A Region-based Business Ecosystem for Industrial Upgrading: Evidence from the Electronics Industry of Shenzhen

by

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Declaration

I hereby declare that except where specific reference is made to the work of others, the contents of this dissertation are original and have not been submitted in whole or in part for consideration for any other degree or qualification in this, or any other University. This dissertation is the result of my own work and includes nothing which is the outcome of work done in collaboration, except where specifically indicated in the text. This dissertation contains less than 65,000 words including bibliography, footnotes and tables and has less than 150 figures.

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Abstract

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This dissertation explores the underlying mechanisms for the upgrading process of the electronics industry in Shenzhen. Industrial upgrading has been an international phenomenon since the globalisation of manufacturing in the late 1970s but to date no comprehensive framework has been proposed for the industrial upgrading in a region. In recent decades, the trend of manufacturing regionalisation and growing uncertainties associated with electronics products in the global market have driven regions that specialise in electronics manufacturing, such as the Chinese city of Shenzhen, to continuously adjust its industrial systems. Such adjustments are mainly based on the evolving business ecosystem they inhabit, which comprises region-specific resources that can be flexibly leveraged by players such as local firms and the government.

To elucidate the interactive mechanisms among actors that facilitate industrial upgrading within the regional business ecosystem, this research integrates and extends the existing literature on industrial upgrading from global and local perspectives and applies a business ecosystem framework to address the main research question and sub-questions:

How does a region act as a business ecosystem to facilitate the upgrading of a region-specific industry?

1. What is the evolutionary pattern of a regional resource pool?
2. How to understand the upgrading of a region-specific industry?
3. How does a regional resource pool interact with regional industrial systems to facilitate industrial upgrading?

In order to answer these questions, a qualitative study on the Shenzhen-based business ecosystem with two streams of embedded cases – electronics companies that have experienced upgrading in Shenzhen and milestone events in Shenzhen's industrial development – was conducted following an inductive approach. After detailed individual and cross-case analyses, the research revealed three main findings. Firstly, the evolution of the regional resource pool is driven by both milestone events throughout the industrial development of the region and local firms' feedback impacts. Secondly, the regional industrial upgrading is an iterative and dynamic process and should be interpreted by adding the regional dimension. At the regional level, there co-exist established industrial systems transformation and new industrial systems emergence throughout the upgrading journey of a region-specific industry. Thirdly, the underlying mechanisms for regional industrial upgrading are enabled by the region-based business ecosystem. A total of eight interactive mechanisms between the regional resource pool and regional industrial systems – four transformation impacts from the resource pool on the industrial system and four feedback impacts from the industrial system on the resource pool – result in an iterative and dynamic co-evolution model that defines the region-based business ecosystem. Theoretically, these findings fill the current scholarly neglect of the fact that a region as a whole can function as a business ecosystem to enhance long-term regional growth through industrial upgrading. In addition to these three main theoretical findings, this PhD research project has a number of practical implications. A mapping tool can be developed for firms or regional governments to use in decision making for industrial development. In addition to the tool development, firms and local government should collaborate following an ecosystem logic to enhance resource strengthening and creation, so as to sustain the regional industrial upgrading.

In summary, this dissertation contributes to industrial systems and business ecosystem literatures in its re-conceptualisation of region-based business ecosystems. By introducing the regional dimension into the research of industrial upgrading, the integrative region-based business ecosystem model enriches our understanding of the co-evolution between the industrial systems and resources in a developing region.

Keywords: Business Ecosystem, Industrial Upgrading, Regional Growth, Co-evolution, Industrial System, Resource Pool, Manufacturing

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Glossary of Terms

BE	Business Ecosystem
CEM	Contractual Electronics Manufacturing
CHTF	China Hi-Tech Fair
CMSK	China Merchants Shekou Industrial Zone
EMS	Electronics Manufacturing Service
Four Asian Dragons	Hong Kong, Taiwan, South Korea and Singapore
GMVN	Global Manufacturing Virtual Network
GPN	Global Production Network
GVC	Global Value Chain
IC	Integrated Circuit
MNC	Multinational Company
NSI	National System of Innovation
OBM	Own Brand Manufacturing/Manufacturer
ODM	Original Design Manufacturing/Manufacturer
OEA	Original Equipment Assembly
OEM	Original Equipment Manufacturing/Manufacturer
PRD	Pearl River Delta
RBE	Region-based Business Ecosystem
RBV	Resources-Based View
RIS	Regional Industrial System
RRP	Regional Resource Pool
RSI	Regional System of Innovation
SEG	Shenzhen Electronics Group
SEZ	Special Economic Zone

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Chapter 1 Introduction

1.1 Research Background

Industrial Upgrading and *Business Ecosystem* are two emerging fields of knowledge explored in this dissertation to understand the mechanisms behind regional urban and industrial development. The phenomenon of upgrading in manufacturing industries has taken places in different countries and regions. Regarding the phenomenon per se, it was first conceptualised by GVC (Global Value Chain) scholar Gereffi as “a process of improving the ability of a firm or an economy to move to more profitable and/or technologically sophisticated capital- and skill-intensive economic niches” (Gereffi, 1999). This implies that industrial upgrading is a process of shifting towards higher value-added[1] activities. Then according to its underlying mechanisms, it was initially classified into four types as process, product, functional and chain or intersectoral upgrading (Humphrey & Schmitz, 2002), with three more types identified later as entry in the value chain, backward linkages upgrading and end-market upgrading (Bamber, Fernandez-Stark, Gereffi, & Guinn, 2014). Although this categorisation covers all possible pathways that firms could take to upgrade their industrial systems at any phase during their development, it is not sufficient to understand the upgrading process of a region-specific industry. This is because in reality industrial upgrading in a region is a continuous process with iterations of industrial systems embedded within the changing regional socio-economic systems. On the one hand, there is a wide range of industrial systems owned or controlled by companies within a region-specific industry, for instance industrial systems of mobile phones, tablets, components etc. within an electronics industry. On the other hand, the regional socio-economic systems can be understood as a huge regional resource pool with various types of localised resources that can be utilised by local industrial systems for business value creation. Regional resources can be conceptualised as four main types, namely material resources, knowledge, power and social capital (Bathelt & Glückler, 2005) and region-specific resources indicate contextuality, difference and contingency for economic development (Bathelt & Glückler, 2003; Glückler, 2007; Sayer, 1991). Thus, it is necessary to employ a framework

[1] Throughout this thesis, value-added is used as an adjective to describe a process that increases the value of a product or service.

linking both industrial systems and regional resource aspects for the analysis of regional industrial upgrading. Business ecosystem, a complex business community with interdependent actors co-evolving with each other for business value creation around an innovation (Moore, 1993, 1996), affords an opportunity to examine industrial upgrading more comprehensively. Therefore, a region-based business ecosystem framework can be developed for the understanding of regional industrial upgrading in a dynamic and systemic way.

Shenzhen is unique in terms of its development path and geographic location. The dramatic transformation of Shenzhen from a small fishing village to China's "Silicon Valley" in only four decades provides unprecedented rich experience in upgrading local industries, especially the electronics industry which acts as one of its economic engines and now has a global impact.

First and foremost, Shenzhen was established as a SEZ (Special Economic Zone) in 1980, which marked the reform and opening up of the Chinese mainland. Being an experimental field, endeavours have been made by local government officials in attracting foreign investments. Guided by the market principles, Shenzhen managed to embark on a journey of industrial development based on foreign capital, local land and labour. With the gradual establishment of modern institutions, including pricing, payment, land and housing systems, more enterprises outside the mainland and multinational companies chose to locate their businesses in Shenzhen, among which enterprises from Hong Kong played an important role.

Located at the east coast of the PRD (Pearl River Delta) and bordering Hong Kong, Shenzhen was endowed with exceptional advantages in terms of channels for importing production materials and exporting manufactured goods, which greatly facilitated its economic growth. Moreover, access to the latest information from the international market enabled manufacturers in Shenzhen to timely adjust their production plans so as to meet the changing demands.

Such characteristics of Shenzhen in its early developmental phase allowed local manufacturers to grow rapidly, especially those in the electronics industry that also took advantage of the industrial transfer from four the Asian Dragons to China since the late 1970s. Beginning with contractual manufacturing for foreign enterprises, local electronics firms accumulated experience and laid the foundation for the industry to root and grow in Shenzhen. Then with progressive improvement in indigenous technological, managerial and operational capabilities throughout the past 40 years, Shenzhen's electronics industry has continuously played an essential role in not only the local economy but also the world market and international trade. Therefore, Shenzhen and its electronics industry provide a distinctive sample in mainland China to reveal the whole evolutionary process of a region and the region-specific industry from emergence to later-on development. Hence, Shenzhen can serve as an ideal test bed for the study of a region-based business ecosystem for regional industrial upgrading. This proposition leads to an overarching research question:

How does a region act as a business ecosystem to facilitate the upgrading of a region-specific industry?

1.2 Research Objectives

In order to answer this research question, this study sets the following objectives:

- To identify the changes in the types of resources throughout the evolution of the regional resource pool
- To understand the upgrading patterns and mechanisms for a region-specific industry
- To define a region-based business ecosystem from an evolutionary perspective

Shenzhen is a region that transformed from a fishing village with poor local resources and weak industrial systems to a modern metropolis with an abundant resource pool and flourishing industries in four decades. From the evidence of local resource development and the electronics industry upgrading, it sets a great example in driving the co-evolution between local resources and industrial systems. This thesis aims to reveal the interactive mechanisms of such a well-functioning business ecosystem at regional level, which has limited generalisability but implies that other developing regions may be able to pursue industrial upgrading by applying similar strategies. More specifically, other regions in mainland China that are under the same political and institutional context as Shenzhen can activate and utilise their corresponding ecosystems based on local resources and industrial systems.

1.3 Thesis Structure

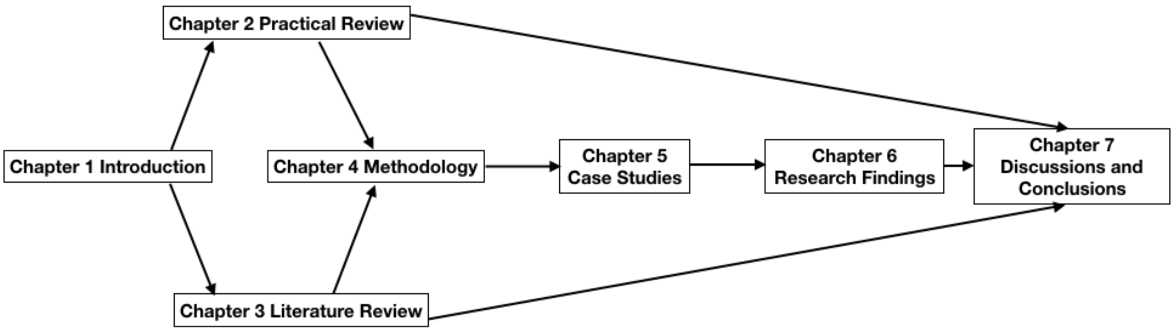


Figure 1-1 Thesis Structure

The thesis is structured as shown in Figure 1-1: Chapter 2 outlines the importance of Shenzhen's electronics industry in regional development and explains how the city serves as the motivation for this research. Chapter 3 examines the literature concerning industrial upgrading and business ecosystem, identifying a number of research gaps along the way. Chapter 4 presents the customised methodology to address the proposed research questions, justifies the philosophical position which determined the choice of research methods, and outlines the data collection and analysis procedures. Chapter 5 comprises six event cases and six company cases embedded in the development of Shenzhen. For event cases, the preparation, launch and impact of each event are examined to show the evolution of regional resources from case synthesis. For company cases, their upgrading paths over time are identified and the co-evolution processes between regional industrial systems and resources are revealed via cross-case analysis. Chapter 6 summarises the findings from the case studies and integrates them into a conceptual model of region-based business ecosystem. Chapter 7 provides a summary of the research findings and discusses the implications of these findings, with future research opportunities suggested.

