CHAPTER 5

Taiwan's Quest for an Innovation Economy

A Tale of Two Transformations

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A distinctive feature of East Asian postwar development is the state's active involvement in the economy. This involvement has stimulated a series of research studies on the so-called developmental state. The literature emphasizes the state's capacities to nurture new industries and induce entrepreneurs to invest in sectors they might not otherwise have considered (Johnson 1982; Woo 1991; Amsden 1989; Wade 1990; Weiss 1998). The successes of the information technology (IT) industry in Taiwan and South Korea, for example, have made these economies poster children and models for emulation (Evans 1995; Rowen, Hancock, and Miller 2007).

Latecomer economies are in a race, trying to keep up with advanced economies while they are in turn being pursued by other, late-latecomer, economies. East Asia's latecomer economies, like Taiwan and South Korea, are constantly searching for a template that will induce entrepreneurial growth and create new innovative industries to keep ahead of the competition. The recommendations they receive along the way often derive from the experiences of the IT industry. Thus, the priority is to develop new capabilities that are more flexible, skill intensive, and innovation driven. The new economy is believed to require the coordination of complex yet flexible institutions in meeting shifting challenges and demands. This setup would be a departure from most developmental states' current practice of scaling up investment policies from a centralized bureaucracy with strong leadership.

Creating the next Silicon Valley is a hot topic dominating policy debates and performance assessments, as is identifying the institutional arrangements that can induce public-private synergy in generating knowledge diffusion and collaboration. To this end, common policy practices are to increase investment in education, to encourage innovation by subsidizing research and development (R&D) (see chapter 6 on Japan and chapter 7 on Korea in this volume), and to encourage entrepreneurship through incubating start-up policies (see chapter 4 on Singapore).

In this chapter, I consider the question of innovation and entrepreneurship clusters. Here I present an overlooked model, proven to be equally successful as the celebrated model common in the IT industry: namely, a model of network-based, innovation-focused small- and medium-sized enterprises (SMEs), as seen in the upgrade of Taiwan's machinery industry. I refer to this alternative as the less-celebrated model.

This chapter demonstrates that Taiwan's SME-based machinery industry has adapted well and shown more resilience in the ongoing quest for innovation than the celebrated model of the IT sector. The chapter is organized as follows: I first give working definitions of innovation and entrepreneurship and show their relationship to the notion of clusters. I then examine the performance of manufacturing subsectors and their innovative capacities by using indicators such as industrial and commerce census data to support the claim that the less-celebrated model of Taiwan's SME-based machinery industry has done just as well if not better than the widely acclaimed IT-based model. A section is devoted to explaining how learning and innovation in the machinery industry have contributed to its resilience. I bring the role of public technology support institutions to the forefront and discuss the specifics of how orchestrating cross-cutting ties and thereby facilitating learning and cross-industry fertilization has been conducive to the collective learning and capacity building that sustain cluster dynamism. By juxtaposing the transformation of Taiwan's IT sector with that of its machinery industry, I conclude with a reconceptualization of development strategies and policy implications.

Defining Innovation, Entrepreneurship, and Clusters

Despite being buzzwords in headlines and among Asian policymakers discussing the next stage of national development, the concepts "innovation" and "entrepreneurship" tend to be vaguely defined, and their implications can be elusive. The term "innovation" is often associated with rapid-speed knowledge and research-intensive industries like IT and biotechnology that involve high entry barriers. In this chapter, I adopt Schumpeter's position on innovation, which considers entrepreneurship as innovation (Swedberg 2002; originally Schumpeter 1934). In his view, entrepreneurship/innovation can be best understood as the recombination of existing means. Innovation is about entrepreneurial activities that break existing routines through recombination and create added value. This might be through introducing new materials, production methods, products, or a new degree of quality; a new market; or even a new organization setup of any industry through a combination of existing means (Schumpeter 1934, 66). Therefore, innovation and the creation of additional value are about an active recombination of people, resources, knowledge, and social networks, as well as about creating new opportunities by pooling previously unconnected resources for an economic purpose (Granovetter 2005). It follows that entrepreneurship and innovation form a dynamic process, rather than a static one measured by the number of new firm entries or a focus on personal characteristics (Imai 2007; Aldrich 2005, 454). This kind of innovative activity may not easily be captured by statistical indicators such as R&D expenditures or number of patents. It demands a qualitative understanding and exploration of the concrete social relationships and interactions among actors. Thus, the focus centers on the interactions among firms/actors instead of on a single actor.

It follows that the analytical questions should move from deliberating whether large or small firms will triumph to investigating the specifics of how an ecosystem or regional economies can link actors and firms of various sizes and competencies together (Castilla et al. 2000, 246). The specific ways in which connections are made among various actors in a system account for the variations in outcomes (Block and Evans 2005). It is in this sense that networks of firms, the linkages among them, and the concept of clustering become relevant to understanding how entrepreneurship and innovation occur. The literature on networks postulates that a social network helps to transmit information and knowledge, and that this in turn generates innovation (Castilla et al. 2000; Smith-Doerr and Powell 2005; Saxenian and Hsu 2001). In particular, networks of social relations embedded in a geographical region are believed to be conducive to new ideas. This is because geographical proximity increases frequent interpersonal contacts that facilitate information exchange and speed up information flow.

Lastly, the kind of innovation I refer to is related to technology development and the potential growth resulting from technological advancements. It follows that manufacturing is important in the so-called knowledge economy because it inspires technological advancement and adds value, creates jobs, and promotes more equitable growth. The effects can be seen by comparing the situations around restructuring in western European countries and the United States. For instance, Germany and small countries like Denmark, instead of deindustrializing, have simply restructured and continued to thrive in high-quality and high-value-added advanced manufacturing, even in the face of competition from Asia (Herrigel 2010). In contrast, studies reveal that increasing inequality in the United States over the past three decades has to do with deindustrialization and increasing financialization, whereby firms do not invest in productive goods but downsize and focus on maximizing short-term profits for their shareholders (Lazonick 2009; Lin and Tomaskovic-Devey 2013). Moreover, the recent efforts to establish many innovation platforms working with SMEs and various incentives and policies aimed at bringing manufacturing back to the United States suggest that innovation cannot take place in a vacuum or the research lab but needs to be close to the shop floor. All in all, manufacturing matters for innovation (Block and Keller 2011; Berger 2013; Locke and Wellhausen 2014).

This chapter builds on these concepts by examining the case of Taiwan and offering an explanation of its resilient SME clusters.

Decentralized Industrialization and Taiwan's Postwar Development

A distinctive feature of Taiwan's postwar economic development was decentralized industrialization, which consists of a system of SMEs clustered in a geographical locale where numerous small firms complement one another in the production process, with each specialized in one phase of production. Together as a whole, they formed the foundation of the "Taiwan miracle," in which various industries claimed world-class distinction by inserting themselves successfully into the global production network and thrived by being international subcontractors for industries ranging from shoes, apparel, bicycles, and machine tools in the 1980s to IT industries from the 1990s onward.

