Prescott take the position that managerial action can shape networks to provide a favourable context for the future and that the structure of inter-firm networks change in potentially predictable ways. The strategic alliances they study cover a broad spectrum of relationships including joint ventures, licensing agreements, and long-term supply agreements and we agree with them when they point out that there are a number of alternative ways to think about the nature of structural change.

What we find distinctive about our paper is its conceptualisation of network structure and change. Networks have shape:

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efforts to control its
environment*

some like the branches of a tree and others like the spokes of a wheel. Supplier networks have frequently been described by distributing of subcontractors into tiers, yet networks are often more than that. We see supplier networks shaped like starbursts or rings as often as we see companies sorted into tiers like a workman's toolkit. As far as reasons for structural change are concerned, we believe a combination of economies of scale due to increasing production volume and greater trust stemming from an accumulated history of successful business interaction are fundamental to changes in network structure.

Some authors have argued that a knowledge-based view of the firm²⁶ may be very helpful to understanding collaborative relations among firms.²⁷ To the extent that such a perspective considers that the ability to integrate the efforts of different actors is as important as the capacity to innovate, we find the approach promising. In particular, we think the implication that inter-firm collaboration may exist to support market contracting in industries that produce complex, multi-component products (e.g. the automobile, aerospace and other machine building industries) is on target.²⁸

*Taiwan has three
kinds of networks: star,
ring and tiered*

Analytical framework

Focussing on the machine tool industry as a local network, it is noted that basic production requirements in terms of cost, flexibility, technical and social relationships often result in a cluster of suppliers evolving into an efficient and balanced network of specialised producers. Previous research in this field has provided some insight into the features of the Taiwanese machine tool industry.²⁹ In particular, while studying Taiwan's milling machine industry, Liu uncovered three distinct types of production networks. In order to understand such network structures and their dynamics, we propose the following framework.³⁰

A model for Taiwanese production networks

There are three basic types of supplier networks in Taiwanese manufacturing: concentrated, dispersed and multi-centred networks. Each has its own characteristics and conditions for success. Dispersed and concentrated networks represent different configurations of lead-firm supplier networks. Multi-centred networks are collections of small enterprises most often devoted to the production of parts and system subassemblies. In a multi-centred network, for a given part and order, a particular firm will act to co-ordinate production. Because such a network will often produce a number of parts for a variety of different customers, the hub firm will change for different products.

Dispersed networks generally take on one of two forms. The first is a star-like structure. The second is a ring-like form which, when seen from a materials flow perspective, has the suppliers orbiting the lead manufacturer like planets, usually with informational rather than material ties to the central firm.

Table 2. Lead firm network patterns: basic conditions, strengths and weaknesses

Dispersed network Star form	Dispersed network Ring form	Concentrated network Tiered form
<p>Basic conditions</p> <ul style="list-style-type: none"> • Small or medium sized work-pieces (low volume and bulk) • Low production volume, low overall value • Variable specifications or frequent order changes • Minimal desire for co-ordination among supplier factories 	<p>Basic conditions</p> <ul style="list-style-type: none"> • Large sized work-pieces (high bulk, high value) • Large production volume, high overall value • Content of product orders relatively stable 	<p>Basic conditions</p> <ul style="list-style-type: none"> • Subcontracting volumes high • Large overall production volume
<p>Advantages</p> <ul style="list-style-type: none"> • Quality control and supervision relatively easy • One-on-one management style • Clear areas of responsibility • Ability to change suppliers 	<p>Advantages</p> <ul style="list-style-type: none"> • Avoids redundant transportation of materials • Requires and encourages communication and technical exchange among suppliers • Inspection time for overall production is faster 	<p>Advantages</p> <ul style="list-style-type: none"> • Allows a firm to work with fewer suppliers • Complexity of subcontracting management is lower • Suppliers can profit from economies of scale and learning effects
<p>Disadvantages</p> <ul style="list-style-type: none"> • Complicated material flows (routing and transportation) • Requires factory floor space • Routine clerical work saps managerial attention • Increases storage costs 	<p>Disadvantages</p> <ul style="list-style-type: none"> • Suppliers must want to work together • Relations among suppliers must be good • Product quality responsibilities must be clearly established • Hard to change suppliers • Managers overseeing suppliers carry a heavy load 	<p>Disadvantages</p> <ul style="list-style-type: none"> • Suppliers must have a strong desire to work together • First tier suppliers must have sufficient scale and management capabilities • Suppliers not easy to replace • Transformation to a tiered structure impacts entire subcontracting system

Both forms may be considered as examples of Taiwan’s centre–satellite manufacturing system.

Most dispersed networks begin as star structures with orders for parts being organised by the lead manufacturer and parts routinely flowing back to the central company before additional processing. Typically, ring-like structures begin to emerge as the supply network is rationalised. Rather than having parts and assemblies constantly returning to the lead firm, parts flow directly from one subcontractor to the next. This simplifies logistics, even as it reduces the lead firm’s control. Necessary conditions for the emergence of the ring form include the existence of good inter-supplier relationships and sufficient lead firm competence in managing suppliers and logistics.