Chapter 2   Practical Review

"The development and experiences of Shenzhen have proved the correctness of our policy on the establishment of Special Economic Zones." – Deng Xiaoping, January 26, 1984

2.1   The Industrial Development of the Pearl River Delta (PRD) Region and the Leading Role Played by Shenzhen

2.1.1 Background

Located in in Guangdong Province in Southern China, the PRD is now known as one of the largest urban areas in the world, within which Shenzhen has been frequently mentioned as China's "Silicon Valley" for its industrial development and innovation. The PRD consists of nine prefecture-level cities and borders Hong Kong and Macau (see Figure 2-1). Before the handovers to China and they became two SARs (Special Administrative Regions) in 1997 and 1999 respectively, these two areas (especially Hong Kong) act as key foreign players in boosting the PRD's economy by setting up manufacturing plants.

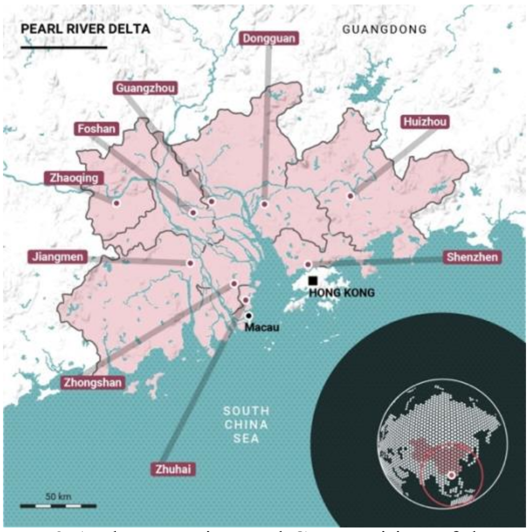


Figure 2-1 The Location and Composition of the PRD

(Source: We Build Value Digital Magazine)

Table 2-1 Number of Industrial Enterprise in the PRD Cities

(Source: Guangdong Statistical Yearbook 2018)

City	Number of Industrial Enterprises above Designated Size (unit)								
	2000	2005	2010	2012	2013	2014	2015	2016	2017
Guangdong Province	19695	N/A	53418	N/A	N/A	41154	42134	42709	47224
Pearl River Delta	15322	28681	41441	29130	31680	31212	31765	32202	36500
Shenzhen	1834	5214	8249	5835	6523	6355	6539	6627	7943
Dongguan	1663	4504	5899	4526	5361	5377	5688	5869	7669
Foshan	2180	5148	7684	5950	6163	5883	5787	5671	6212
Guangzhou	4531	5240	6969	4373	4811	4767	4644	4660	4661
Zhongshan	1074	3291	5063	3192	2973	2963	3045	3089	3211
Huizhou	689	1243	1853	1430	1702	1815	1893	2140	2366
Jiangmen	1599	2365	3246	1851	2007	1961	2036	1998	2112
Zhuhai	771	992	1347	927	1054	1008	1023	1048	1163
Zhaoqing	981	684	1131	1046	1086	1083	1110	1100	1163

Table 2-2 Gross Industrial Output Value of PRD Cities

(Source: Guangdong Statistical Yearbook 2018)

City	Gross Industrial Output Value (100 million yuan)								
	2000	2005	2010	2012	2013	2014	2015	2016	2017
Guangdong Province	12480.93	N/A	85824.64	N/A	N/A	119713.04	124649.16	133768.04	135722.42
Pearl River Delta	10694.83	31614.71	72102.70	79954.57	90691.47	97830.61	101645.70	108960.64	112644.06
Shenzhen	2566.93	9867.55	18526.82	21363.05	23095.21	24777.59	25542.44	27292.29	32119.15
Foshan	1560.55	4780.88	14527.47	14653.96	17121.88	18796.65	19544.95	21187.32	21015.53
Guangzhou	2568.57	6032.05	13831.25	14857.09	17192.88	17997.97	18424.73	18906.55	17751.17
Dongguan	914.64	3940.11	7739.09	9492.55	11023.45	12133.71	12744.42	14692.46	17628.53
Huizhou	657.83	1428.66	3905.17	5477.28	6605.29	6901.35	7044.73	7617.34	8166.93
Zhongshan	532.95	2221.45	5023.63	5702.16	5673.75	6032.09	6345.28	6614.80	4916.88
Jiangmen	871.15	1453.25	3828.91	2519.47	3107.86	3625.49	3998.76	4274.38	4161.11
Zhuhai	630.17	1569.56	2976.18	3072.56	3460.86	3702.26	3966.02	4353.38	3943.56
Zhaoqing	392.04	321.20	1744.19	2816.44	3410.29	3863.50	4034.37	4022.12	2941.20

As Tables 2-1 and 2-2 show, the PRD accounted for most of the industrial development of the province. Among these nine PRD cities, Shenzhen is now ranked as the highest in terms of number of industrial firms and output value. As China’s first Special Economic Zone (SEZ), Shenzhen was granted flexibility in policy making and independence on trading in 1980, and as a coastal city neighbouring Hong Kong, the city was able access to the latest global market information and thus became the pioneer in receiving industrial transfers from the outside world.

2.1.2 Phases of Industrial Development in Shenzhen and the PRD

With Shenzhen playing the leading role, the industrial development of the PRD can be broadly categorized into three phases:

1978-1995

With China's economic reform initiative in 1978, the PRD region in Guangdong was chosen as an experimental field for opening up to global business activities. In 1979, the National People's Congress approved the "Law on Joint Ventures Using Chinese and Foreign Investment", marking the fact that a legal framework for Foreign Direct Investment (FDI) had been established in China. In the same year a strategy called "three plus one trading mix" ("San Lai Yi Bu" in Chinese) was applied in the PRD to attract foreign investors. "Three" refers to manufacturing with given raw materials, processing with given samples and assembly with supplied components while "one" stands for the compensation trade where machinery and equipment are supplied by foreign investors for products to be manufactured in China. This initiative facilitated Hong Kong and foreign enterprises to set up factories in the PRD region, especially in Shenzhen and Dongguan. As a result, a contractual manufacturing model emerged in the PRD and export-oriented manufacturing industries began to flourish.

SEZs were established in southern China to experiment with "special policies and flexible measures". Among these SEZs, Shenzhen was the only one within the PRD. Extensive legal and administrative power was given to Shenzhen to manage FDI and it also received a wide range of incentives and supporting facilities from the central government. With preferential policies, local enterprises were motivated to enhance efficiency. The geographical proximity to Hong Kong and Macao enabled Shenzhen and other cities within the PRD to undertake industrial transfers with traditional manufacturing sectors from these two areas and successfully establish the "front shop, back factory" model. At the same time, the wave of import substitution of household appliances created opportunities for the PRD, and production lines and components introduced from overseas greatly enhanced the development of local light industry. With an abundant supply of cheap labour, local manufacturing bases were formed for labour-intensive light industry, and products such as electric fans, washing machines and fridges were sold on the domestic market and also exported to foreign countries and regions.

In the early 1990s, Taiwanese enterprises started to transfer their manufacturing sites to the PRD, specifically to Shenzhen, Huizhou and Dongguan. Again, this industrial transfer process benefited both sides and the PRD learned from Taiwan about producing electronic goods. Although during that period the production was mainly labour-intensive assembly, it helped the PRD to establish a foothold in the world market and subsequently start to increase its market share. Deng Xiaoping's southern tour of China in 1992 was a key milestone in the development of the PRD. During his visits to Shenzhen, Zhuhai and Guangzhou, he encouraged Guangdong to modernize and catch up with the "Four Asian Tigers" in twenty years. By the end of 1992, about 20,000 FDI projects had been set up in Guangdong and local manufacturing activities were further enhanced. Following Deng's suggestion, the Guangdong provincial government established the PRD Economic Zone in 1994, and one year later it released the "Modernisation Plan for the PRD Economic Zone (1996-2010)", aiming to further enhance the regional competitiveness in terms of industrial capabilities.

Since then, foreign investments and exports have become the main driving forces behind local economic growth in mainland China and specialized industrial clusters were gradually formed in the PRD to serve both foreign and domestic markets. Companies from Japan, South Korea, the US and European countries began to transfer their manufacturing branches to the PRD due to the cost advantages offered by doing so. The secondary industry of the PRD gradually moved towards skill-intensive manufacturing as products became more diversified and complex. This shift was accompanied by the burgeoning Chinese telecommunication equipment companies in Shenzhen from the mid-1990s onwards and the rise of Guangzhou as the centre for vehicle manufacturing via cooperating with Japanese companies such as Toyota.

All opportunities were accompanied by potential threats. In 1994, the municipal government of Shenzhen noticed the stagnation of economic growth and environmental pollution in the city caused by the heavy reliance on low-end manufacturing. Although the 3+1 trading mix strategy still contributed significantly to local GDP, the government realised that fully depending on this manufacturing model was unsustainable. Instead of being locked in the low value-added segments, upgrading local industries was deemed crucial for continuous growth. From 1995 onwards, then, the Shenzhen government initiated the move first to no longer accept applications for setting up factories for 3+1 manufacturing. Simultaneously, it actively encouraged local enterprises to shift towards higher value-added manufacturing by offering them subsidies and preferential policies to invest more in technologies and R&D. Other cities in the PRD gradually learned from Shenzhen's experience in structural upgrading.

1996-2008

In 1996, Shenzhen established the Hi-tech Industrial Zone and started attracting talent to the city to set up their own private businesses. More government spending was injected into the development of hi-tech industrial sectors such as electronics and communication technology, bio-tech and new material. Two years later, the municipal government launched the "Provisions on Further Supporting the Development of the High-tech Industry" (known as "22 Rules"), to date the most supportive policy framework for encouraging and supporting hi-tech businesses within mainland China. With the benefits brought by this policy, many indigenous firms grew quickly and a number of them went on to become national giants.

The Asian Financial Crisis in 1997-98 had a significant impact on the Four Dragons (Hong Kong, Taiwan, Singapore and South Korea) by sharply slowing growth in the PRD where the factories of Hong Kong and Taiwan enterprises were concentrated. This crisis clearly alarmed the cities and enterprises in the PRD, and starkly revealed the risks involved of being over-reliant on low-end manufacturing, spurring them to follow the path Shenzhen had taken some years previously. Since Shenzhen had proactively broken out of its comfort zone of processing manufacturing and had instead begun to upgrade local industries towards hi-tech, the city suffered less during the crisis. Moreover, Shenzhen transformed its "Lychee Festival" trade fair into the Hi-Tech Fair (known as the "China Hi-Tech Fair", or CHTF) in 1999, and since then it has become an annual event with not only national but also global impact. The Hi-Tech Fair attracts many talents and investors from across the world and promote collaboration for innovative products. For instance, the local ICT giant Tencent got its first round of investment of 2.2 million USD from two investors after attending the first CHTF.