Various industries within Taiwan's decentralized industrial system have the following general characteristics in common:

- The SME-based production system encompasses an extensive division of labor in which firms complement one another in the production process. They cluster in a geographical locale, or "industrial district" (Piore and Sabel 1984), where numerous firms compete and cooperate in the same industry. Many of the SME network-based industries in Taiwan focus on (a) assembling or (b) parts. The assembling industry involves an extensive system of subcontracting and a high degree of specialization. Extensive subcontracting is also exercised within the parts industry. The various components of a part are subcontracted to small factories that specialize in manufacturing them.
- The SME production network consists of numerous independent parts makers and processing specialists who focus on intermediate input and do not make the final product.
- Production networks are decentralized in the sense that they are open networks in which suppliers and specialist firms are usually not tied to particular assemblers. They can supply several firms within the industry or sell to other industries.
- Parts makers and specialist firms are incorporated into the global production network and compete directly in the world market rather than being completely dependent on domestic assemblers. The ability of SMEs to export directly—since the start of export-led industrialization in the 1970s—has been exceptional when compared to neighboring countries like Japan and Korea, where large conglomerates handle most of the exports.

One immediate consequence of such decentralized industrialization is that interindustry linkages are high. In an open and independent network, information not only travels within the industry but cascades among industries. Workshops that perform some processing jobs for bicycle assemblers and parts suppliers—such as drilling, lathing, milling, metal surface finishing, and anodizing—are not locked into one particular supplier or one industry. They perform processing jobs for a variety of industries. Moreover, the ability of parts makers to connect with the global market means that their points of access to information are multiple, so they have multiple sources of learning. This means that knowledge and ideas cross industry boundaries and are not contained under a single roof. As will be discussed later, these characteristics affect how one understands where breakthroughs and technological learning come from and how innovation occurs.

Highlighting Taiwan's decentralized development sets the groundwork for a discussion of innovation and industrial upgrading, by identifying key innovation actors and driving forces. A dominant view in the literature on latecomer economies is that Taiwan's decentralized SME system may have already run its course in the current quest for innovation, and that production, organizations, and resources should be scaled up to capture technological rents. As can be seen in the global value chain literature, it is lead firms, which are usually large firms, that will orchestrate innovation activities and the capture of rents (Amsden and Chu 2003; Gereffi, Humphrey, and Sturgeon

2005; Gereffi 2013). On the other hand, an increasing body of literature suggests that networks of firms will prevail in the current quest for innovation, in light of the transformation that took place in Silicon Valley (this might be termed a continuity thesis). Here, interindustry connections prove to be an advantage. The idea of interindustry learning is pertinent because connecting to different clusters and different supply chains in different industries creates opportunities for the recombination of valuable new information and thus better learning. Having access to multiple, nonredundant information sources is conducive to learning and innovation because moving in different circles connects one to a wider world, whereas a closed network might lead to a locked-in effect (Burt 2004).

Where Do Innovations Come from? A Tale of Two Transformations

Indicators of Innovative Capacities

The following section sketches an overall picture of Taiwan's technological development since 2000. The empirical task here is to identify which sector has been driving Taiwan's innovation and industrial transformation in the past two decades. Over this period, Taiwan, like Japan and Korea, increased its R&D. For instance, in 2001, national R&D expenditures were about 2.02 percent of gross domestic product (GDP), a remarkable increase from 1.7 percent in 1990. By 2006, they were 2.43 percent of GDP, reaching 2.90 percent in 2011 and 3.16 percent in 2016. At the same time, the key spenders on R&D shifted from the public to the private sector. For instance, the government was responsible for over 50 percent of R&D expenditures in 1990; this figure went down to 30.10 percent in 2001, then steadily declined to 28.68 percent in 2006, 23.85 percent in 2011, and 19.66 percent in 2016. In contrast, R&D expenditures by private companies went from 64.86 percent in 2001 to 67.15 percent, to 72.60 percent, to 77.74 percent in the respective periods (see table 5.1).[1] IT industries (including various electronic components, computer and computer peripheral equipment, and semiconductors) continued to consume a large bulk of national R&D expenditures, moving from 40.57 percent in 2001 to 56.64 percent in 2016.[2] In contrast, the metal and machinery industries,

1 The figures are from the National Science and Technology Survey: https://wsts.most.gov.tw/stsweb/technology/TechnologyStatisticsList.aspx?language=E, retrieved March 30, 2018.

2 The data were retrieved from the National Science and Technology Survey and calculated by the author.

TABLE 5.1 Major R&D indicators in Taiwan (in millions of New Taiwan dollars)

	2001		2006		2011		2016	
	Value	Percentage	Value	Percentage	Value	Percentage	Value	Percentage
R&D expenditures	204,974	100.00	307,037	100.00	414,412	100.00	541,360	100.00
Funds from business enterprise sector	132,950	64.86	206,177	67.15	300,874	72.60	420,873	77.74
Funds from government	61,702	30.10	88,044	28.68	98,840	23.85	106,444	19.66
Funds from university fund	6,636	3.24	8,399	4.07	9,624	3.20	8,991	2.14
Funds from higher education sector	2,719	1.33	3,257	1.06	3,918	0.95	3,590	0.66
Funds from private nonprofit sector	931	0.45	1,071	0.35	1,007	0.24	995	0.18
Funds from abroad	35	0.02	91	0.03	148	0.04	466	0.09
R&D expenditures as a percentage of GDP								
(R&D expenditure/GDP)	204,974	2.02	307,037	2.43	414,412	2.90	541,360	3.16

	2001	2006	2011	2016
R&D expenditures by industries' manufacturing sector (aggregated)				
Total R&D expenditures	119,898	190,744	278,669	384,701
R&D expenditures/sales (%)	—	1.21	1.60	2.36
R&D expenditures/national R&D expenditures (%)	58.49	62.12	67.24	71.06
IT industries				
Total R&D expenditures	83,164	143,884	218,719	306,646
R&D expenditures/sales (%)	—	5.53	8.73	13.88
R&D expenditures/national R&D expenditures (%)	40.57	46.86	52.78	56.64
Metal and machinery sector				
Total R&D expenditures	19,052	25,896	31,440	38,703
R&D expenditures/sales (%)	—	4.24	5.11	5.86
R&D expenditures/national R&D expenditures (%)	9.29	8.43	7.59	7.15

SOURCE: National Science and Technology Survey, Taiwan, https://wsts.most.gov.tw/stsweb/technology/TechnologyStatisticsList.aspx?language=E.
NOTE: GDP = gross domestic product; R&D = research and development.

constituting less than 10 percent of national R&D expenditures, went from 9.29 percent in 2001 to 7.15 percent in 2016.