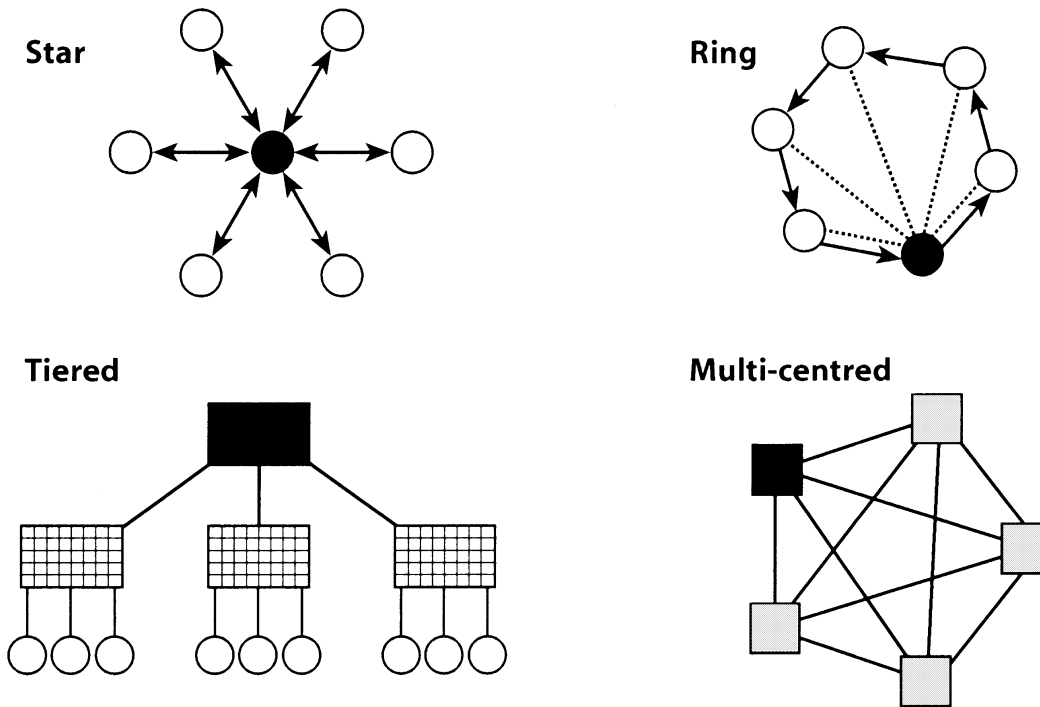


Figure 1. Ideal type network shapes

Concentrated networks also involve a lead firm, but instead of having a myriad of small suppliers surrounding the central firm, concentrated networks involve a smaller number of larger firms, each of which tends to undertake a more extensive set of tasks. As a result, such networks tend to take on a tiered shape. Because alternatives are fewer, lead firms must work to maintain good relations with suppliers. At the same time, because there are fewer suppliers, ties among suppliers tend to be cordial.

Production volume and processing balance are critical issues for concentrated networks. If production volume is too low, suppliers will find themselves hard pressed to make a profit. If processing tasks are unbalanced and/or constantly changing, expensive equipment may sit idle. In either case, the supplier suffers. For a summary of lead firm network types, see Table 2.

Each type of production network has its own conditions for success. For example, dispersed makers will tend to be found in industrial areas with dense inter-firm ties. They will also tend to supply relatively standard products for the market.

Multi-centred networks of small firms are yet another form of manufacturing organisation. Usually this kind of network is involved in the production of parts or subassemblies. In this network, there is no single lead firm. Instead, the role of the leader changes depending on the product and order. This kind of network organisation often leads to a very fine division of labour and is conducive to the development of specialist firms. Moreover, such networks are very flexible. Given a reasonable amount of co-operation among firms, such networks can often

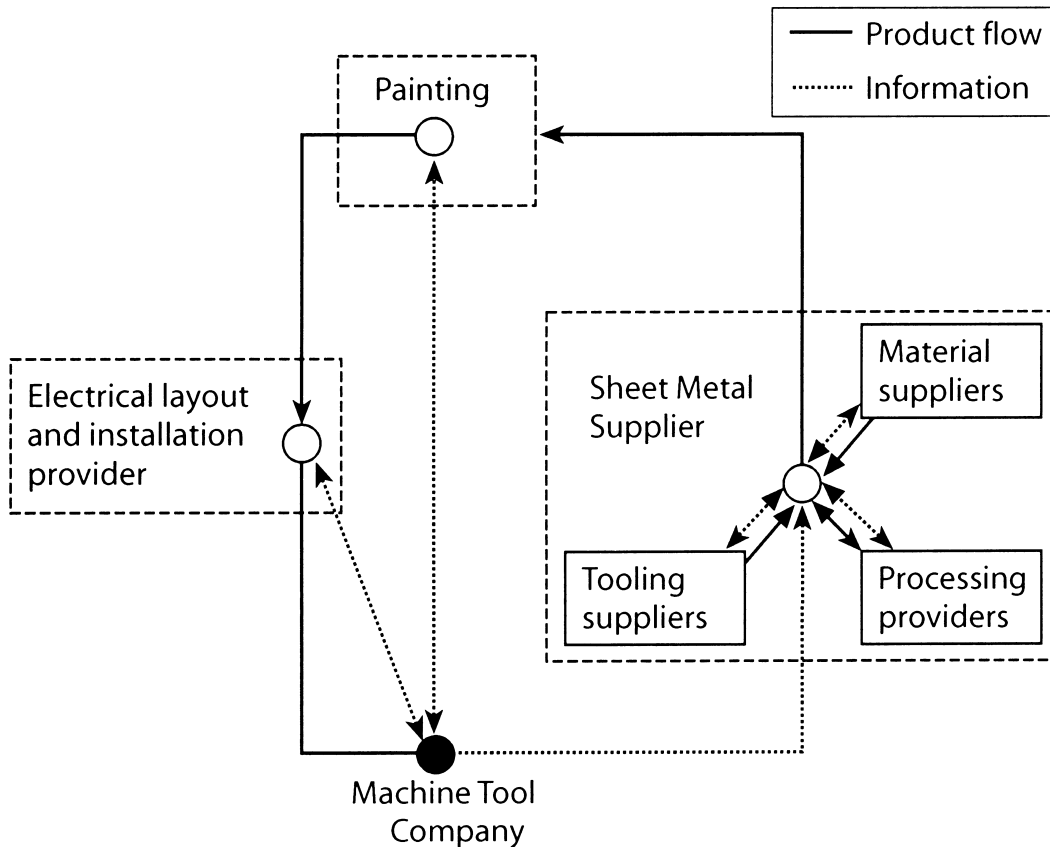


Figure 2. An integrated view of supplier networks: electrical box procurement

avoid dissolution by migrating from the manufacture of one product to another according to the logic of product life cycles (see Figure 1 for an illustration of ideal type network shapes).