After China successfully joined the World Trade Organisation (WTO) in 2001 and embraced the world's trading rules, more opportunities were brought to the PRD. For the whole region to adopt international rules and maintain its leading position in economic development, the

Guangdong government launched the "Coordinated Development Plan of Urban Agglomerations in the PRD (2004-2020)" to promote wider regional cooperation. Construction projects for infrastructure such as expressways and inter-city railways were pushed forward. The development of transport facilities greatly reduced transportation costs for local firms. In 2005, the provincial government tried to reduce regional disparities by transferring the labour-intensive industries from developed cities such as Shenzhen to relatively underdeveloped areas. Firms that chose to invest in these areas were subsidised. Industrial transfer parks were established in peripheral areas of the province to accommodate those low-end industries and space released in cities was assigned to hi-tech firms for research and development purposes. This strategy became known as "Double Transfer" and "empty the cage and attract new birds".

In addition to the top-down regional plan for infrastructure construction, during the same period an interesting grassroots phenomenon named "Shanzhai manufacturing" emerged and soon proliferated in the PRD. "Shanzhai" simply means copycat version of trademarked brands, mainly in consumer electronics products. These "Shanzhai manufacturers", which were originally contracting service providers, clustered in Shenzhen and initially focused on the manufacturing of mobile phones, of which more than 200 million were produced in 2008. Soon after, component suppliers, design houses and manufacturers who were involved in "Shanzhai" production, somewhat unintentionally, built a strong manufacturing network for electronics goods. With experience accumulated from imitating during the Shanzhai wave, many of them started to innovate and become "Makers".

The Global Financial Crisis in 2007-2008 hit global economic growth and many firms trapped in low-end manufacturing went bankrupt. In contrast, companies engaged in the hi-tech sectors and with their own R&D not only survived but also further enhanced their positions. Huawei is an outstanding example, as its business grew steadily during the crisis because of its low level of dependence on foreign inputs and continuous investments in R&D. The crisis acted as a double-edged sword for the PRD since, on one hand, it had negative impacts on the local economy as many companies were driven out and factories were shut down. On the other hand, however, space and resources were released for newcomers and emerging firms to develop products in new sectors. For existing firms to survive and achieve continuous growth, strategies had to be adopted to transform or upgrade themselves.

2009-2018

From 2009 onwards, many post-crisis adjustments took place in the PRD to help cities step out the shadow of the crisis. Facing growing pressures in terms of population, land and the environment, Shenzhen further transferred manufacturing sites from its inner to outer districts and to neighbouring cities. Since a growing number of individual companies which had previously been involved in “Shanzhai” manufacturing and had become “Makers” by engaging in design and R&D for new market opportunities, “Maker Spaces” were established to accommodate their needs. During the 2014 World Economic Forum in Davos Premier Li Keqiang emphasised the importance of grassroot innovation. Shortly thereafter, the “Opinions of the State Council on Several Policies and Measures for Vigorously Advancing the Popular Entrepreneurship and Innovation” was launched to encourage grassroots with innovative ideas to form start-ups.

The regional cooperation plan for the PRD initiated in 2009 further enhanced the integration of its cities. Three urban clusters (Shenzhen-Dongguan-Huizhou, Guangzhou-Foshan-Zhaoqing and Zhuhai-Zhongshan-Jiangmen) were gradually formed according to their geographic proximity and complementarities. In addition, the Pan-PRD economic co-operation initiated in late 2003 intended to expand the PRD economic zone and strengthen interactions and collaborations between Guangdong and other adjacent mainland provinces.

A more recent development related to the PRD is known as the “Guangdong-Hong Kong-Macau Greater Bay Area” initiative, aiming to integrate those nine cities within the PRD with two SARs and establish a megacity to compete with other similar areas in the US and Japan. As shown in Figure 2-2, this Greater Bay Area is expected to become the world’s largest urban region in the near future, with a population of more than 70 million and a GDP of more than 1.5 trillion USD. Construction of infrastructure has been pushed forward by the government and once all these four projects (Hong Kong-Zhuhai-Macau bridge, Shenzhen-Zhongshan bridge, Humen Pearl River bridge and High speed rail link) are accomplished, the transportation time between cities within the Bay Area will be significantly shortened. It will be more efficient to combine the advantages of SARs as mature financial centres and the strong manufacturing and technology capabilities of PRD cities in delivering products and nurture new industrial sectors.

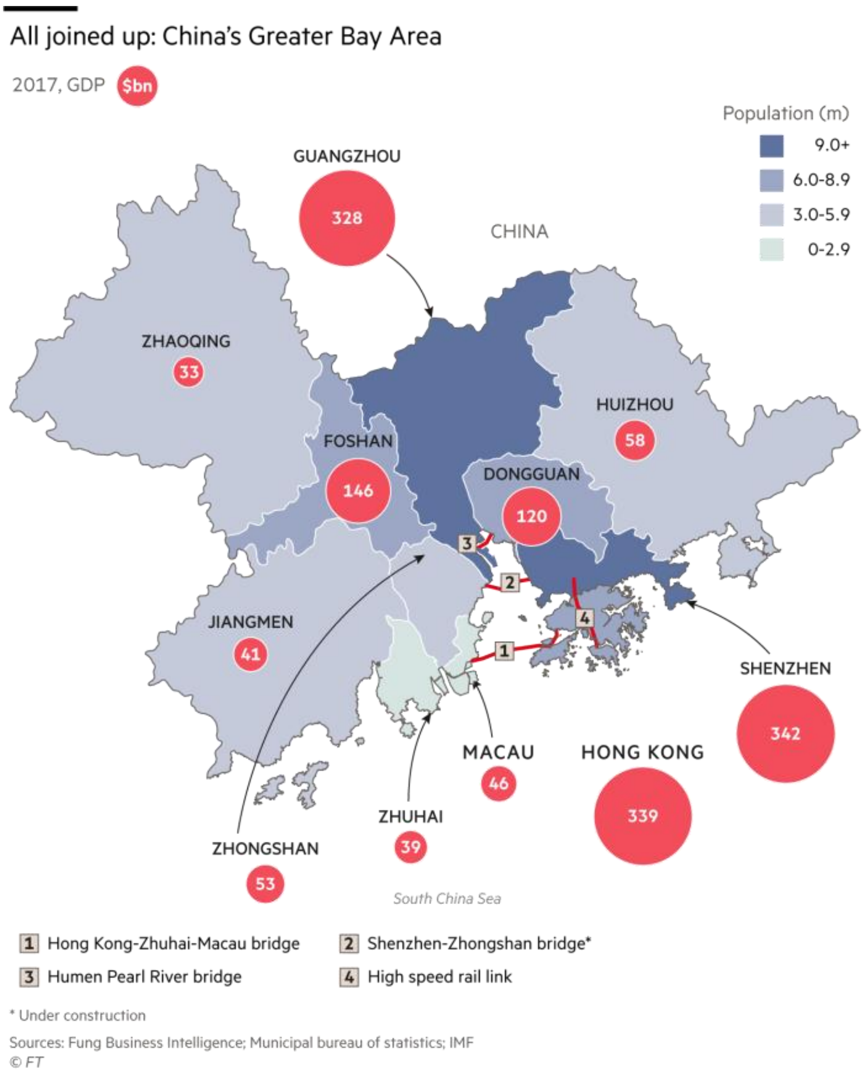


Figure 2-2 The Greater Bay Area Initiative

(Source: Financial Times)

2.2 The Electronics Industry in Shenzhen: Economic Engine for the PRD's Take-off and Continuous Growth

In the PRD, the electronics industry has long been a leading industry in the story of the region's development since the late 1970s. After Shenzhen was set up as the first SEZ in 1980, many electronics manufacturers in Hong Kong transferred their production lines to this city, where costs were much lower. From 1979 to 1985, the electronics industry in Shenzhen grew from only one firm to more than 170 companies with over 17,000 employees, producing colour TVs, radio-cassette recorders, microcomputers, telephones and other electronics components.[2] The output value of Shenzhen's electronics industry was ranked 7th among all 28 provinces on the mainland[3], implying that the total output from the electronics industry of the whole PRD region at that time was even higher since other cities within the PRD such as Dongguan and Shunde were also engaged in manufacturing a wide range of electronics products. In 1988, according to a report issued by the National Ministry of the Electronics Industry, the export value of Shenzhen' s electronics industry reached 779 million RMB, accounting for 21.48% of China's total export value[4], making the city first among all mainland cities.

Entering the 1990s, the PRD economy was booming according to the industrial transfers [from the Four Asian Dragons. In 1995, the PRD accounted for 93% of Guangdong province's electronics industry output. Clusters were gradually formed in different cities along the two wings of the PRD. For instance, there were consumer electronics clusters in eastern Shenzhen and Dongguan while household appliance clusters were located in Foshan and Zhuhai along the west side. From 1999 to 2017, the number of enterprises in the PRD's electronics industry experienced a dramatic growth, with much higher output value and value-added achieved (see Table 2-3). Although the global financial crisis in 2007-08 led to an increasing number of loss-making enterprises and bankruptcies, the region has recovered and stepped into a new growth period in its electronics industry.

2 Source: https://tech.hqew.com/news_1346032
3 Source: http://stic.sz.gov.cn/kjfw/rkx/rkxcgsjk/201711/P020171101399161490676.pdf
4 Source: http://www.chinadaily.com.cn/dfpd/2010-07/19/content_11020642.htm

Table 2-3 Statistics of the Electronics Industry in the PRD (1999-2017)

(Source: Guangdong Statistical Yearbook, 2000-2018)

Main Indicators of Industrial Enterprises of the Pearl River Delta in Manufacture of Communication Equipment, Computers and Other Electronic Equipment (100 million Yuan)	**Number of Enterprises (unit)**	**Loss-making Enterprises**	**Gross Industrial Output Value (at current prices)**	**Value added[5] of Industry (by production approach)**
2017	5421	870	36018.71	7843.50
2016	4724	817	32383.23	6924.15
2015	4515	897	29463.68	6236.28
2014	4357	757	27149.00	5881.66
2013	4319	760	24921.63	5532.05
2012	3763	766	22149.55	4674.09
2011	3603	643	20789.92	4071.80
2010	4455	798	18573.08	4088.96
2009	4368	1048	15288.88	3309.47
2008	4565	1288	14987.92	3132.79
2007	3439	804	13033.81	2423.58
2006	2929	697	11653.41	2458.32
2005	2790	755	9562.44	2028.66
2004	1819	469	7267.23	1424.23
2003	1622	366	5734.51	1293.36
2002	1479	393	4102.44	863.03
2001	1315	391	3045.12	638.04
2000	1234	331	2341.56	564.58
1999	1112	352	1885.97	421.60

5 Here value added is used as a noun, which means the increase in value of a product as it goes through the stages of being developed and produced. It can be calculated as the difference between output value and input costs.

The statistics for the year 2016 showed that with only 30.5% of the total Guangdong land area, the PRD accommodated more than half of the province's permanent population and contributed to 79.7% and 83.4% of the GDP from secondary and tertiary industries respectively, while 80.5% of the value added to industry from the firms listed in Table 2.3 and 94.4% of Guangdong's exports came from the PRD.[6] By 2016, Guangdong accounted for the largest portion of the output from the electronics industry in mainland China (see Table 2-4), which implied that the PRD played a key role in driving national economic output. Guangdong also dominated production in a wide range of electronics goods such as TVs, mobile phones, smart phones and SPC (Stored Programme Control) exchanges (see Table 2-5).