Using patents as a proxy for innovation and technological capacities, Taiwan has consistently ranked fifth—as measured by the number of patents among all countries filed at the U.S. Patent and Trade Office (USPTO)—since 2000. The total number of patents increased from 4,667 in 2000 to 6,128 in 2008 to 8,781 in 2011 to 11,690 in 2015. According to patents filed at the USPTO, the semiconductor industry (under the IT sector) has been the key patent generator among all industries from Taiwan (and also South Korea). Yet at the individual firm level, the Taiwan Semiconductor Manufacturing Corporation (TSMC), Taiwan's top generator of patents awarded by the USPTO, contributed 7 percent of Taiwan's total patents in 2007 and about 15 percent in 2015.[3] At the same time, the top ten patent-holding organizations are from the IT sector, and half of them are semiconductor industries, but they constituted only 41 percent of patents within the IT sector and about 24 percent of Taiwan's total patents from the 2000–07 period (Wang 2010, 297).

To sum up, the IT sector has continued to be the key driver of Taiwan's innovation in the past two decades, according to the indicators of R&D expenditures and patents. Looking at patent distributions, IT innovation activities continue to be relatively diffused across firms in the IT sector when compared to South Korea, where Samsung Electronics prevails. That company alone created about one-third of the USPTO-registered patents coming from Korea in 2015.

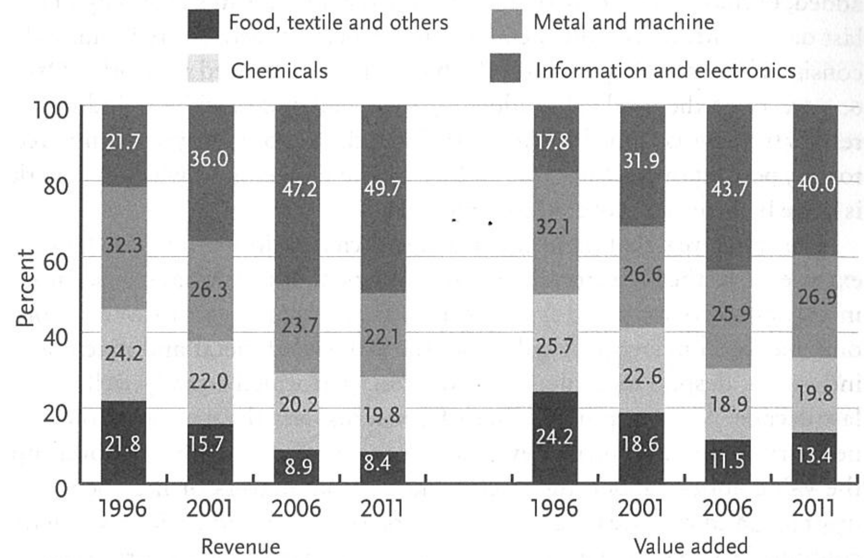
Sectoral Transformation Reconsidered, 1996–2011

Employing industrial and commerce census data,[4] figure 5.1 presents the transformation in Taiwan's manufacturing sector from 1996 to 2011, a period when Taiwan allegedly went through major restructuring, both economically and politically. Conventionally, this period is associated with the dominance of high-tech IT exports as a key driver of Taiwan's economy, replacing labor-intensive industries. There was increased internationalization of production by Taiwanese firms through an arrangement called "triangle manufacturing," whereby transactions between foreign buyers and Taiwanese producers were conducted in Taiwan, while the final products, ranging from those of light industries to IT production, were exported through another country, for example, from offshore factories in China and Vietnam. Lastly, large firms gained an increasingly strong foothold in the manufacturing sector.

3 The patent figures are from USPTO (2000, 2007, 2011, and 2015). The percentages were calculated by the author.

4 The data from the 2016 industrial census had not been released as of the date of this writing; the discussion is therefore based on data collected from 1996 to 2011.

FIGURE 5.1 The contribution of revenue and value added of the four major industries in Taiwan's manufacturing sector



SOURCE: Directorate-General of Budget, Accounting and Statistics. Industry, Commerce and Service Census Taiwan-Fukien area, the Republic of China, 1996–2011, https://wsts.most.gov.tw/stsweb/technology/TechnologyStatisticsList.aspx?language=E.

The industrial and commerce census data reveal that the IT sector created the most revenue and value added in Taiwan's manufacturing sector, constituting almost 50 percent (49.7 percent) in 2011, up from 21.7 percent in 1996. This sector generated 40 percent of the total value added in the manufacturing sector, up from 17.8 percent in 1996.[5] In contrast, the aggregated metal and machinery industries made up 22.1 percent of revenue in the manufacturing sector but generated over 26.9 percent of the total value added in the manufacturing sector in 2011 (see figure 5.1). Examining the composition of the industries within the IT sector, the picture looks slightly different. The semiconductor industry constituted 6.2 percent of the total revenue of the manufacturing sector in 2011 but generated 17 percent of the manufacturing sector's total value added. In contrast, computer and computer peripheral equipment industries gobbled up 26.5 percent of revenue in the manufacturing sector but created only 5.6 percent of the value added. In other words, the metal and machinery industries (26.9 percent of the total

5 The value added is calculated as total gross output minus intermediate input consumption. Basically, it is about the value created by the economic activities undertaken by each firm. The reason that the computer and peripheral sectors generated much revenue but low value added is partly a result of triangle manufacturing, where the value created for the Taiwanese parent company relates only to the outsourcing processing fees.

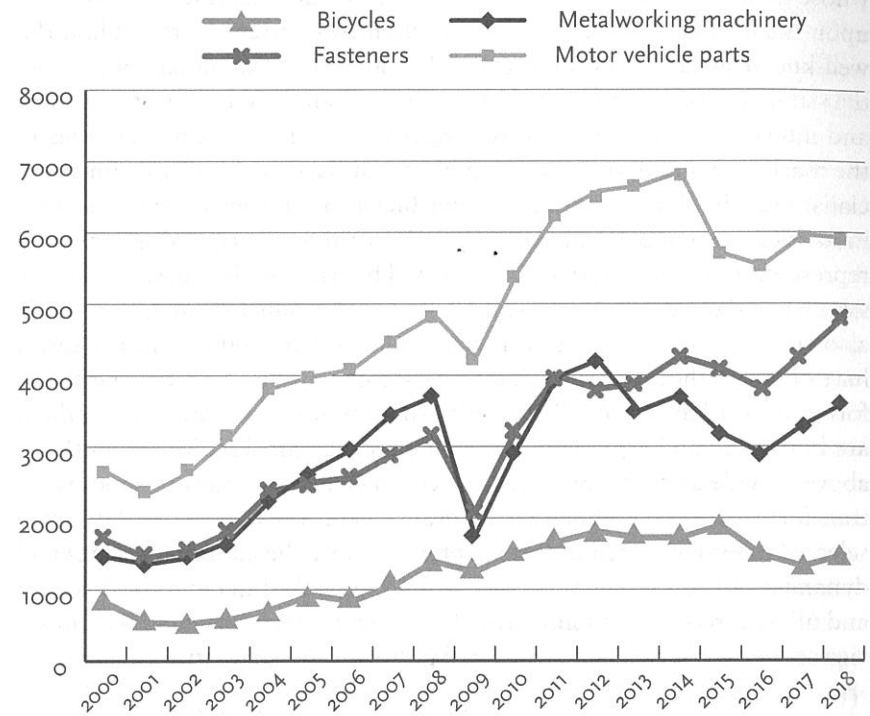
value added) performed as well as the IT sector (23 percent of the total value added, excluding the semiconductor industry) in Taiwan's economy in the last decade. Moreover, the metal and machinery industries predominantly consist of SMEs and operate on the basis of decentralized networks. Over 60 percent of the total value added by the metal and machinery industries results from work done by firms with fewer than 200 employees, compared to 78.5 percent of the total value added by the IT sector, in which the work is done by firms with over 500 employees.[6]