Complete production networks in Taiwan will typically be made up of large-scale, lead firm networks in which are embedded a number of smaller multi-centred networks. An example of such an articulated production network is given in the figure below (see Figure 2).

We believe the patterns identified here apply generally in Taiwan’s machine tool industry and so are very useful for selecting subjects for in-depth study. Of course, for multinational companies, networking can be extended to consider international/global support, transportation costs, delivery schedules, technical capability and company manufacturing strategy—all of which will shape network patterns. Here, however, we are looking at examples of locally dedicated networks.

Case studies

Overview

There are more than 2000 companies linked to the machine tool industry in Taiwan. Among such firms, three features are prominent: 95 per cent of them are small, 80 per cent are con-

centrated in and around Taichung (a city in central Taiwan), and multi-centred supply networks are very active. Following Liu and as has been described above, three case studies have been investigated.³¹ Two of the cases concern lead-firm networks. The third considers relations in a multi-centred network.

The three case studies were taken from an eight-year research project on Taiwan's machine tool industry overseen by Ren-Jye Liu at Tunghai University. Between October 1996 and March 1998, a number of interviews and factory visits were undertaken. Both lead firms were visited three times each, and a total of 24 interview hours were logged. Interviews were conducted with top management as well as outsourcing and manufacturing managers. In addition, six suppliers and six members of the multi-centred network were interviewed for about two hours each. At each of these firms, the interviews were conducted with the owner/president. Half of these companies were visited twice. Two research assistants accompanied Professor Liu on his visits, and Jon Brookfield also met with a number of companies while pursuing his doctoral research in Taiwan. Overall, 14 enterprises have been visited on 24 separate occasions. In total, more than 50 hours have been spent with over 30 managers during the course of this project.

The first case concerns Fair Friend, the second largest manufacturer of machining centres in Taiwan (see Table 3). Founded in 1985, the company is located in Taichung's Industrial Park, and as a typical dispersed producer, it purchases most of its parts from outside suppliers. Fair Friend has 210 employees—most of them in R&D, design, marketing and assembly. Overall, only four employees work in its part-making machine-processing department.

The second case subject is Seyi, Taiwan's top press manufacturer (see Table 5). Due to its location in Taoyuan county (northern Taiwan), Seyi finds it very difficult to get favourable business from suppliers in the Taichung area. A typical concentrated producer, Seyi has 253 employees, and with more than 40 employees in its machine-processing department, the department is considerably larger than Fair Friend's. Nevertheless, Seyi still outsources about 50 per cent of component manufac-

*we report three cases
based on detailed
study*

Table 3. Basic information on Fair Friend and its suppliers

Companies	Central factory	Satellite suppliers		
	Fair Friend	Hsian Wei	Yong Ye	Ling Wei
Year established	1985	1987	1989	1995
Capital (million \$NT)	150	40	1	0.3
Sales (million \$NT)	1100	36	10	4.5
Employees	210	16	12	5
Location	Taichung, Industrial Park	Taichung, Fengyuan	Taichung, Daya	Taichung, Dajia
Major Products	CNC lathes, machining centres	Sheet metal	Painting	Electrical boxes

Table 4. Basic data on Fair Friend's relationship with suppliers

Companies	Fair Friend satellite suppliers		
	Hsian Wei	Yong Ye	Ling Wei
Length of relationship	9 years	7 years	2 years
Dependence (% of supplier's sales)	55%	90%	100%
(% of such parts supplied)	~ 100%	100%	~ 100%
Work	Sheet metal	Painting	Electrical boxes
Nature of communication	Face-to-face Phone Fax	Face-to-face Phone	Face-to-face Phone Fax
Frequency	Often	Very frequent	Very frequent
Contact unit(s)	Procurement, Manufacturing	Manufacturing	Procurement, Controller's Division
Delivery destination	Yong Ye, Fair Friend	Ling Wei, Fair Friend	Fair Friend

ture. Because there are fewer machine companies in Taoyuan, Seyi's suppliers are relatively well connected to one another.

The third case investigates a multi-centred supplier network in the Taichung area. Multi-centred networks play an important role in the industry, especially in Taichung where more than 1000 small manufacturers provide castings, heat treatment, machine processing, part assembly and so on. We examine connections among six small companies, each of which have 4–16 employees, in an attempt to find out how they work together (see Table 8). As the term indicates, multi-centred networks have no clear lead firm. For the purpose of this paper, however, we have named the case 'San Yuen' after one of the network's member companies.

Fair Friend

Although Fair Friend was only established in 1985, it is already a top class manufacturer in Taiwan's machine tool industry. Making use of Taichung's mature industrial environment has been a key factor (see Tables 3 and 4).

In the beginning, Fair Friend tended to buy parts from the outside, assemble them in-house, and then ship the finished products to users. Consequently, the structure of its network looked much like a star (see Figure 3).