Table 2-4 Economic Indicators of Enterprises above Designated Size in the Electronics and Information Industry (2016)

(Source: Statistical Yearbook of China's Electronics and Information Industry, 2016)

Provinces and Direct-controlled Municipalities or Districts in Mainland China	Number of Enterprises (unit)	Loss-making Enterprises	Revenue from Operation (100 million Yuan)	Total Profit (100 million Yuan)
Tianjin	413	129	2570	168
Hebei	332	40	999	76
Shanxi	48	15	833	30
Inner Mongolia	34	8	121	2
Liaoning	236	60	729	70
Jilin	50	4	141	11
Heilongjiang	39	11	70	5
Shanghai	692	167	6086	170
Jiangsu	4016	648	27248	1561
Zhejiang	2259	307	5121	420
Anhui	787	78	3028	176
Fujian	693	74	3997	261

[6] Data for the year 2016 from the latest Guangdong Statistical Yearbook (2018)

Provinces and Direct-controlled Municipalities or Districts in Mainland China	Number of Enterprises (unit)	Loss-making Enterprises	Revenue from Operation (100 million Yuan)	Total Profit (100 million Yuan)
Jiangxi	623	48	3312	230
Shandong	1259	141	7489	434
Henan	552	38	4565	182
Hubei	579	72	2819	136
Hunan	625	39	2432	109
Guangdong	5827	1126	35495	1749
Guangxi	159	15	1834	150
Hainan	5	2	33	1
Chongqing	452	49	4142	145
Sichuan	517	60	3676	126
Guizhou	131	18	395	11
Yunnan	32	9	115	0
Tibet	N/A	N/A	N/A	N/A
Shaanxi	191	31	1114	102
Gansu	23	7	85	8
Qinghai	19	5	106	5
Ningxia	11	3	131	10
Sinkiang	17	4	143	15

Table 2-5 The Production of Main Electronics Products in China (2016)

((*Source: Statistical Yearbook of China's Electronics and Information Industry, 2016)*

Provinces and Direct-controlled Municipalities or Districts in Mainland China	Colour TV	LCD TV	Smart TV	Mobile Phone	Smart Phone	SPC (Stored Programme Control) Exchange
	(10 thousand units)					
Total	15770	15714	9310	205819	153764	1458
Beijing	305	305	193	6924	6795	0
Tianjin	224	224	224	4973	4284	0
Hebei	0	0	0	0	0	14
Shanxi	0	0	0	2693	2693	0
Inner Mongolia	27	27	27	0	0	0
Liaoning	145	145	0	641	641	37
Jilin	0	0	0	0	0	0
Heilongjiang	0	0	0	0	0	0
Shanghai	115	115	93	4801	4415	75
Jiangsu	1383	1383	640	5352	4999	1
Zhejiang	658	658	505	5100	4576	219
Anhui	829	829	571	141	41	0
Fujian	1016	1016	1008	2569	1875	0
Jiangxi	20	20	0	7414	6399	0
Shandong	2067	2067	1581	6083	4585	0
Henan	14	14	0	25236	17158	0
Hebei	9	9	0	6221	4904	0
Hunan	18	18	6	23	0	4
Guangdong	**7440**	**7384**	**4261**	**95230**	**76497**	**1103**
Guangxi	178	178	0	546	428	0
Hainan	0	0	0	0	0	0

Provinces and Direct-controlled Municipalities or Districts in Mainland China	Colour TV	LCD TV	Smart TV	Mobile Phone	Smart Phone	SPC (Stored Programme Control) Exchange
	(10 thousand units)					
Chongqing	18	18	18	25500	10399	0
Sichuan	1106	1106	62	4469	2684	1
Guizhou	191	191	119	1859	384	0
Yunnan	4	4	0	37	0	5
Shaanxi	3	3	3	8	8	0
Gansu	0	0	0	0	0	0
Qinghai	0	0	0	0	0	0
Ningxia	0	0	0	0	0	0
Sinkiang	0	0	0	0	0	0

In sum, the PRD region has become a national leader in electronics production, with strong manufacturing capabilities developed from both foreign and indigenous firms. Among the PRD's nine cities, Shenzhen took, and has kept, the lead role in introducing foreign investors to initiate manufacturing activities, particularly in electronics products, and supporting indigenous firms in enhancing not only manufacturing but also R&D capabilities. The evolution of Shenzhen's electronics is mapped out as Figure 2-3 and all details about the changes in policy, industry, firm and infrastructure are shown in following Figure 2-3 (1) (2) (3) (4).

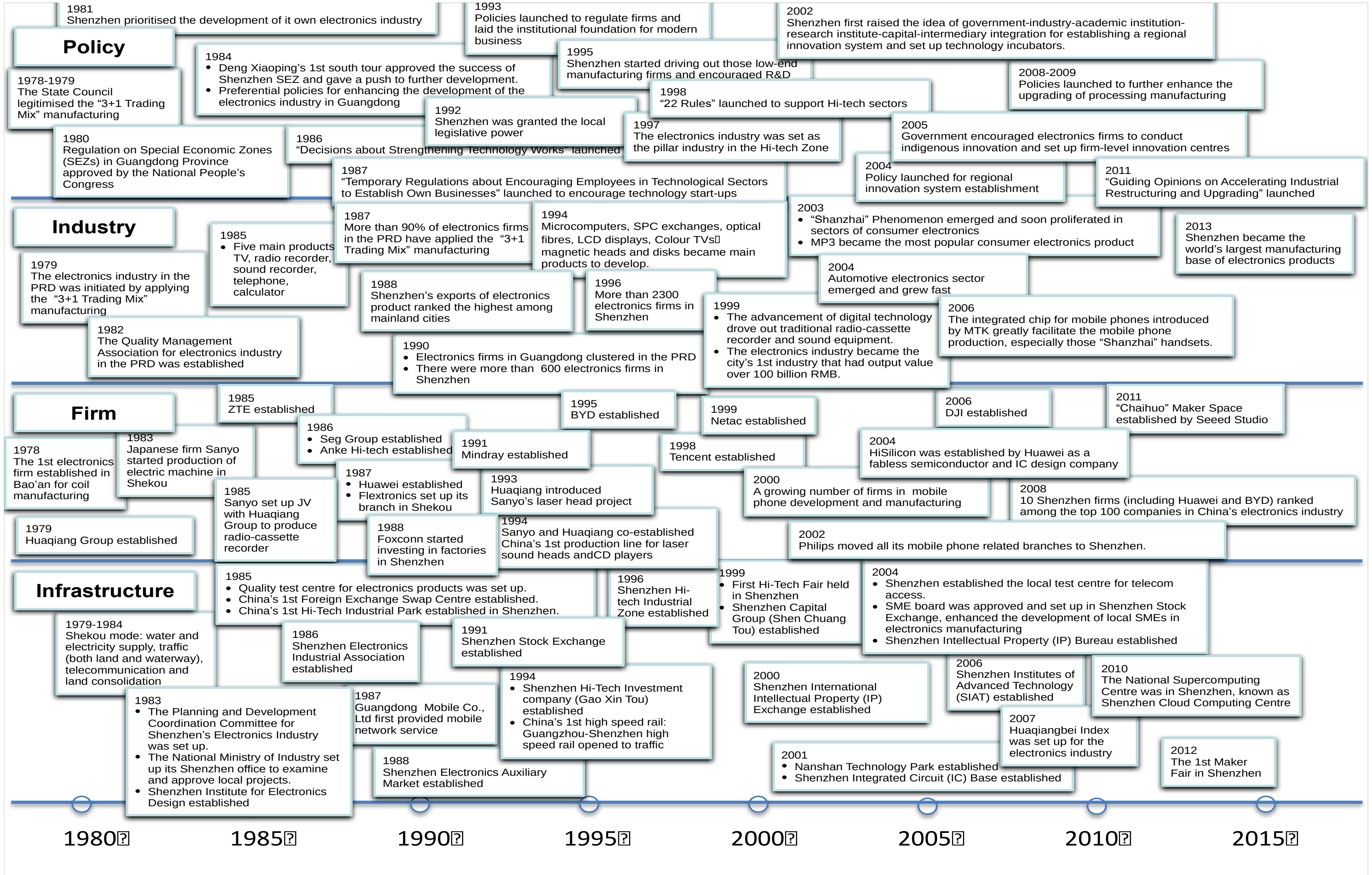


Figure 2-3 The Evolutionary Mapping of Shenzhen's Electronics Industry

(Source: data collected from various sources and edited by the author)