The data reveal that the acclaimed high-tech transformation based on the experience of the IT sector distorts the understanding of what has occurred in Taiwan's economy, and that this sector's contribution to Taiwan's economy has been misrepresented. Also, the SME-based metal and machinery industries, despite receiving less attention, performed equally well in the last decade. Moreover, in the face of concerns over the demise of the SME network system, empirical evidence suggests that SMEs have moved up the value-added ladder and become key global players or indispensable upstream and midstream global suppliers for several industries. SMEs have continued to be strong exporters, including of parts; and export diversification has been integral to upgrading strategies. Export-oriented industries like bicycles, machine tools, auto parts, and fasteners have continued to be strong exporters, and statistics suggest that total export values doubled or even tripled in the last decade, as illustrated in figure 5.2. Moreover, parts suppliers have been strong exporters by inserting themselves into various global production networks, as exemplified by the increasing export shares of bicycle parts, auto parts, and fasteners. Lastly, unlike European industrial districts that went into decline in the face of globalization and from Asian competition in the 1980s, Taiwan's clusters and accompanying decentralized network-based production have continued to be resilient locally, even with internationalization. Central Taiwan has continued to be the hub for the domestic machine-tool industry as well as the bicycle industry and related machinery parts; Hsinchu has continued to be the hub for the IT industry, the semiconductor industry, and IT-related industries; and southern Taiwan has continued to be the hub for steel- and metal-related industries.

In short, SME-based entrepreneurship has continued to thrive and has played an important role in Taiwan's quest for an innovative economy. If one invokes the conventional proxy (i.e., patents) used to measure innovative or technological capacity, this reaffirms the relative importance of the machinery industry in driving Taiwan's transformation over the past decade. Three

6 The data on the transformation of the manufacturing sector are drawn from Hsieh (2014).

FIGURE 5.2 Export value of selected subindustries, 2000–18 (US$ millions)



SOURCE: Bureau of Foreign Trade: http://cus93.trade.gov.tw/fsci.

of its subindustries—machine tools, transportation equipment, and sports equipment—also ranked among the top ten patent-holding subindustries in Taiwan (Wang 2010, 301). The fact that half of patent holders in Taiwan's machinery industry were registered as individuals as opposed to organizations suggests that SMEs have continued to be sources of innovation.

Sources of Growth in the Celebrated IT Model vs. the Less-Celebrated SME Ecosystem

Taiwan's SME-based decentralized network production is conventionally perceived as growing independent of the state, contrary to the celebrated IT model, in which the Industrial Technology Research Institute (ITRI) and the government have been considered the key drivers of technological development and diffusion.

In what follows, I compare and contrast the organizational principles of the two ecosystems, with special attention to the less-celebrated model, whose merits are underexplored. The data for the celebrated model build upon the extensive research that has arisen from attempts to explain the well-known achievements of Taiwan's IT industries. The sources of data for the SME-network ecosystem include my more than fifteen years of fieldwork and interviews with various actors related to manufacturing activities in the machinery industry, from assemblers and parts makers to various specialist firms in bicycles, auto parts, machine tools, fasteners, and hardware industries to engineers in public research institutes (PRIs) and government representatives. The interviews conducted focused on the question of how SMEs have adapted their processes so as to retain production in Taiwan while also successfully ascending to higher-value-added production. Because I have observed these cases over a long period of time and tracked their transformations, I have been able to verify that the lessons gleaned from them are both valid and representative. While the statistical indicators outlined above provide an overview of the structural changes in Taiwan's industrial transformation and technological advancement, the qualitative data from selected interviews cited in this chapter illustrate the common themes and dynamics of the learning processes, centering on the interactions of actors, and allow a reconstruction of the worldview of entrepreneurs. The interviewees presented carefully considered positions and qualitative evaluations.[7]

The Celebrated IT Ecosystem Model

The transformation of the IT sector in Taiwan is often attributed to the role of the state in creating new industry. The Hsinchu Science-Based Industrial Park (HSIP, established in 1980) is a prominent example of a government-created cluster, where most IT-related high-tech firms and start-ups are located. The region—with its connections to California and its similar dynamism—is often thought of as the Silicon Valley of the East. Yet, Shih, Wang, and Wei (2007) point out that a crucial difference between HSIP and Silicon Valley is the pivotal role of PRIs as the driving force for technology creation and diffusion. In particular, ITRI (established in 1973), located close to HSIP, plays a pivotal role in developing integrated circuit (IC) technologies and creating spin-off firms. Therefore, the public-private linkages and the IT high-tech cluster in the Taiwanese context center on the role of state-funded research institutions, such as ITRI, and their collaboration with the private sector. And these are often invoked in accounts of Taiwan's success in moving to high-tech industrialization (Wang 2010; Amsden and Chu 2003; Chen 2003; Shih, Wang, and Wei 2007; Fuller, Akinwande, and Sodini 2003; Breznitz 2007). Most of the narratives have agreed that a functional division of labor between the state and industry players contributed to the ascent of Taiwan's IT sector. Unlike what occurred in Korea's IT sector, where large firms such as Samsung and LG did much of the technology acquisition and development, Taiwan relied on PRIs such as ITRI to acquire and absorb new technologies and conduct most of the R&D, especially initially. In turn, ITRI introduced needed technologies, through technology transfer, to the private sector or spin-off firms (Shih, Wang, and Wei 2007).

The other key element of technology diffusion was through the movement of Taiwanese returnees from Silicon Valley to ITRI and to HSIP companies, and personnel moving from ITRI to the private sector.[8] The latter, for example, have constituted an important channel for technology diffusion. Of the more than 16,000 employees who have trained at ITRI since 1973 and subsequently left, 81 percent have gone on to private industry, with more than 5,000 going on to HSIP, especially in the semiconductor and computer peripheral industries (Shih, Wang, and Wei 2007, 111). Job mobility from ITRI to the private sector differentiates ITRI significantly from its Korean and Japanese counterparts, where mobility between researchers in PRIs and the private sector remains limited (Interview Lee 2015; Hashimoto 2013).[9]

While ITRI played a pivotal role at the initial stage of technology development, the private sector has shifted into the driver's seat over the last two decades, as illustrated by the rise and growth of numerous IT companies in HSIP and by the aforementioned R&D indicators. Nevertheless, ITRI has continued to be R&D intensive and plays an important role in Taiwan's high-tech development and dissemination. For instance, it has ranked fourth in patents granted by the USPTO among all Taiwanese organizations over the past two decades. Meanwhile, since the mid-1990s, collaborations between ITRI and the private sector have evolved from an earlier approach of PRIs leading most of the research, and a technology spin-off model, to a joint collaboration between PRIs and the private sector, with research funding shared by both sectors as a way to push ITRI closer to industry (Wang 2010; Shih, Wang, and

7 My interview sources cited below are roughly anonymized—these citations consist of "Interview" plus the surname of the interviewee and the year the interview took place.