Because Fair Friend has provided low cost products, its sales over time have increased dramatically. Recently, with the entry of many new companies to the industry, things have become more competitive. To adapt, Fair Friend has begun to change the structure of its supplier network. We use a typical component, the electrical box, to illustrate changes in the company's network structure.

In 1994, to produce an electrical box, Fair Friend first needed to order metal forms from a sheet metal supplier, at which point the supplier purchased materials from a suitable

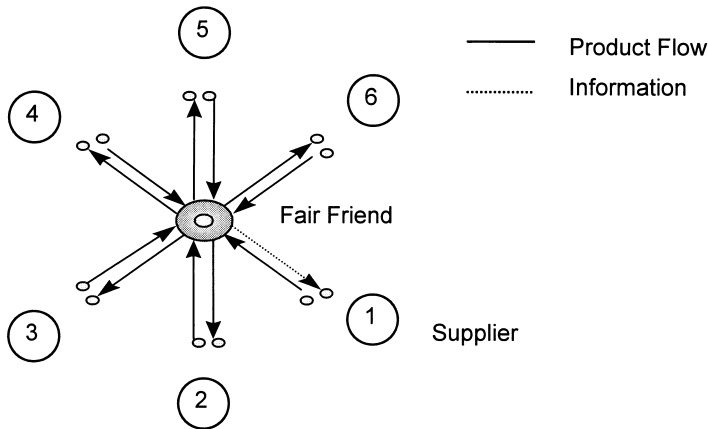


Figure 3. Early Fair Friend: a star shaped network structure

Fair Friend is a top class manufacturer

vendor. The sheet metal supplier then modified the materials and delivered them back to Fair Friend's storehouse. Afterwards, Fair Friend would check its production schedule and contract a painting firm to take the objects. After being painted, the metal boxes were sent directly to an electrical layout supplier to install all necessary components. Finally, the boxes were delivered back to Fair Friend.

It is clear that, even in 1994, Fair Friend's suppliers had already initiated some improvements on a star type network. However, networks are not static and Fair Friend's supplier network has continued to change. Currently, after readying the sheet metal, the sheet metal producer delivers the products directly to a painting firm. After processing, the painting firm sends them to the electrical layout supplier to install all components and wait for instructions from Fair Friend before delivering the units to the company (see Figure 4).

As one can see, Fair Friend's supplier network has become more logical over time and rationalisation has included a reduction in the number of deliveries, relocation of stock to an up-stream processor and the integration of informational and

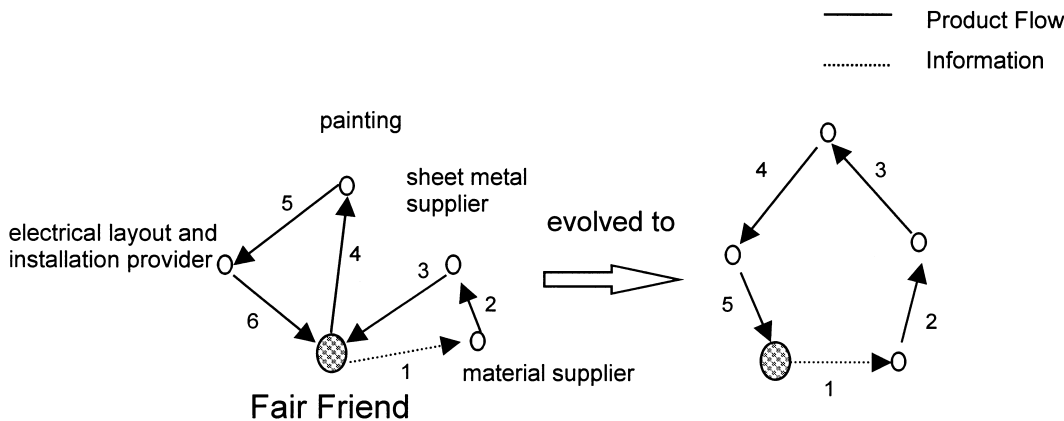


Figure 4. From semi-star to ring: transforming Fair Friend's supplier network

Fair Friend established many mechanisms for communicating with suppliers

logistical processes. In addition, structural changes in Fair Friend's supplier network have allowed specialisation, saved 1500 ft² in factory space and reduced management and inventory costs. From a supplier perspective, Hsian Wei notes that quality consciousness has been raised among its employees and that long-term co-operation has been enhanced. Other suppliers have found that their output has increased since the reorganisation and most appreciate Fair Friend's more co-operative management style.

These changes, however, have not come without a struggle. At times, Fair Friend has found it difficult to determine where responsibility for product quality should lie and also in establishing a single point of contact between its production unit and its subcontractors. Moreover, Fair Friend's suppliers have complained about the cost of new equipment needed to make the changes work, and they have also noted that co-ordination with upstream producers has not always been smooth.

Offline and informal communication

In addition to routine contact directly related to logistics and material flows, Fair Friend has also established a number of other mechanisms for communicating with suppliers, including a supplier association, supplier meetings and a periodic review. Fair Friend's supplier association meets at least once every six months. Such meetings not only provide an opportunity for Fair Friend to announce company policies and indicate future plans, but also to give suppliers a chance to make their opinions known. Such meetings help facilitate the flow of ideas and technology. In addition, every month Fair Friend's vice president holds two supplier meetings. In such meetings, the company seeks to introduce new concepts and procedures for improving quality, which can involve asking suppliers to participate in further training. When problems are severe, Fair Friend will commonly organise additional discussions and invite a group of related companies to participate. Recently, Fair Friend has further strengthened its ties with satellite suppliers by jointly attending seminars on quality control and production followed by regular discussion sessions. Every three months, Fair Friend implements a supplier review, evaluating companies in terms of product quality, costs and delivery times. By participating in company movements and integrating one another's comings and goings, suppliers have been able to reach a reasonable level of synchronisation and mutual success.