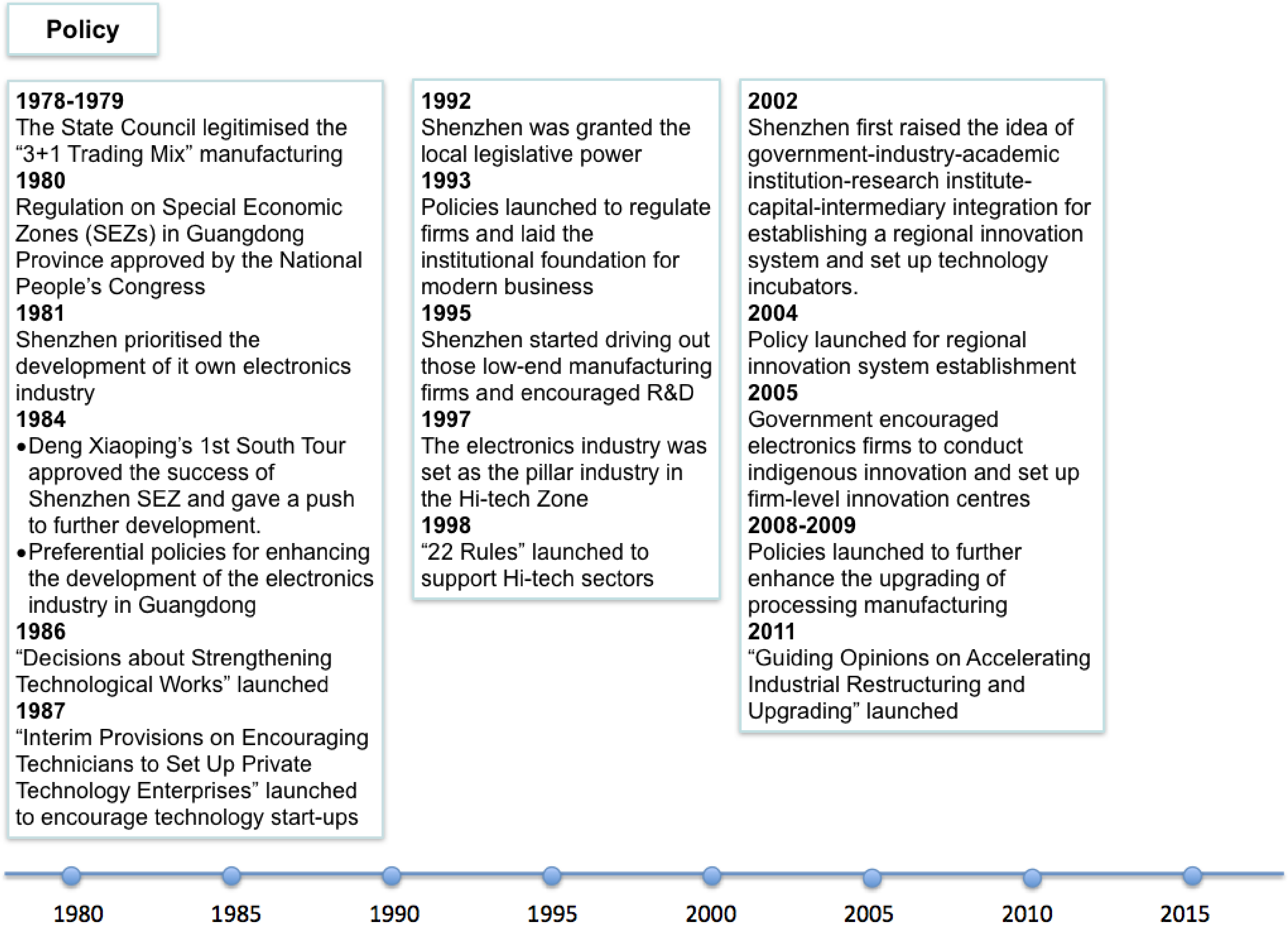


Figure 2-3 (1) Policy

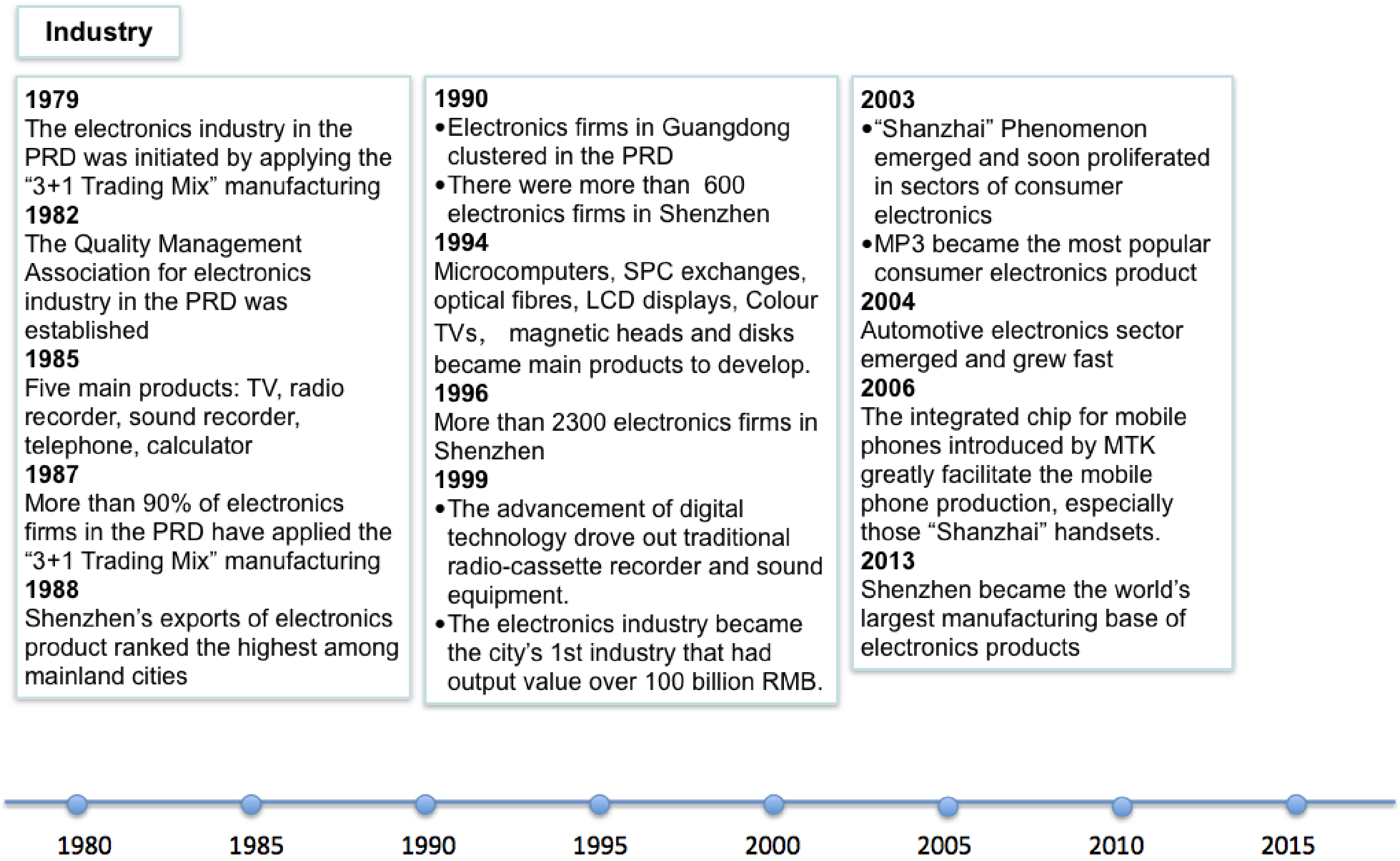


Figure 2-3 (2) Industry

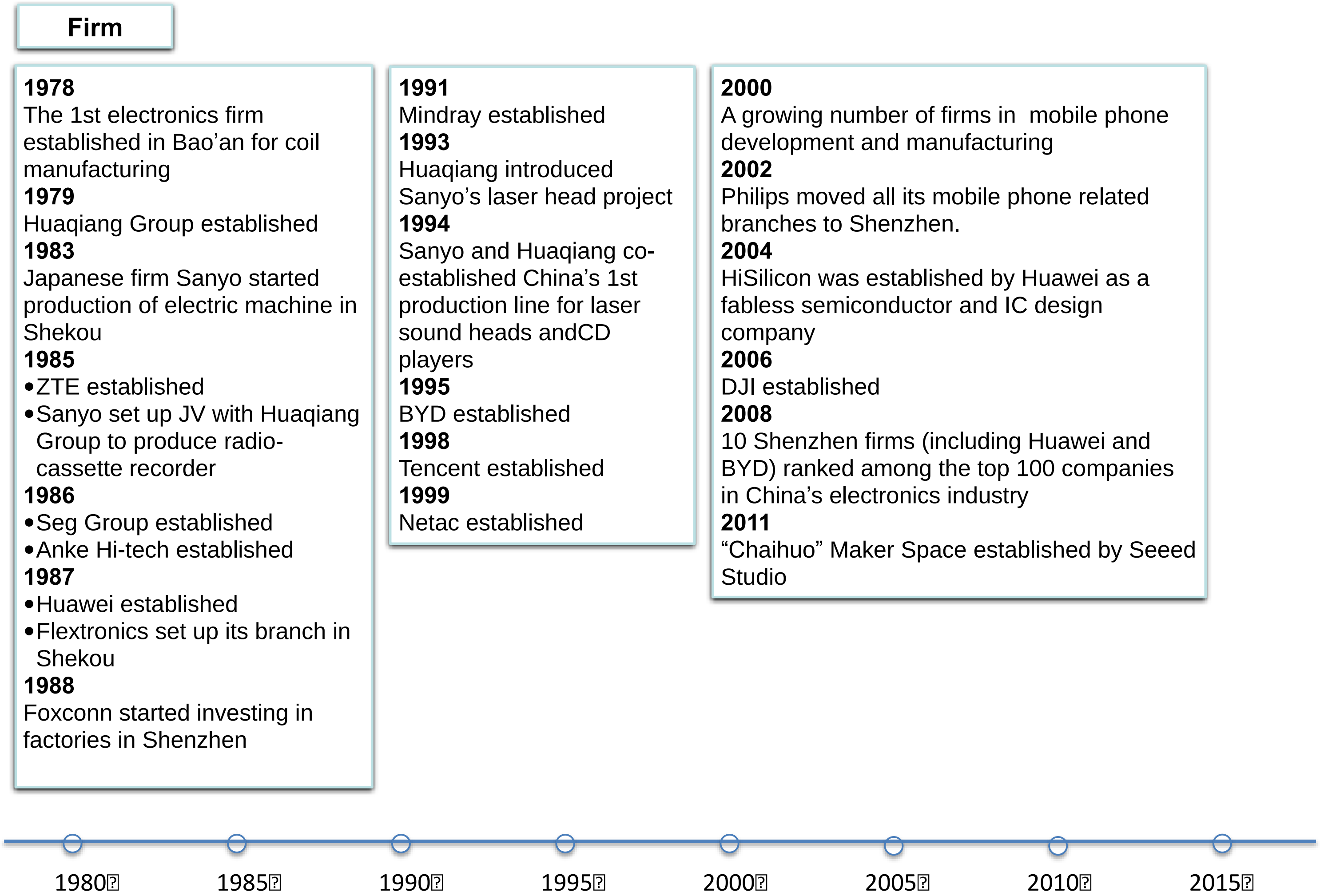


Figure 2-3 (3) Firm

Infrastructure

1979-1984
Shekou mode: water and electricity supply, traffic (both land and waterway), telecommunication and land consolidation

1983
- The Planning and Development Coordination Committee for Shenzhen's Electronics Industry was set up.
- The National Ministry of Electronics Industry set up its Shenzhen office to examine and approve local projects.
- Shenzhen Institute for Electronics Design established

1985
- Quality test centre for electronics products was set up.
- China's 1st Foreign Exchange Swap Centre established.
- China's 1st Hi-Tech Industrial Park established in Shenzhen.

1986
Shenzhen Electronics Industrial Association established

1987
Guangdong Mobile Co., Ltd first provided mobile network service

1988
Shenzhen Electronics Auxiliary Market established

1991
Shenzhen Stock Exchange established

1994
- Shenzhen Hi-Tech Investment company (Gao Xin Tou) established
- China's 1st high speed rail: Guangzhou-Shenzhen high speed rail opened to traffic

1996
Shenzhen Hi-tech Industrial Zone established

1999
- First Hi-Tech Fair held in Shenzhen
- Shenzhen Capital Group (Shen Chuang Tou) established

2000
Shenzhen International Intellectual Property (IP) Exchange established

2001
- Nanshan Technology Park established
- Shenzhen Integrated Circuit (IC) Base established

2004
- Shenzhen established the local test centre for telecom access.
- SME board was approved and set up in Shenzhen Stock Exchange, enhanced the development of local SMEs in electronics manufacturing
- Shenzhen Intellectual Property (IP) Bureau established

2006
Shenzhen Institutes of Advanced Technology (SIAT) established

2007
Huaqiangbei Index was set up for the electronics industry

2010
The National Supercomputing Centre was in Shenzhen, known as Shenzhen Cloud Computing Centre

2012
The 1st Maker Fair in Shenzhen

1980 | 1985 | 1990 | 1995 | 2000 | 2005 | 2010 | 2015

Figure 2-3 (4) Infrastructure

In July 1978, the State Council legitimised “3+1 Trading Mix” manufacturing, processing with given materials or given designs, assembly with given components and compensation trade with given machinery. Then in December 1978, just before China’s reform and opening-up was officially launched, the first factory for processing with given materials was established in Bao’an (the former name of Shenzhen, until it was officially changed on 5th March 1979). This factory was jointly set up by Hong Kong enterprise Eagle International and the local Shangwu Community for coil manufacturing and it can be seen as the first foreign invested electronics firm in Shenzhen. Following this, factories applying “3+1 Trading Mix” manufacturing mushroomed in the PRD, kick-starting the local electronics industry. In addition to these spontaneous, “bottom-up” forces, the Provincial Government also took action by transferring three affiliated electronics factories from peripheral areas in Guangdong to Shenzhen and established the Huaqiang Group of electronics manufacturers in September 1979. The Shekou Industrial Zone was set up within Shenzhen in the same year as a space for experimental production practices could take place.