8 For a detailed discussion of the role of linkages between Silicon Valley and Taiwan's IT development, see Saxenian (2006). Shih, Wang, and Wei (2007) write a detailed account of the role of returnees in the origins of Taiwan's IT industry and their involvement in establishing ITRI.

9 In my comparative research of PRIs in Taiwan, South Korea, and Japan, the Korean interviewees remarked that they were impressed with the level of mobility between ITRI and private industries, whereas job mobility and the level of interaction between the Korean PRI and the private sector is much more limited. Researchers at the Japanese PRI also concurred that the interaction between the PRI and the private sector is largely formal and cases of job mobility are rare.

Wei 2007). ITRI has become a technology-supporting institution, playing a role similar to PRIs in the less-celebrated model (discussed below).

While many IT firms started small, many have grown much larger in scale and become leading global players. However, it is important to highlight that the network-based system has persisted even in the IT sector, especially in the semiconductor industry, Taiwan's leader in technological innovation. For instance, firms insert themselves in the semiconductor industry's global production, with many firms focusing on manufacturing application-specific integrated circuits (ASICs), as opposed to mass-producing dynamic random-access memory (DRAM), in which Korea has prevailed. In fact, the creation of pure foundry manufacturing by TSMC,[10] a spin-off from ITRI, in 1987 was an organizational innovation in the industry and from that time established a new business model for the global semiconductor industry (Chen 2003). The presence of TSMC and other specialized foundry manufacturing firms that focused on midstream wafer manufacturing has induced many local IC chip-design SMEs to insert themselves into the value chain by focusing on upstream design. IC chip design firms have proliferated, from 56 companies in 1990 to 140 in 2000, and to over 250 companies since 2003 (ITRI, various years). There are specialized firms focusing on downstream packing and testing. As a whole, firms have tapped into the highly specialized network in HSIP to work closely with related IT industries to develop end products, mostly electronics and IT components. The growth in ASIC chip design and manufacturing has contributed to the scope of IT-related products/components coming out of Taiwan because most IT components require ASIC chips.

The Ecosystem of the Less-Celebrated SME Model

The transformation of the metal and machinery industries raises the question of how SMEs could have performed so well. The adaptation and upgrading of SME-based metal and machinery industries resemble the flexible specialization production capitalism that Piore and Sabel (1984) characterize as a historical alternative to the mass production system associated with modern industrial capitalism. The SMEs in the flexible specialization production system manufacture a wide range of customized products using flexible, general-purpose machines that require skilled labor capable of multitasking and who are adaptive to changing demands (Zeitlin 2008; Sabel and Zeitlin 1997). In this alternative model, firms focus on niche markets and compete in the quality

10 TSMC started as a joint venture between the government and Phillips. The government (through a national development fund) continues to be the second-largest institutional shareholder (6.38 percent), next to TSMC (20.68 percent), with one seat on the board.

segment of the value chain rather than in the price-sensitive segment of mass production of standardized items. Thus, value is added through quality as opposed to efficiency, which is about making things cheaper by producing more of them. On the other hand, the flexible specialization system can be conducive to permanent technological innovation because firms need to redesign products and methods to address growing competition and find new ways to reduce the cost of customized production. This motivation, in turn, encourages technological sophistication and innovation (Piore and Sabel 1984, 207). Often involved are innovations through recombination, such as the reorganization of production, new material applications, innovation in manufacturing processes, the introduction of products to a new market, export diversification, and improvements in the quality of trade.

Contrary to the celebrated model, which attributes responsibility for incubating new technology to the ITRI and the government, Taiwan's SME-based, decentralized industries are often seen to grow independent of the state. For instance, while the state was crucial in orchestrating the formation of the IT cluster, various export-oriented, SME-based industries and clusters in the machinery sector organically evolved in central Taiwan, such as the bicycle industry, machine tools, hand tools, auto parts, hardware, and various machinery accessories. A resilient and vibrant network of SMEs in the metal and machinery industries renewed interest in studying these hidden champions.

The dynamism of the clusters in central Taiwan resembles Marshall's notion of industrial agglomeration and contemporary industrial districts, discussed in the literature in the 1980s and 1990s (examples include Third Italy, southern Germany, and Denmark; see Piore and Sabel 1984; Herrigel 1996; Kristensen 1995). Many interviewees, when asked how they started their business, stated that they worked for firms in similar industries and decided to set up their production focusing on one stage of the production process and supporting others. As one interviewee put it, "You may change jobs, but you never leave the industry" (Interview Chou 2010). Another interviewee's remark captured the role of geography: "All suppliers are within a radius of 60 km and this is how our business operates" (Interview Hsu 2004). The existing network-centered, market-responsive approach suggests that trust and kinship contribute to entrepreneurship as firms spin off in response to the call of export-led industrialization. As the story goes, SMEs successfully connect to the world market and assert themselves in global production networks through original equipment manufacturing (OEM) and respond to demand from buyers (Chen 1994; Hamilton and Kao 2011; Gereffi 1994).

The literature on clusters emphasizes the advantage of agglomeration economies as "collective efficiencies," for agglomeration helps to reach economies of scale. Moreover, trust and cooperation through frequent interactions and kinship account for the flexibility of the clusters and their network-based organizational setup (Powell 1990). Yet, trust and dense ties do not say much about upgrading and capability building. Learning is relevant in understanding innovative capabilities because it induces entrepreneurship and self-discovery/exploration. Self-discovery is largely a problem of complex coordination (Sabel 2012). However, in a context of decentralized clusters, learning can be a problem; decentralization often generates competition and thus diminishes the returns on self-discovery, not to mention that individual SMEs may not have the resources and manpower needed to develop innovation and learning capacities. Therefore, the question is: How do these Taiwanese SMEs learn to improve their quality, given that their R&D expenditure is relatively low (as indicated in table 5.1)? Put differently, how can a system of SMEs build the technical capacities necessary to meet the stringent quality requirements of export markets and succeed in the world market, given their small-scale R&D expenditures and size?

Contrary to a conventional view that assumes that the growth of a network of SMEs is independent of the state, the following section unpacks the black box of learning in a decentralized system. I show how the state could expand the limits of self-learning by addressing collective problems and building external economies and public goods that each individual SME could not realize on its own, so as to induce entrepreneurs to engage in exploration and capability building. This kind of support focuses on an overarching plan to solve collective problems, alleviate the R&D burden of SMEs, and shorten their learning curves to induce firms to engage in complementary learning and investment in a context of decentralized production. It includes a variety of widely practiced but unrecognized initiatives, including manufacturing extension programs, export promotion services, and quality and capability building by the state, that address collective problems and build external economies (public goods) for firms to tap into Taiwan's decentralized setting. Such initiatives have been crucial in accounting for the upgrading of SMEs. In other words, the state builds the hidden infrastructure of those export-led economies that have facilitated SMEs' technology learning and success in the world market. These initiatives are considered hidden infrastructure because they are loosely connected with the economy. Here the role of para-state institutions, such as PRIs (focusing on applied research), are embedded in the ecosystem of the less-celebrated model and serve as the institutional linkages that connect the various actors.