There are also a number of more informal social events that may be held in the course of a year. A good example of such social interaction is the traditional year-end *weiyu* dinner. *Weiyu* banquets are meals of thanks to which companies invite important stakeholders, including customers, suppliers and employees. Depending on the circumstances, a company may host a number of such dinners, each with a different audience and focus. Such events help bind a company's suppliers together

in co-operative and friendly relations. They also provide an opportunity for the exchange of information. Overall, informal activities are more common than formal ones, but because such interaction can vary greatly such activity is not easily summarised. Similar off-line interaction and informal social activities may also be found among Seyi and its suppliers.

Seyi

As already pointed out, Seyi is located far from the Taichung area. Nonetheless, Seyi’s development of its supplier network (see Tables 5 and 6) can be compared to Fair Friend’s. As an illustration, we use the processing of small and large castings to investigate the structure of Seyi’s supplier network.

In the case of the small-sized castings, processing includes four steps: the provision of materials, die-casting, lathing and drilling/milling. Each step is performed by a separate company. Some network changes have been similar to those in the Fair Friend case. For example, materials are delivered directly to the drilling/milling producer after the lathing process, instead of being returned to Seyi. In addition, Seyi has also persuaded the lathing company to purchase some drilling and milling machines so that production of these processes can be done in one place. In short, Seyi has consolidated the entire process into a two-tier process for operational efficiency (see Figure 5).

In the processing of large castings, we find an even fuller expression of this consolidation and reorganisation. The processing of large castings includes material procurement, welding, annealing, sandblasting and machining, and Seyi has already worked to rationalise the process. However, the company still thinks it has too much work, especially in terms of organising different suppliers and co-ordinating the process. In an attempt to focus on certain essential components, Seyi has tried to persuade related suppliers to join forces, and in so doing, relieve Seyi of some of its subcontracting management burden. Seyi’s processing network for large castings can be seen in Figure 6.

Seyi has been able to rationalise its logistics

Table 5. Basic information on Seyi and its suppliers

Companies	Central Factory	Satellite suppliers		
	Seyi	Kun Yuan	Jin Shun Long	Jen Hsing
Year established	1962	1992	1985	1978
Capital (million \$NT)	195	7	13	51
Sales (million \$NT)	1300	72	14	65
Employees	253	32	10	25
Location	Taoyuan, Kuishan	Taoyuan, Yingge	Taoyuan City	Linkou Industrial Park
Major products	Presses, hydraulic equipment	Castings	Lathe processing	Large items, drilling/milling

Table 6. Basic data on Seyi's relationship with suppliers

Companies	Seyi satellite suppliers		
	Kun Yuan	Jin Shun Long	Jen Hsing
Length of relationship	5 years	12 years	7 years
Dependence (% of supplier's sales)	50%	100%	30–35%
(% of such parts supplied)	75%	70%	40%
Work	Castings	Lathe Processing	
Nature of communication	Face-to-face	Face-to-face	Face-to-face
	Phone	Phone	Phone
	Fax		
Frequency	Very frequent (delivery every day)	Very frequent (delivery every day)	Often (delivery every 2–3 days, phone every 1–2 days)
Contact unit(s)	Purchasing	Manufacturing	Procurement
Delivery destination(s)	Downstream plants (like Jin Shun Long), Seyi	Seyi	Seyi

Compared to suppliers in the Taichung area, Seyi subcontractors have their disadvantages. Nonetheless, Seyi has been able to rationalise its logistical supply patterns. Moreover, it has endeavoured to use the merits of its suppliers (e.g. their inside connections) to build a new structure that economises on network transaction costs. From Seyi's perspective, the changes have cut the number of suppliers it must deal with by 25 per cent and thereby reduced administrative costs. Delivery times have also been reduced. Suppliers note an increased freedom to plan production and so minimise production inefficiencies. At the same time, their responsibilities have become heavier. Jin Shun Long notes its revenues have doubled and it has been able to profit from the increased scale. At the same time, as a consequence of such changes, the level of mutual dependence between Seyi and Jin Shun Long has also increased.

Again, as in the Fair Friend case, these changes have not come without work. It has not been easy for Seyi to maintain the level of quality to which it had become accustomed and finding the appropriate incentives to generate co-operation among suppliers has been difficult. Seyi's suppliers have noted the high cost of new equipment, and that to succeed a supplier must have sufficient scale and ability to manage the subcontracting process. By summarising the changes in Fair Friend and Seyi's supplier networks, Table 7 provides a useful comparison of the two transformations.

Table 7. Network changes: causes, difficulties and consequences

	Fair Friend	Suppliers	Seyi	Suppliers
Causes of network change	1. Space limitations 2. Serious redundancies in material flow	1. Desire to co-operate with central factory policy changes	1. Simplification of sub-contracting logistics 2. Internal resources inadequate for increase in production volume	1. Desire to co-operate with central factory policy changes
Difficulties of network change	1. Determining responsibility for product quality 2. Establishing a single point of contact between production unit and sub-contractors	Hsian Wei: Meeting the costs of new equipment Yong Y: Meeting new factory and equipment costs Ling Wei: Co-ordinating with upstream producers	1. Meeting accustomed quality levels 2. Generating co-operation from suppliers not easy 3. Finding appropriate incentives to motivate suppliers	Kun Yuan: — Jin Shun Long: High costs for new equipment Jen Hsing: Must have sufficient scale and ability to manage the sub-contracting process
Reflections on the transformation process	1. Moving from a Star to a Ring structure for castings and assembly 2. Changes allow specialists to do specialised work 3. Changes have saved 1500 ft ² , reduced management and inventory cost	Hsian Wei: Quality consciousness has been raised, long term co-operation has been enhanced Yong Y: Assembler has introduced new clients, increased output Ling Wei: Assembler has initiated co-operative management style	1. Delivery times have been reduced 2. Number of satellite suppliers has been cut 25% and reduced related costs	Kun Yuan: Self-inspection strengthened Jin Shun Long: Revenues have doubled and firm has profited from economies of scale, level of mutual dependence has increased Jen Hsing: Increased freedom to plan production process and seek out greatest efficiencies, but responsibilities have also become heavier