In May 1980, the Huaqiang Group introduced two production lines for audio recorders from Japanese firm Sanyo, which triggered the collaboration between local firms and Japanese enterprises. On 26th August of that year, Shenzhen officially became China’s first SEZ and more preferential policies were awarded to the city to attract foreign investors. In the following year, Shenzhen Municipal Government put an emphasis on the development of the local electronics industry and assigned an area of land of 300,000 m^2 for an electronics industrial zone. By the end of 1981, 11 electronics firms had started production in Shenzhen. In 1982, Hong Kong enterprise Luks was approved to set up its fully-owned factory in Shekou, which started the production of colour TV four years later. In the same year, the National Ministry of Electronics Industry was set up and the Quality Management Association for the electronics industry in the PRD was established to enhance the quality of products manufactured by local factories. In 1983, another foreign fully-owned factory was set up in Shekou by Japanese firm Sanyo for electric machine production and Sanyo also continued its collaboration with the Huaqiang Group by forming a joint venture for radio-cassette recorders two years later. Foreign enterprises were more willing to invest in Shenzhen for electronics manufacturing as a number of local institutions were established to support joint ventures, such as the Planning and Development Coordination Committee for Shenzhen's Electronics Industry, the Quality Test Centre for electronics products, Shenzhen Institute for Electronics Design. Moreover, the National Ministry of Industry set up its Shenzhen office in 1985, a move which greatly facilitated the efficiency for examining and approving local projects with foreign investments. Since there was a growing number of electronics firms, Shenzhen Electronics Industrial Association was established in 1986 to bridge communication between enterprises and government officials in order to explore their needs and requests. The Shenzhen Electronics Group (SEG) was established in the same year, pooling local 117 electronics firms together to form China's first export-oriented cooperation, as well as the first Electronics Auxiliary Market to satisfy increasing demand for electronics components. EMS (Electronics Manufacturing Service) providers such as Flextronics and Foxconn set up branches in Shenzhen one after another and, by the end of 1988, Shenzhen had become the largest exporter of electronics goods in mainland China, with more than 90% of those firms engaged in "3+1 Trading Mix" manufacturing activities.

The launch of "Decisions about Strengthening Technological Works" in November 1986 and "Interim Provisions on Encouraging Technicians to Set Up Private Technology Enterprises" in February 1987 by the municipal government of Shenzhen can be seen as triggers for the emergence of hi-tech companies. For instance, Huawei, Mindray and BYD were established after the implementation of the latter policy. By 1990, there were more than 600 electronics firms in Shenzhen and two thirds of them received foreign investment. Clusters for diverse products were formed in the PRD and in Shenzhen, microcomputers, SPC exchanges, optical fibres, LCD displays, Colour TVs, magnetic heads and disks became the main products. In 1992, Shenzhen was granted local legislative power and in the following years policies were designed more efficiently to guide local industries towards the hi-tech sector. For instance, policies related to firm regulations were launched in 1993, laying the institutional foundations of modern business in Shenzhen. The Hi-Tech Investment Company (Gao Xin Tou) was established to cultivate and support emerging firms with technologies and the Hi-Tech Industrial Zone was used to accommodate these start-ups. After 1995, the local government further enhanced hi-tech industrial development by, on the one hand, driving out low-end manufacturing that still applied the outdated "3+1 Trading Mix" and, on the other hand, launching preferential policies for hi-tech start-ups, most importantly constructing platforms such as the Hi-Tech Fair for investors, enterprises and talents to communicate on potential collaborations. Moreover, venture capital was introduced to support hi-tech start-ups and the Shenzhen Capital Group (Shen Chuang Tou) was established and acted as a venture capitalist for local firms. In 1999, as digital technology advanced, traditional radio-cassette recorders and sound equipment were driven out of the market and the electronics industry entered a new era with more dynamics, opportunities, and uncertainties.

In the beginning of the 2000s, Shenzhen and the PRD witnessed a growing number of firms involved in the development and manufacturing of mobile phones. Foreign giants such as Philips had moved all its Chinese branches related to mobile phone production to Shenzhen and local grassroots that learned from these factories started their own businesses and actively engaged in supplying components for mobile phones and other portable consumer electronics devices. With lower costs and higher efficiency in design and manufacturing, white brand mobile phones soon proliferated in Shenzhen and the PRD, marking the beginning of the "Shanzhai" phenomenon. After an investigation, the local government determined that the root cause of the proliferation of "Shanzhai" counterfeit phones was the complicated process of the test for telecom network access that was compulsory for companies to pass before launching their mobile phone products, and there was no test centre in Shenzhen at that time. The local government then sent request to China's Ministry of Industry and Information Technology to set up a test centre in Shenzhen, which was subsequently approved in 2004, fully funded by the government. This significant move accelerated the application process for network access and facilitated local enterprises to establish their own mobile phone brands.

From 2005 onwards, more hi-tech oriented movements were conducted by both the public and private sectors. The government encouraged local electronics firms to invest more in R&D by setting up firm-level innovation centres. The Shenzhen Institute of Advanced Technology

(SIAT) was established in 2006 to offer local enterprises help in terms of the latest technologies. By 2008, 10 local companies ranked among the top 100 companies in China's electronics industry and their successes could be attributed their continuous investments into indigenous R&D activities. For example, Huawei has set up HiSilicon as a fabless semiconductor and IC design company and concentrated on the development of chips for mobile devices. In 2010, the establishment of the Shenzhen Cloud Computing Centre further facilitated local enterprises in big data analysis and application.

With the global economic downturn after the financial crisis of 2007-08, together with the appreciation of the RMB and the introduction of the new labour laws in Mainland China, many manufacturing firms producing electronics goods in a labour-intensive way with low value-added suffered. Without actively upgrading themselves, they could barely survive. A series of industrial policies were launched by the municipal government to guide the upgrading of processing manufacturing in Shenzhen and to establish the regional innovation system to encourage firms to take the leading role. In 2011, the "Guiding Opinions on Accelerating Industrial Restructuring and Upgrading" was introduced by Shenzhen government to further enhance the local upgrading process. In addition to the transformation of existing enterprises into higher value-added or more technologically advanced sectors or economic niches, local grassroots also started engaging in technological innovations, known as "Makers". Maker spaces were formed to provide an open environment and equipment for makers to exchange ideas and collaborate, among which the Chaihuo Maker Space was the first one in Shenzhen, and it went on to become the organiser of the annual Shenzhen Make Fair since 2012.

2.3 Summary and Research Motivation

Nowadays, Shenzhen is known as the world's factory because this city contributes to the manufacturing of 90 percent of the world's electronics [7] ranging from simple and specific

7 https://www.inc.com/will-yakowicz/shenzhen-city-of-electronics.html

components to integrated and advanced products such as consumer drones. The electronics industry in Shenzhen has experienced the ebbs and flows of the world's demand and technological advancement, through which companies have strived to survive and upgrade periodically. Central to this process of industrial upgrading, Shenzhen has also transformed itself from a small fishing village to a modern metropolis in only four decades, a transformation which is far from over. This development stimulated research interest into how industrial upgrading takes place in a region, a city such as Shenzhen, and how upgrading can be facilitated by regional development, or more specifically, how a city's "business ecosystem" for various entities to do businesses can be shaped and harnessed for sustainable economic growth.

Chapter 3 Literature Review: Understanding Industrial Upgrading in a Region from Different Perspectives

Industrial upgrading is generally perceived as a phenomenon or a result associated with structural changes taking place in an industry. It has been widely accepted that upgrading in a manufacturing industry can be simply summarised as the process from OEA production (Original Equipment Assembling) to OEM (Original Equipment Manufacturing), to ODM (Original Design Manufacturing) and then OBM (Own Brand Manufacturing) (Kaplinsky & Morris, 2000). Different streams of research have investigated and analysed industrial upgrading issues and provided a wealth of empirical evidence in support of their claims. The root of discussions about industrial upgrading can be traced back to Porter's competitiveness research. He first raised the value chain as a basic tool to examine how competitive advantage can be generated from all strategically relevant activities firm performs (Porter, 1985). Then, in the 1990s, he introduced another concept – "cluster" - as an extension of the value chain to include both functional and spatial aspects for competitiveness analysis by applying his diamond model (M. Porter, 1990). The following cluster literature suggests that local networks of public and private sector institutions provides the support structure for upgrading through local-level governance (Humphrey & Schmitz, 2000). Under the context of globalisation, especially after the mid-1990s in East Asia, regional practices have offered rich examples of industrial upgrading that have been analysed from global and local perspectives. However, the selectivity of development among city-regions needs to be explained by a more comprehensive framework that captures the main forces of their development (Storper, 2013). Today, how to facilitate and sustain the upgrading process of local industries based on resources from globalisation and localisation over time has become a more critical issue for regional governments and enterprises to consider for enhancement of competitiveness. This also implies that such a framework should not only outline changing resource conditions and iterating industrial systems but also showcase the co-evolution between industrial systems and regional resources during the upgrading process in a region.

3.1 From Global Perspective

3.1.1 Flying Geese (FG) / Latecomer catch-up (1970-80s)

The economic take-off of East Asia has been summarised as the wild-geese-flying pattern of industrial development to address the catching-up process of less-advanced economies with the advanced countries (Akamatsu, 1962). This is now known as the Flying-Geese (FG) model (a term coined by the Japanese economist Kename Akamatsu), with Japan acting as the leading goose and the Newly Industrializing Economies (NIEs) - South Korea, Singapore, Hong Kong and Taiwan – as the following geese. The electronics industry was the fastest growing industry in these four NIEs (later known as the "four dragons") and they shared four common features underpinning their successful development in electronics: skilled local entrepreneurs, intense domestic competition, public investment in education and training, and the coupling of technological learning with export demands (Hobday, 1994). Akamatsu's FG model was built upon the idea that any given national economy would move to higher stages of industrial development over time (Korhonen, 1994) and industrial upgrading can be seen as the process of bridging established and new sectors through creative destruction (Shigehisa, 2004). Although this model highlights the important role played by Japan in assisting those NIEs with FDI, aid, joint ventures and through training for local technicians, engineers and managers, it underplays the role played by the US as well as some European countries and fails to recognise indigenous efforts and divergent strategies applied to accumulate technology and to export overseas (Hobday, 1995b).

As the "four dragons" developed, local firms learned to assimilate process and product technologies from the application of subcontracting and OEM mechanisms. They were then able to accumulate technological capabilities as well as a deeper understanding of global market needs, even form some strategic partnerships with global leaders in the industry (Hobday, 1995a). The idea of a latecomer firm was suggested to describe one existing or potential industrial enterprise that faces technological and market barriers when competing in the export markets and in non-Japanese East Asia. Latecomers have used different strategies to overcome their disadvantages, for instance coupling technology development with export market needs, licensing, subcontracting, joint ventures and acquisitions, among others (Hobday, 1998). Being a latecomer country, China has endeavoured to catch up with leading nations by attracting TNCs (Transnational Corporations) to set up local branches on one hand, and encouraging local firms to conduct OEM on the other hand (Hobday, 2001). In China, the abundance of cheap tech-skilled labour, such as software engineers from universities and public technology institutes, enabled many local firms to conduct innovative activities, including the re-engineering and improvement of products and processes at a much lower cost than in developed countries (Hobday, 1995b, 2001). The "China miracle" further challenged the cascading development patterns implied by the FG paradigm that Japan could always maintain its leadership. The model was then expanded by Kojima into three models: the catching-up process through diversification/rationalisation of industries; the PROT(pro-trade-oriented) FDI; and agreed specialization (Kojima, 2000). The FG model can also be reformulated to show structural upgrading that occurs periodically in terms of a sequence of growth stages, in each of which a leading growth sector can be identified as the main engine of structural transformation into a higher value-added level (Ozawa, 2003).