Building an Innovation Ecosystem: Connecting Decentralized Networks of Firms with Public Institutions that Support Technology

The transformation of SMEs in the metal and machinery industries suggests that decentralized, broad, but overlapping ties among different actors were constructed to facilitate learning and establish the quality and technological capabilities needed to succeed in the global market. The actors involved included relatively low-ranked state agencies (such as the Industrial Development Bureau [IDB] under the Ministry of Economic Affairs), engineers from a variety of technology support institutions (such as industry-specific R&D centers, which receive much less funding than does ITRI), industry associations, and SMEs; each actor is connected with the others in multiple ways. Cases from the machinery industry, including bicycles, auto parts, machine tools, and fasteners, illustrate how building capability by constructing cross-cutting ties can help induce export-oriented entrepreneurship and innovation.

The state's quest to upgrade and overcome the problems of decentralized production in SME-dominant industries, starting in the 1990s, can be exemplified by IDB's Program for the Development of Critical Components and Parts. Several industry-specific research centers were established in central Taiwan, where various machinery industries are located, including the Automotive Research and Testing Center (ARTC), the Bicycle R&D Center (BIRDC), the Precision Machinery Research and Development Center (PMC), the Plastic Industry Development Center (PIDC), and the Footwear Technology Research Center (FTRC). These industry-specific R&D centers are considered public-private partnerships, since funding comes from both government and industry, and board members include firm representatives, Ministry of Economic Affairs' representatives, and university professors. IDB's programs in the 1990s stressed that assistance and research should be more responsive to the private sector and practically applicable. Despite an initial goal to develop critical components and parts, studies have revealed that services (such as establishing industry-specific testing labs) that provide external economies applicable to all firms in an industry do the most to help firms move up to a higher-value-added trade segment in the global market. So do services that bridge production networks and facilitate cross-industry fertilization to help induce entrepreneurship and innovation through recombination.

Providing External Economies and Fostering Collective Problem Solving

The aforementioned industry-specific R&D centers build internationally accredited independent/professional R&D testing labs for each industry and provide testing and certification of products for designated markets. These services have been fundamental (though their effect is often underestimated) in fostering R&D for SME's high-value-added production and export diversification, and in meeting the stringent quality control standards of advanced economies.[11]

R&D-related testing has been crucial in solving problems related to complex product development and is fundamental to innovation. The services provided by industry-specific R&D centers and the Metal Industries Research and Development Center (MIRDC) have encouraged self-discovery and learning by inducing firms to explore more creative ways to develop their products than they might otherwise have undertaken. Engineers of industry-specific R&D centers see their research labs as functioning to entice firms into exploratory research and to disseminate the knowledge gained. The following remarks by an interviewee capture the necessity of collective problem solving provided by an industry R&D center:

> SMEs tend to expect the industry R&D center to solve collective problems.... You can consider the PMC as a place to incubate technical skills and a think tank for collective problem solving. For instance, we provide training of skilled technicians for new technologies, disseminate those technologies and develop new testing methodologies as technologies evolve. It is like sowing seed. (Interview Chan 2011)

The testing services of industry R&D centers can also mitigate undue risks because firms can take advantage of their testing facilities without having to make unnecessary investments. One interviewee reiterated the importance of working with research labs like the MIRDC, as it bypasses the limits of self-learning: "It is imperative that we work with the R&D lab at the stage of product development because we can use their facilities for testing, so we don't have to invest in testing equipment in advance for something that we don't even know is going to work" (Interview Lee 2010). The following remark by another interviewee highlights the necessity of collective technology support services to shorten the learning curve and induce exploration:

> You can't just tell them to buy advanced equipment that, for all they know, might not even work. No SME owners dare to break their banks to purchase advanced technological equipment unless they are certain this will work. Moreover, exploring this new technology may involve a lengthy self-learning curve. This is why I urge the association to purchase the machine so that we can explore it together. Without these kinds of collective technology support programs, no one is going to try new things out. (Interview Wu 2016)

Each industry R&D center has built a database of worldwide industrial standards for its export-oriented industry and specific testing methodologies. These are used to not only certify the testing results but also provide feedback regarding improvements and solutions. They foster collective problem solving, such as in testing and standards compliance, have alleviated the burdens of SMEs by reducing entry barriers for exports, support R&D, and bolster SMEs' place in the world market. For instance, even though Taiwan does not have a strong auto assembly industry, it has developed a vibrant and export-oriented auto parts industry in which component suppliers have successfully inserted themselves into the global supply chain as aftermarket suppliers in the U.S. and European markets. Having access to collective testing facilities provided by ARTC in central Taiwan facilitates such entry into global markets. A veteran engineer at PMC acknowledged that one of the R&D center's first tasks was to develop testing technology that would enhance quality and innovation in the machine tool industry (Interview Huang 2011). Compliance with CE standards (for products sold in the European Economic Area)[12] and the U.S. Fastener Quality Act in the 1990s were crucial for machinery exports and metal products like fasteners and hardware. The PMC and MIRDC proactively responded to potential changes in export market standards, and studied and disseminated the changes needed for testing methodologies and manufacturing methods for the machine tool industry and fasteners to ensure that firms were not shut out of the export market (Interview Chan 2011; Lin 2013). MIRDC established internationally accredited testing and research labs for various small-metal industries, such as for fastener testing or plumbing research and testing. All industry R&D centers actively study and follow the changing regulations and acts of the designated export market, as these changes might affect new material applications, new manufacturing technologies, and involve new testing methodologies.

Having access to industry-specific R&D centers and labs in central Taiwan means that SMEs, especially parts makers, can tap into the external economies provided by public technology support agencies, whereas an individual SME is unlikely to be able to function effectively on its own. This is particularly the case where these SMEs thrive in a niche market in which each export

11 Interviewees from the metal hardware and bicycle industries reiterate the importance of meeting industrial standards for export markets because these items belong to a niche market in which European countries and the United States may have completely different specifications and standards (interview info).

12 European safety standards demand that goods entering the European Union meet the requirements of applicable European Commission regulations and directives. They came into effect in 1995.

destination may require different specifications and standards. The result has been export diversification among SMEs in the machinery industry and transportation sector. For instance, in the past decade, about half the total exports went to the top five destinations in the aggregated transportation industries, while over one-third of the total exports went to destinations outside the top ten countries. In the machinery industry, over 50 percent of the total export value went to countries outside the top ten export destinations, while the top five export destinations received less than 50 percent of the total exports (Hsieh 2014).