San Yuen

Multi-centred networks represent something of a wild card. They can replace a whole network or just a portion. Here, we would like to use the production of a key machine part—the linear rail—to introduce this form. Our case includes six small producers with business ties (see Table 8). Half of the companies are run by bosses who worked for machine tool companies

Table 8. Basic information on multi-centred network firms

Companies	Chun Yu	Chu Yang	Chu Ta	Hsian Wei	Yuan Jing Ping	Taichung Heat Treatment
Year established	1986/1987	1991	1993	1987	1970	1975
Capital (million \$NT)	5.5	5	5	40	0.45	6
Sales (million \$NT)	6	30	20	36	20	10
Employees	4	15	8	16	10	12
Location	Taichung Taiping	Changwa Fang Fan Industrial Park	Taichung Taiping	Taichung Fengyuan	Taichung Taiping	Taichung City
Major products	Machine parts, processing	Auto parts, hand tools, valves, copper parts, stainless steel forgings	Moulds for auto parts, hand tools, valves and copper forgings	Sheet metal	Grinding for medium and large size machine tools	Heat treatment for machine tools

before founding their own firms. For example, San Yuen's boss originally worked for Victor Taichung and, to this day, continues to have dealings with them. Bosses at two of the companies (San Yuen and Chu Yang) are friends from their military service. All are located near one another.

Such ties are typical in Taiwan, where business relations often stem from interpersonal networks, and Granovetter's notion of 'embeddedness' seems tailor-made for such an environment.³² Buyer-supplier links, specialised skills and profit seeking also play a part in determining the direction of long-term co-operative relations (e.g. at the same time, while San Yuen and other network companies engage in close social relations, their activities are also highly specialised and complementary). Overall, mutually advantageous business relations are commonly maintained through a complex and overlapping set of personal ties, production necessities and economic incentives.

As far as the manufacturing process goes, when San Yuen accepts an order of linear rails from its finishing treatment supplier, it contacts Chu Yang for forged products. Chu Yang then contacts Chu Ta for supplying the required moulds. Except for obvious differences in the products they make, all three companies are in similar situations (see Figure 7).

An interesting point regarding multi-centred networks is that there are no regular lead companies like in Fair Friend or Seyi's supplier systems. In fact, three of the six (San Yuen, Chu Yang,

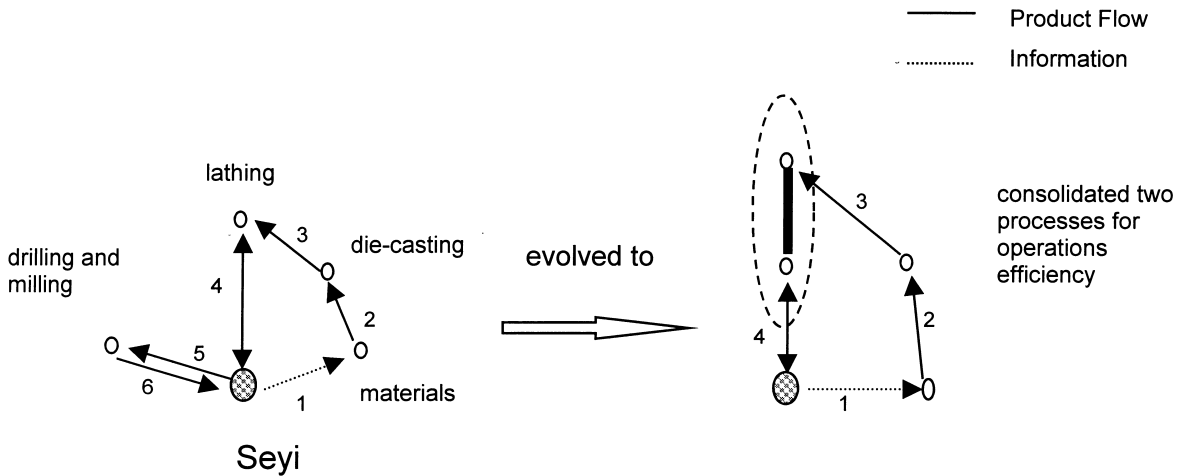


Figure 5. From semi-star to embryonic tier: the transformation of Seyi's supplier network for small castings

and Chu Ta) have acted as leaders at various times. When acting as a focal factory, a firm must co-ordinate with customers as well as tooling, material, part and finishing treatment suppliers. Typically, a product order has a lead company and a star network, regardless of scale. In actuality, San Yuen is a four-person trading company set up by the current boss of Chun Yu and now controlled by his wife. Nowadays, San Yuen handles customer orders and Chun Yu carries out the network's lathe work.