From Akamatsu's original FG paradigm describing Japan as the follower of advanced Western economies to a modern FG model viewing Japan as the leader for other Asian countries to imitate, regional industrial upgrading or restructuring has gradually shifted from bottom-up to top-down in forming the industrial hierarchy in East Asia (Shigehisa, 2004). However, since the rise of China and every developing economy seeking to upgrade its own industries rather than simply following others, such a hierarchy was demolished. Instead of the Flying Geese formation, China has been described as "a huge bird flying side by side with the various layers of flying geese at various levels of industrial production" (Chan, 1993, p16). From China's industrial development we can see that it has not only developed towards hi-tech sectors but also kept consolidating its labour-intensive segments. Also, China has many more comprehensive supply chains and value chains for the production of consumer goods such as electronics products than previous leaders had, including Japan and the "Four Dragons". Nevertheless, China still shared some similarities with them in boosting industrial development. For instance, the Chinese government put great effort into enhancing knowledge transfers from multinationals to local companies, which was similar to the "Four Dragons", whereby the state played a key role in facilitating the emergence of indigenous firms and enabling them to rapidly learn from abroad by fostering and protecting the learning process (Fransman, 2018).

3.1.2 Global Commodity Chain (GCC) and Global Value Chain (GVC) (1990s)

From the FG paradigms and catching-up phenomenon in East Asian economies, the industrial upgrading issue has been inspected from a macro perspective. When we narrow down the focus to a specific production chain or network, there are already some micro level discourses.

A global commodity chain (GCC) is defined as "a network of labour and production processes whose end result is a finished commodity" (Hopkins & Wallerstein, 1986, p159) and consists of "sets of interorganisational networks clustered around one commodity or product, linking households, enterprises, and states to one-another within the world-economy" (Gereffi & Korzeniewicz, 1994, p2). Industrial upgrading under the GCC is "a process of improving the ability of a firm or an economy to move to more profitable and/or technologically sophisticated capital- and skill-intensive economic niches"_(Gereffi, 1999, p51-52). This implies that industrial upgrading in a regional economy mainly refers to the process from simple assembly to more integrated form of production with greater coverage of forward and backward linkages. Derived from GCC studies, global value chain (GVC) was established to investigate industrial upgrading in greater depth. A GVC can be seen as a value chain divided among multiple firms and geographic locations. From the GVC perspective, upgrading mechanisms undertaken by firms or groups of firms can be classified into four types: namely process upgrading, product upgrading, functional upgrading along the GVC and inter-sectoral upgrading to a new GVC (Humphrey & Schmitz, 2000). Value chain analysis is important for understanding industrial upgrading because it offers taxonomy that incorporates firms, related actors and agencies, as well as identifying the role played by leading firms (Kaplinsky, Morris, & Readman, 2002).

Some global industries have exhibited patterns of upgrading that involve global and/or local factors and mechanisms. For example, the apparel industry was the first global industry that was investigated by scholars for upgrading issues because most countries started their industrialisation from such labour-intensive manufacturing (Bair & Gereffi, 2001, 2003; Gereffi, 1994, 1999). Empirical evidence from the globalised apparel industry has shown upgrading trajectories for developing regions from assembly to OEM and OBM export roles (Gereffi, 1999). Then the industrial transfer of the electronics industry from developed countries to East Asia offered those Asian countries and regions opportunities to catch up and upgrade (Ernst, 2000, 2001, 2002b). These practices can be analysed through a value chain framework for industrial upgrading, extending the firm-level analysis to cover inter-firm linkages and governance (Gereffi, 2005; Kaplinsky et al., 2002). The governance structure of global value chains can be summarised as five forms (Figure 3-1), namely market, modular, relational, captive and hierarchy (from low to high degrees of explicit coordination and power asymmetry) (Gereffi, Humphrey, & Sturgeon, 2005).

The GCC framework emphasises the powerful roles played by large retailers (in buyer-driven chains) and large manufacturers such as General Motors (in producer-driven chains) in the governance of global production and distribution, while the GVC framework classifies governance forms into different types and provides explanations for changes in governance patterns for buy-driven and producer-driven chains over time (Frederick, 2016). Buyer-driven chains tend to be coordinated via market, modular, or relational governance, and producer-driven chains tend to be coordinated via captive or hierarchical governance.

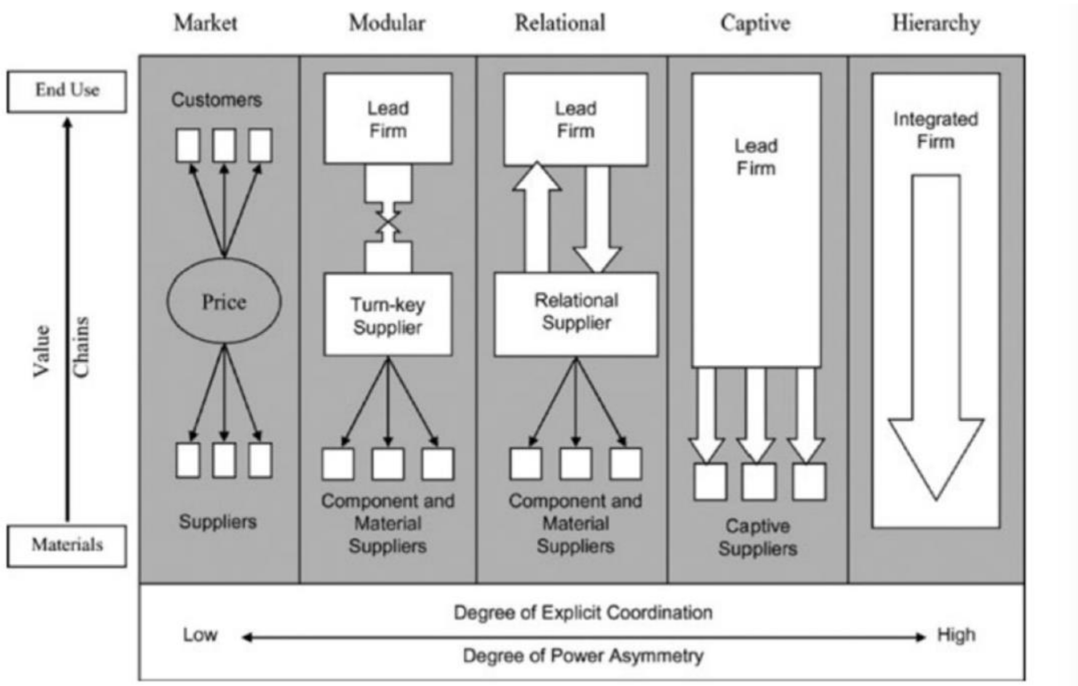


Figure 3-1 Five Governance Types of GVCs (Gereffi et al., 2005)

3.1.3 Global Production Network (GPN) (2000s)

The chain approach gives the impression of conceptualising production and distribution processes as vertical and linear, as well as neglecting the autonomy of individual firms (Henderson, Dicken, & Hess, 2002) whilst, in reality, economic activities are more complex with various types of linkages and firms are able to take autonomous actions to pursue upgrading. The GVC tends to have more explanatory power on the functional aspect of how latecomer firms in developing countries can catch up with those developed ones through upgrading (Humphrey, 2004), but it has not fully covered the spatial aspect regarding how corresponding regions can co-evolve with the industry that is experiencing upgrading. Besides this relative overlooking of territorial organisation, the GVC can also be challenged for failing to theorise competitive dynamics and evolutionary processes in multicommodity or multi-industry production networks (Chung, Yeung & Coe, 2015). In the contemporary global economy, GCC and GVC studies on industrial upgrading that focus on the firm-level competitiveness within a specific industry can only partially answer the question about the winners and losers (Bair, 2005). Another stream of research, the global production network (GPN) approach, has considered the spatial factors of upgrading activities by combining insights from GCC/GVC and emphasising the importance of power, value and embeddedness in regional development and clustering dynamics (Coe, Dicken, & Hess, 2008). Although GPN differentiates itself from GCC and GVC by adding the societal, network and territorial embeddedness of firms and economic activities into the analysis (Hess & Coe, 2006), it is still not sufficient to explain the dynamics of local industrial upgrading because it focuses more on the orchestration of global leaders rather than local firms (Liu, 2017).

Based on the actor-network theory, the idea of GPN was raised as an organisational innovation of international business that "combine[s] concentrated dispersion of the value chain across firm and national boundaries, with a parallel process of integration of hierarchical layers of network participants" (Ernst & Kim, 2001, p1). A conceptual framework of GPN was established to analyse the relationships between the evolution of GPNs, the role of network flagships in transferring knowledge, and the formation of capabilities by local suppliers. Strengthening that constant upgrading of absorptive capacity was crucial for these domestic firms to stay on the GPN (Ernst & Kim, 2002). From the GPN perspective, industrial upgrading was defined as "a shift to higher-value-added products, services, and production stages through increasing specialization and efficient domestic and international linkages" (Ernst, 2002b, p2) and the GPN study also provided a more detailed analysis of the recognised upgrading in East Asia's electronics industry by stating that transformations in vertical specialisation, coordination and content, and location were the root causes (Ernst, 2004). For the location factor, China has acted as a black hole absorbing FDI into the region continuously for the emergence and fast growth of the local electronics industry. Most Chinese firms had a foreign joint venture partner and local manufacturers were gradually pushed into upgrading their operation and production skills to meet the quality of products required by foreign companies (Dicken & Henderson, 2005).

Under GPN, industrial upgrading can be achieved separately through parallel development in different nodes of a value chain rather than the gradual upgrading from lower-end to higher-end (Chen & Xue, 2010), whereas the production of electronics products has become more fragmented with technological advancement. Nevertheless, within the electronics industry, the benefits of engaging in GPNs for local upgrading was limited because most high value-added activities were still kept in the home countries of foreign multinationals which were orchestrating the GPNs.

In addition to the discourse on industrial upgrading, GPN studies have also provided a framework (see Figure 3-2) to conceptualise regional development by considering the interactions among GPNs, institutions affecting the region and regional assets.

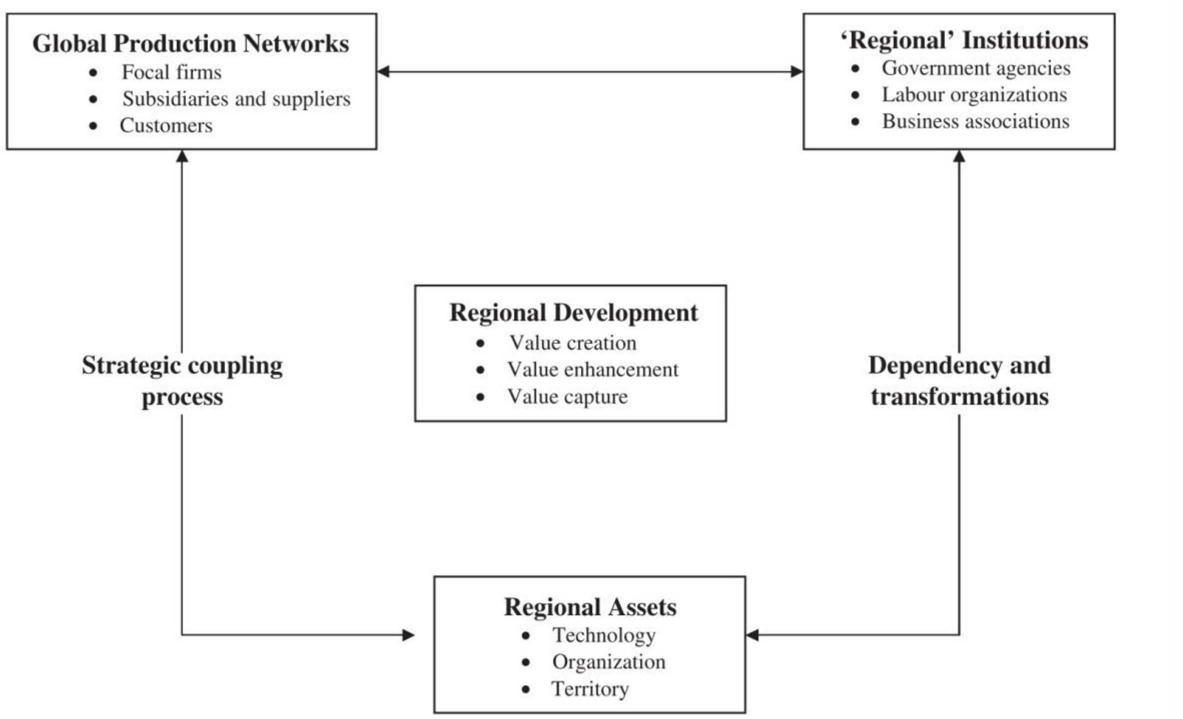


Figure 3-2 A Framework for analysing regional Development and GPNs

(Coe, Hess, Yeung, Dicken, & Henderson, 2004)

The strategic coupling[8] process links industrial upgrading and territorial transformations in regional and national economies with the dynamic configurations of GPNs (Chung, Yeung & Coe, 2015). The regional institutions and regional assets will also evolve through the coupling processes and this will lead to the accumulation and enrichment of the local resource pool, which may further enhance the local industrial upgrading. For local factors and mechanisms that facilitate industrial upgrading, we need to consult other streams of literature from the local perspective.