Inducing Innovation and Entrepreneurship through Cross-Cutting Ties

As discussed, a key feature of Taiwan's decentralized network production is that firms have multiple channels of access to information. Yet decentralization requires coordination to turn access to information into enhanced capability and innovation without producing chaos. Public technology support agencies can induce firms to explore possibilities in complementary areas by bridging different networks and resources. They connect SMEs from various production networks and facilitate cross-industry fertilization, through which innovation and breakthroughs occur by recombining existing means. In other words, innovation occurs when technology and knowledge diffusion induce collaboration in exploring possibilities.[13] The following examples of the technology support offered by the MIRDC and industry-specific R&D centers illustrate this.

Industry R&D centers help to develop and disseminate particular manufacturing technologies by working with SMEs to improve the entire supply chain for a specific technology, including through fostering locally built equipment. In fact, technology adaptation and breakthroughs often occur at the level of intermediate input (meaning the parts subindustry) and work upward and downward along the supply chain to create backward linkages.[14] For instance, in an initiative to apply hydroforming manufacturing technologies to bicycle tubes, the MIRDC first developed locally built equipment for manufacturing this technology, although the technology was initially applied in heavy industries with equipment acquired from Germany. The MIRDC formed a research consortium and connected firms from different production networks, including materials suppliers, mold-making specialists, processing specialists, equipment builders, bicycle-tube makers, and bicycle assemblers. The MIRDC engineer responsible for the project explained that the rationale for bringing other industries on board to develop a particular technology is to broaden the application of this technology and encourage technology spillover. He observed: "Once we can build the equipment for this manufacturing technology locally at a modest cost that fulfills the functions, we are able to induce others to apply this new production technology. We then broaden the impact of [the] application of this technology" (Interview Chung 2016).

A-Team, an alliance within the bicycle industry established by two leading assemblers and parts suppliers in the 2000s, is an example of the industry's collective effort to move to high-value-added production and sustain a cluster in Taiwan—when the industry faced a potential hollowing-out crisis after a number of firms migrated to low-wage countries. This case exemplifies how innovation in a decentralized setting involves collaborative learning and the bridging of networks. One of the first tasks in A-Team's upgrading process was to adopt the Toyota Production System (TPS, a just-in-time system) for bicycle production. When asked whether the alliance was an attempt at supply chain integration by bringing suppliers into the orbit of leading assemblers, the president of the assembling company stated with no hesitation, "The team was about 'learning,' not about supply-chain integration. They are not our exclusive suppliers" (Interview Tseng 2010). When another leading assembler was asked why his firm invited its competitor to participate in the alliance (it involved team members visiting one another's factories), his response illustrated quite well the problems of coordination in a decentralized network: "Even if we are considered the biggest bicycle manufacturer in Taiwan, we alone could not capture the whole export market, and we need some commitment from other assemblers to induce suppliers to participate" (Interview Hsu 2004). The parts suppliers all gave credit to the advantages of collaborative learning, even though their competitors also participated in the alliance. The members acknowledged that individual firms had considered adapting the TPS and associated methodologies in their own factories, but their attempts had not been successful. The TPS system requires coordination and improvement from the upstream to the downstream of supply networks (Interview Chen 2010).

While SMEs initiated the consortium, IDB acted as a mediator by connecting Toyota Taiwan to the bicycle A-Team for implementing TPS. The IDB officer

13 Hsieh (2015) provides a detailed case study of how breakthroughs in manufacturing technology occur through cross-industry fertilization and collaboration.

14 The following section draws extensively from the case of the bicycle subindustry. This may not be a big component of the machinery industry in terms of the total value added, but its upgrading process is representative inasmuch as it used to be a labor-intensive industry and was expected to be one of the first industries that would migrate completely to low-wage countries, following their European and Japanese predecessors. Contrary to the predictions, the bicycle cluster in central Taiwan has continued to be vibrant, showing no signs of hollowing out. Moreover, its organization of production and its connections to the wider machinery industry are typical of Taiwan's SME network system and, thus, make it a representative case to illustrate their transformation.

in charge of industrial development programs in the machinery industry considered these alliances as sowing a seed, as he explained: "Once these parts suppliers learn the trick they will pass on the information to their downstream suppliers, as they all need to meet the requirements set by the A-Team. We thought to use this to bring about some transformation in the industry, given the limited resources we have"[15] (Interview Yeh 2014).[16] The Bicycle R&D Center also participated in this project and went on to work with other firms (not included in the alliance) in the bicycle industry. These efforts helped the industry to become the key player in the high-end quality segment of the bicycle trade, where the total export values increased almost four times to US$1.9 billion in 2015 from its lowest point of US$0.5 billion in 2002 (see figure 5.2). The average price of a bicycle coming out of Taiwan in 2017 was over US$550 (Free on Board, FOB), up from US$290 (FOB) in 2009 and US$120 (FOB) in 2002, when the alliance was first formed amid serious concerns about declining export values and a hollowing out of the industrial base in central Taiwan.[17] In fact, the resilience and dynamism of the clusters actually persuaded firms that had closed their operations and moved production offshore to return production to Taiwan to tap into the external economies and technological prowess provided by the region.

Subsequently, a similar alliance (M-Team) was introduced into the machine tool industry while exploring how TPS could be applied to that industry and other machinery industries in their quest for quality innovation. Recent efforts to move into advanced manufacturing (or smart manufacturing), such as by exploring Industry 4.0, have continued to run according to these institutional arrangements (Interview Chen 2016). The aim is to promote cross-industry fertilization and build a platform that can connect different industries and industry-specific R&D centers and IDB, even as multiple actors are loosely connected in an ecosystem of machinery clusters.

One might question if these industry-specific R&D centers are in tune with the world market and are capable of connecting suppliers from different fields, since they are not firms competing in the market. This is especially true when the R&D done by PRIs have frequently been criticized for resulting in technologies that have no commercial value or are so advanced that they cannot be easily commercialized when working with SMEs. How could these parastate agencies be able to identify partners for product development and capability building?

15 The implication is that the resources, in monetary terms, could easily be dissipated without making a dent, given the decentralized industrial structure.

16 Other assemblers who were not in the alliance also concur that their parts suppliers who participated in the alliance shared their experience and advised them to speed up their restructuring (Interview Liang 2011).

17 The data are from Bureau of Foreign Trade: http://cus93.trade.gov.tw/fsci.

These case studies reveal that learning and capability do not simply flow from a mentor to mentees, but in both directions. In the case of the A-Team, Toyota Taiwan acknowledged that it learned a great deal from the project. The general manager of Toyota Taiwan, who actively participated in the project, perceived the alliance as an experiment, as Toyota was not sure whether a production system designed for the automobile industry organized in a closed network could be applied to the decentralized/open network production system of Taiwan's bicycle industry. The engineer who coordinated the hydroforming project emphasized that Toyota learned tremendously from working with bicycle manufacturers and, in turn, by applying that experience to working with firms in other industries. Engineers from the MIRDC credit the variety of industrial training, new technology development, problem solving, technology extension, and testing services they provide for connecting them with SMEs in various industries, especially in the parts sector. In particular, testing services provided for various industries have helped them create knowledge and gain access to industries (Interview Chung 2008; Wang 2013; Lin 2013; Kao 2013).