Multi-centred networks are formed by a combination of regional connections, business opportunities, process links and personal contacts, and they may be found in nearly all comprehensive production systems. Generally speaking, most inter-firm activity occurs directly between owners and, relative to larger enterprises, interactions among firms in multi-centred networks tend to be less formal. Detailed written agreements are uncommon, and when, for example, a new outsourcing opportunity presents itself, multi-centred networks are unlikely to formally bid out the work as might be done by lead firms like Fair Friend or Seyi.

Discussion

In the above cases, we have seen Fair Friend move from a star to a ring network and Seyi move from a ring to a tiered organisation of suppliers. The cases have provided useful information on the nature of supplier networks in Taiwan's machine tool industry, but a number of questions remain, including: Why do we see the forms we do? What factors influence network structure?

In listening to suppliers, it is clear that the impetus for change came from the lead assemblers. Suppliers for both companies agreed that policy changes by lead firms were key factors

*in multicentred
networks there are no
regular lead
companies*

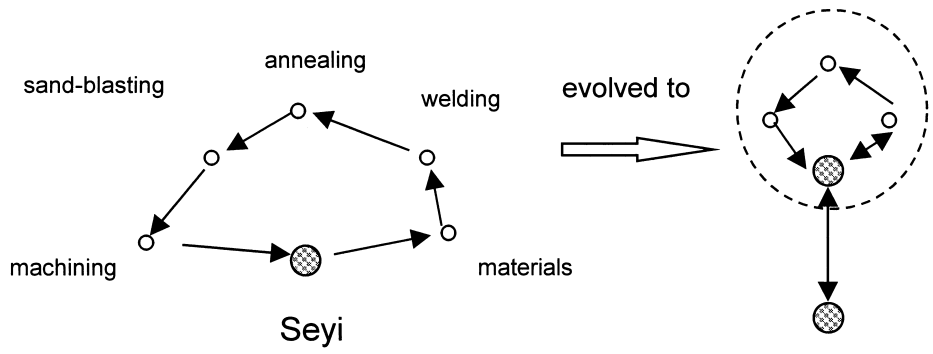


Figure 6. From ring to tier: the transformation of Seyi's supplier network for large castings

and that they, the suppliers, were merely trying to co-operate with those policies. As for the lead firms, Fair Friend noted that space limitations and serious redundancies in material flow were prime factors in its decision to change. Seyi points

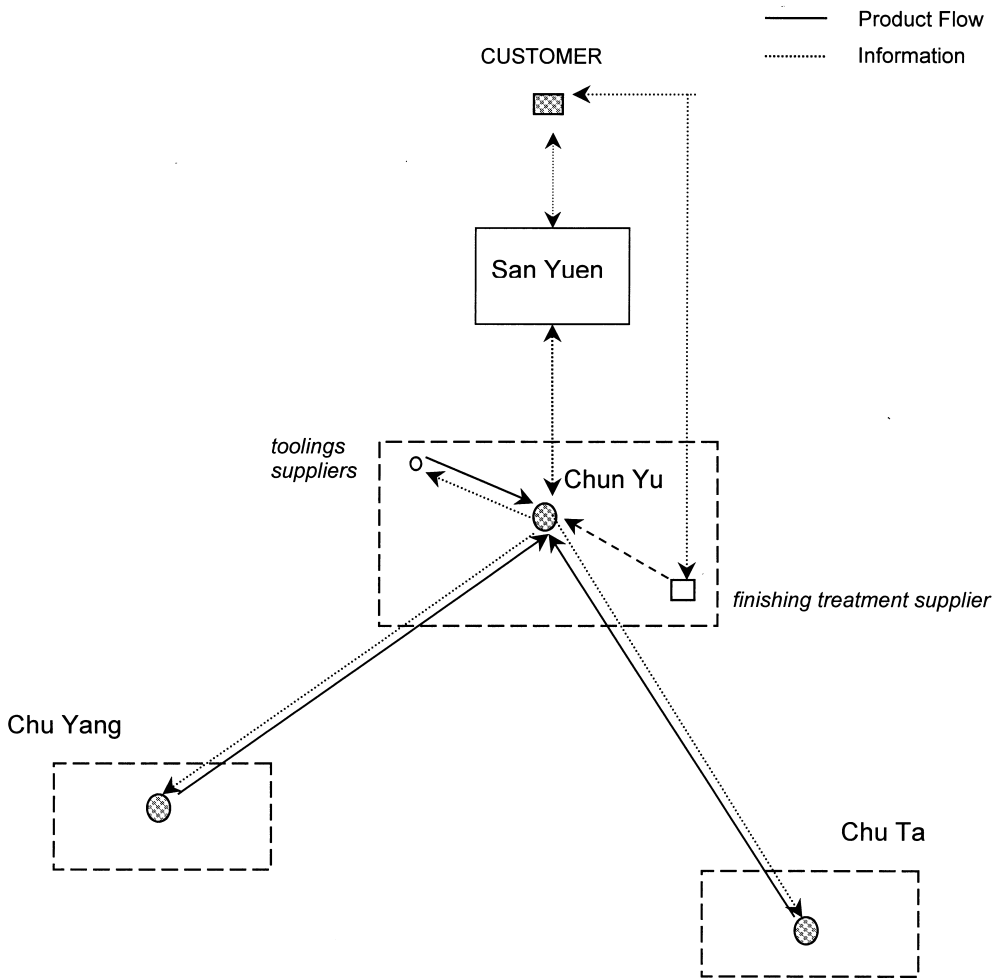


Figure 7. A hydra: the multi-centred network structure

out that its subcontracting logistics needed to be simplified and that its internal resources were inadequate for the increased production volume.