Lastly, not all industrial development programs or research consortia work equally well under the arrangements seen in a decentralized network. For instance, engineers from public technology support agencies acknowledged that projects connecting different PRIs and the machinery industry to explore the application of a new lightweight material, magnesium alloy, fell short because of difficulties in commercialized production presented by the material's highly explosive nature. Nevertheless, each exploration and collaboration is about building technological capabilities, and this was agreed upon by most of the people I interviewed (Interview Chung 2008; Chiang 2011; Cheng 2016).

In the ecosystem of Taiwan's machinery industry, exploring a new technology or the application of new materials often involves trying to find collaborators by connecting firms from upstream material suppliers to downstream final producers and varieties of specialist firms, possibly from different industries, for collaboration and discussion. Most of my interviewees concurred that innovation and product development for SMEs is often about searching for ideas and tapping into external economies in central Taiwan beyond their own industry boundary: "I frequently visited different trade shows, like machine tool industry and even aerospace industry trade shows, to get ideas to see if we can apply some technology to our industry..." (Interview Wu 2016). A senior engineer from the MIRDC illustrated how the dynamics of technology development in Taiwan center on working with networks of SMEs rather than trying to do everything solo:

> I have visited a lot of companies, and I know whom to contact if I am developing a new product/process technology. How can these companies realize the project? We know that their supply networks could assist them (such as numerous specialist firms). When we call the meeting, the companies usually call their suppliers and friends to join the discussion to explore solutions and possibilities. We often end up with a solution beyond my original imagination. (Interview Cheng 2016)

In other words, technology support services and on-site factory visits are not about troubleshooting and top-down assistance, but about exploring manufacturing methods and searching for potential collaborators when new development projects and ideas arise.

These initiatives fly under the radar and are conducive to broad-based entrepreneurship as opposed to the industrial targeting described in literature on the developmental state. The technological support offered by PRIs is not about targeting R&D subsidies to selected, individual firms but about inducing exploration among a network of firms. The responses of my interviewees illustrate these dynamics well. In the interviews, if I asked the question whether they received support from the government, the answer was usually no. But if I reframed the question by asking if they had used the testing services provided by an industry-specific R&D center, the answer was yes. One interviewee said: "I don't think R&D subsidies to individual firms are effective. Instead, it is imperative for the government to construct ties among different industries and the government can establish a platform for firms to tap into" (Interview Wu 2016). Another interviewee thought that his company's participation in the MIRDC's research consortium connecting different industries was about learning: "You asked me how I participated in the project that connects firms across different industries to explore a new manufacturing technology. MIRDC's engineer approached me on this case. It is not really about the amount of R&D subsidies I can get; but as long as there is an opportunity for learning and exploration, I will join" (Interview Chen 2014).

To sum up, in the context of a decentralized industrial system, technology extension services focus on enhancing local spillover effects, integration, and developing the technical capabilities of an entire supply chain as opposed to a top-down technology transfer to selected firms. This explains why, despite relatively low R&D expenditures, a system of SMEs has been able to tap into external economies, and how through recombination and cross-industry fertilization, SMEs have thrived in higher-value-added production chains.

Conclusions and Implications

This chapter takes a network approach to understanding innovation and entrepreneurship. It demonstrates the qualitative aspect of innovation, which often occurs through interactions among different actors (e.g., interfirm linkages). The transformations of Taiwan's SME-based machinery industry suggest alternative possibilities to innovation and prosperity in which collaborative learning and technology diffusion can be conducive to new kinds of entrepreneurship, rather than reliance upon the hefty R&D expenditures of individual firms. These initiatives tend to be invisible and decentralized in the sense that they deploy relatively flattened resources and low budgets. This is contrary to common policy practices that focus on promoting innovation by increasing investment in R&D by focusing subsidies on selected firms, or policies that encourage entrepreneurship by increasing the number of firms in targeted clusters or government subsidies to an increasing number of start-ups, as in Japan and Singapore, respectively. Case studies of innovation clusters using these common practices reveal the poor performance of their firms in terms of both production and technological capabilities—due to a top-down selection process or a decoupling of policies focused on entrepreneurship vs. science and technology (chapters 4 and 6 in this volume; Lee 2000).

Taiwan's less-celebrated model raises a question regarding the proper unit of analysis for studying innovation. This distinction matters because it affects the policy choices for nurturing ecosystems for entrepreneurship and innovation, which entail completely different notions of clustering and ways of constructing cross-cutting ties. In Taiwan's SME network, the unit of analysis is a system comprising networks of firms that complement one another and tap into external economies. Thus, capability building is about (1) bridging different production networks to create technological advancement along an entire supply chain, and (2) sustaining clusters. Success or failure is not measured by the size, number of patents, or performance of an individual firm, but by the viability of the system overall. On the other hand, in a firm-centered innovation system, cross-cutting ties are created in a different way; state agencies connect a variety of governmental resources and PRIs to nurture individual, selected firms. In this case, capability is fostered by bringing different resources to individual firms, as can be seen in the Korean experience of constructing regional innovation clusters (Hsieh 2018).

Lastly, the lessons from the less-celebrated model of Taiwan's machinery industry suggest that what makes a cluster tick is not the size of its firms, but the specific ways in which networks of firms and PRIs are linked in a decentralized system. Each actor is connected in multiple ways to tap into external economies so as to pursue collaborative learning. Even in the celebrated model of the semiconductor industry, firms have continued to tap into decentralized networks to enhance production and spark innovation despite having grown in size and scale. State institutions and a variety of parastate institutions, such as PRIs, are loosely connected in the system; this bypasses the limits of self-learning by bridging different networks to induce collective learning and innovation. This kind of a flexible and dynamic ecosystem is one way for clusters to remain resilient, territorially rooted, and globally connected in the face of globalization.

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CHAPTER 6

Innovative Cluster Policies ·

Evidence from Japan

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Amid the huge wave of globalization in recent decades, trade costs, including tariff and nontariff barriers, have dropped worldwide. Communication costs have also decreased dramatically through the development of information technology. Today, capital and labor are highly mobile across countries and regions. Consequently, the globalization wave has resulted in intense global competition. In order to survive, many developed countries—such as France, Germany, and Japan—have sought to enhance productivity by creating innovative industrial clusters. These build on economic theories and models such as Marshallian externality and Porter's diamond (Porter 2000), which consider industrial clusters as sources of innovation and economic growth.

Regardless of the policies behind them, industrial clusters in reality seem to lack both innovation and success. While it is hard to find a successful industrial cluster, the large variety of subsidy programs inherent to them require high management costs and sufficient budgets. Yet governments have adopted many cluster policies over recent decades without carefully evaluating their viability through econometric analysis. Only recently have such policy evaluations, using microdata from academic research and advanced econometrics to measure the impact of cluster policies on productivity and