In general, it may be said that production volume, trust and the level of competition among suppliers are all important. How production volume and trust influence network organisation may best be understood in terms of the flow of material and information. Star networks permit focal factories to exercise a high degree of control, but also require a great deal of oversight and logistical movements. Ring networks save on transportation costs, but when problems with product quality occur, such a structure makes it more difficult to identify the responsible party. Tiered structures can save on transportation expenses and information processing costs of the lead firm, but trust among suppliers and between suppliers and the lead firm is crucial. The level of competition among suppliers also matters. Star and ring networks allow lead firms to change suppliers most easily. If a company is located in an area where there are few suppliers, however, switching suppliers may not be viable and so such flexibility may be less important.

How does an analysis of these general forces square with observed patterns? As mentioned, dispersed networks are most common in Taichung. Concentrated networks generally appear elsewhere. Star and ring forms of organisation are more likely to be found in dispersed networks. Concentrated networks are more likely to evolve into tiers.

In the case of Seyi, inside connections have provided the trust that has allowed a tiered structure to emerge. Moreover, a relative scarcity of suppliers in the area means that the structure's rigidity, vis-à-vis switching suppliers, is not a serious problem. However, such an explanation would seem to deny the information processing and transportation cost savings of a tiered structure to firms in Taichung. In practice, the ubiquity of multi-centred networks in the area appears to provide lead firms with those very savings without the need to consciously organise suppliers into tiers. Overall, the capabilities and values of member companies, business demand and industry competition are all major factors influencing the configuration of supplier networks in Taiwan.

Reasons for the success of Taiwanese manufacturing

Broadly speaking, there seem to be three major advantages to Taiwan's manufacturing system: a specialised division of labour, widespread entrepreneurship, and flexible adjustment to changing conditions. As far as machine parts are concerned, Taiwan has a number of specialised producers, including Hiwin for ballscrews, Taiwan Keyarrow for sheet metal, Fongge for chip conveyors, etc. In addition, while machine tools have been around for decades, that has not deterred would-be bosses from founding new companies. A number of machine tool companies and related suppliers were founded in the 1980s and this continues into the 1990s. Moreover, with so many compa-

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nies in the industry, each with its own skills, manufacturers have been able to reconfigure themselves and their production networks in line with a changing business environment. Overall, these advantages and the structures from which they stem are not limited to Taiwan's machine tool industry, but may be extended to a number of industries. What can be learned from the machine tool industry need not be limited to it.

Implications for theory

Compared to the organisations described by Snow, Miles and Coleman, Taiwanese supplier networks seem to share characteristics of both stable and dynamic networks. Like dynamic networks, they use outsourcing extensively and are flexible. Similar to stable networks, many suppliers are often nestled around a larger core firm. Compared to the strategic centres described by Lorenzoni and Baden-Fuller, Taiwanese lead producers are smaller and more focussed on production.

As far as Taiwanese manufacturing networks are concerned, we find them consistent with a number of patterns described in the industrial district literature.³³ If industrial districts are spatially concentrated networks of small and medium sized companies that often use flexible production and have extensive interfirm linkages, then Taiwan's machine tool industry would seem to qualify. Flexible firm boundaries, self interested co-operation and trust are all important to the effective functioning of Taiwanese networks. While it is hard to rigorously measure the social atmosphere of a place, it would seem that entrepreneurship is valued in a way similar to what Saxenian found in Silicon Valley and that the desire to be one's own boss is strong. At the same time, Taiwanese networks do not involve the same level of local and regional government support as those found in Italy. Collectively provided business services and unions also seem less important. While a number of similarities may be found between Taiwanese manufacturing networks and those found elsewhere, because the focus of this paper has had been on the shape of supplier networks and other micro-level co-ordination issues often missing from other accounts, many of our observations are not directly comparable.

Implications for managers

In today's global environment, as a matter of business intelligence if nothing else, it is important to know how things are organised in other parts of the world. This paper has tried to assist in that mission by bringing to light a number of organisational patterns in Taiwanese manufacturing. In addition, by identifying particular types of supplier networks in Taiwan's machine tool industry along with the forces that influence them, these findings have implications for managers when structuring their own supplier networks. Specifically, when production volumes are low and trust within the supplier community is minimal, star networks seem desirable. As production volumes and trust increase, ring and tiered structures may be

more effective. While these results are derived from the experience of a single industry, we expect they should hold in most manufacturing settings. Moreover, in helping managers think about the overall structure and dynamics of supplier networks, we feel the analysis presented should prove particularly useful for managers in industries requiring complex assembly.

Knowledge management

The cases described in this paper also have a number of implications for knowledge management.³⁴ Change is more than an annual investment in modern computer systems. Effective knowledge management is at least as much organisational as technological. The organisational response of Taiwanese machine tool firms to the increased administrative complexity brought on by strong growth is a good illustration of this point. Effective knowledge management requires more than a technological fix.

The change process

As far as organisational change is concerned, at least two points have emerged from the experience of the firms under investigation. First, change is not easy and companies initiating change must be aware of where the burdens of change will fall and be ready to modify their incentive systems accordingly. Second, because change often plays havoc with established routines, knowing who is responsible for what is critical. Reviewing, and if necessary, remapping lines of authority and zones of responsibility must be made part of any transformation process.

Conclusion

In describing the nature of supplier networks in Taiwan's machine tool industry a major factor behind the competitive advantage of Taiwanese manufacturing as a whole is revealed. What we find distinctive about this paper is its way of seeing network structure and understanding structural change. Among lead firm networks, there seem to be three basic organisational patterns: stars, rings and tiers. In addition, multi-centred networks of small firms appear integral to manufacturing on the island. As far as network changes are concerned, scale economies, inter-firm trust and industry competition all appear to have an important influence on the evolution and development of Taiwanese supplier networks.

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