3.1.4 Defining Industrial Upgrading

Industrial upgrading is initially termed in competitiveness literature, which can be classified into the general Economics domain. Then from the global perspective reviewed in previous sections, industrial upgrading has been defined in a slightly different manner, as shown in Table 3-1. Adapted from these definitions, the upgrading of a region-specific industry can also be understood as a process of movements from low value-added to higher value-added manufacturing activities.

[8] Strategic coupling is defined as “a mutually dependent and constitutive process involving shared interests and cooperation between two or more groups of actors who otherwise might not act in tandem for a common strategic objective”. Here, under the context of regional development, strategic coupling refers to the dynamic processes through which actors in regions coordinate, mediate, and arbitrage strategic interests between local actors and their counterparts in the global economy (H. W. Yeung, 2009).

Table 3-1 Definitions of Industrial Upgrading from different perspectives

Theoretical Perspective	**Definition of Industrial Upgrading**
Economics	As capital (both human and physical) becomes more abundant relative to labour and the endowments of other countries, nations develop comparative advantages in capital- and skill-intensive industries (Porter, 1990)
FG	the process of bridging established and new sectors through creative destruction (Shigehisa, 2004)
GCC/GVC	a process of improving the ability of a firm or an economy to move to more profitable and/or technologically sophisticated capital- and skill-intensive economic niches (Gereffi, 1999)
GPN	a shift to higher-value-added products, services, and production stages through increasing specialisation and efficient domestic and international linkages (Ernst, 2004)

3.2 From Local Perspective

In reality, local industrial upgrading is more complicated, involving not only firm-level interactions but also interplays between firms and the local environment, including the government, infrastructure and supporting intermediaries. Moreover, in recent years, the emergence of regional chains rather than global chains is a new trend and needs to be further explored (Bamber et al., 2014).

3.2.1 Industrial Agglomeration Research

The academic research on industrial localisation can be traced back to Marshall's work on the concentration of specialised industries in particular localities (Marshall, 1890). Marshall then sparked an investigation into industrial agglomeration and termed those localised concentrations of economic specialisation 'industrial districts'. Marshallian industrial district was defined as a socio-territorial entity that was characterised by the active presence of both a community of people and a population of firms in one naturally and historically bounded area (Becattini, 1990) and could be characterised in terms of a triad of external economies, as shown in Figure 3-3 (Martin & Sunley, 2003). It was then used to denote the agglomeration of small to medium-sized enterprises (SMEs) specialising in one or a few industries in a region (Paniccia, 2006).

Figure 3-3 Marshall's Industrial Localisation (Martin & Sunley, 2003)

Based on Marshall's works and ideas that emphasised the importance of 'industrial atmosphere' in enhancing local economic growth and facilitating the generation and diffusion of new ideas (Marshall, 1920), agglomeration research can be classified into two streams. On the one hand, Porter's cluster metaphor considers more the functional aspect of industrial agglomeration (i.e. the determinants of the competitiveness of firms, industries and regions) and practical tool development for firms and governments. On the other hand, economic geographers have put more emphasis on the spatial aspect and engaged in more general theoretical discussions.

Porter's Cluster and Evolutionary Economic Geography

Defined as geographic concentrations of interconnected companies and institutions in a particular field (Porter, 1998), clusters act as the manifestation of Porter's diamond model in competitiveness analysis (Porter, 1990), where innovation and upgrading are seen as the result of interactions among actors within clusters (Porter, 1990, 1998). As shown in Figure 3-4, local concentrations of leading rival firms facilitates interactions between the factors in the diamond, a point which can be seen as the reinvention of Marshall's ideas (Martin & Sunley, 2003).

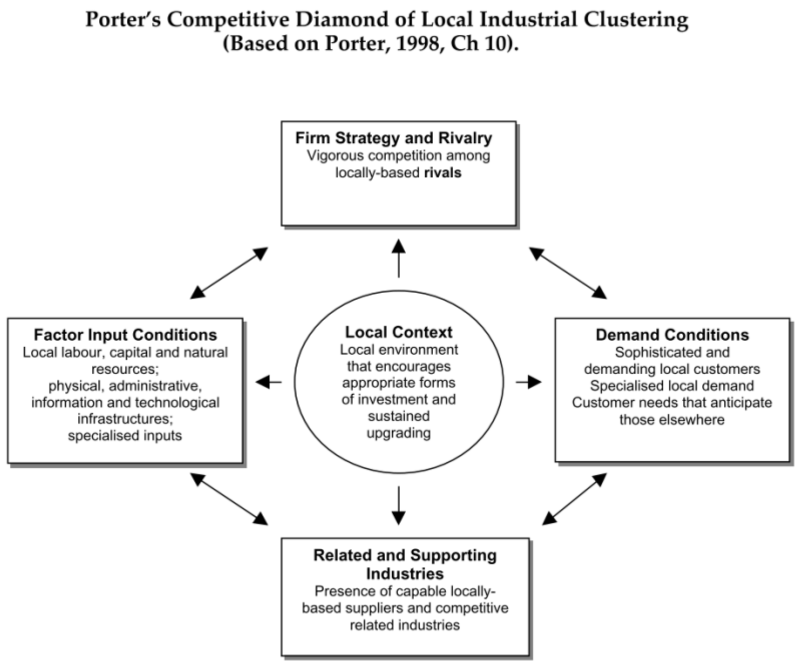


Figure 3-4 Porter's Cluster as the manifestation of the 'Dimond Model'(Martin & Sunley, 2003)

Chiming with Marshall's 'industrial atmosphere', clusters have a business environment dimension in terms of cluster-specific conditions resulting from individual and collective actions taken by actors in the cluster (Porter & Ketels, 2009). The popularity of Porter's cluster is based on its practicability for a wide range of research purposes and its aim to build synergies between groups of firms and public or private research institutions (Belussi & Caldari, 2009). These institutions can be summarised as institutions for collaboration and institutions for knowledge (see Figure 3-5) that connected to firms through spatial and functional linkages (Wang, 2010).

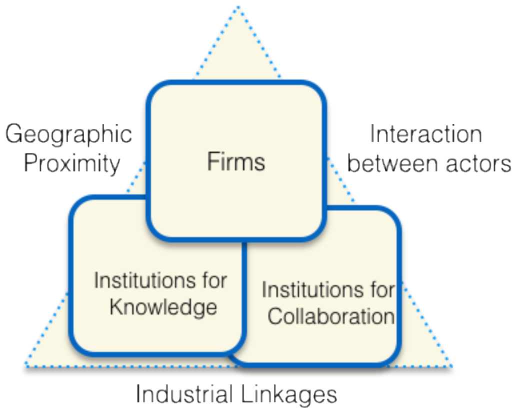


Figure 3-5 The Constitution of Clusters: Actors and Linkages (Wang, 2010)

As cluster research developed, its focus gradually shifted towards dynamic evolution rather than exploring its structure or constructs statically. Martin and Sunley (2011) introduced the adaptive cycle model from evolutionary ecology to analyse dynamic cluster evolution processes. Adapted from four sequential phases - exploitation, conservation, release and reorganisation of the evolution of a complex system (Gunderson & Holling, 2002; Holling, 2001) - the cluster evolution can be depicted as a panarchy process with evolutionary trajectories (see Figure 3-6) (Martin & Sunley, 2011). Being complex adaptive systems in reality, clusters show this kind of reflexive emergence that actors learn through interactions and recognise the contexts in which they operate and continually modify their behaviour as a consequence (Martin & Sunley, 2012). Therefore, dynamics associated with cluster evolution should be analysed by viewing the cluster as a whole rather than focusing on one set of components or one dimension of variability. However, such a model does not address detailed processes of changes along with the cluster evolution, for instance the industrial upgrading takes place across different phases.

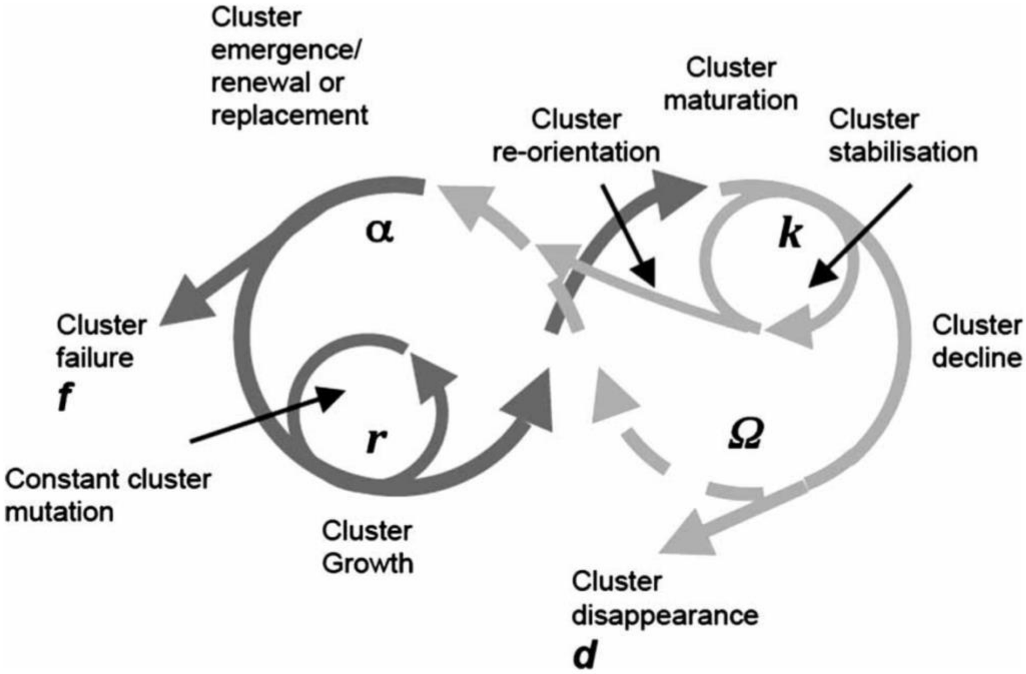


Figure 3-6 Adaptive Cycle Model for Cluster Evolution (Martin & Sunley, 2011)

A tripolar analytical framework was then suggested to analyse cluster evolution (see Figure 3-7). This framework offers a systematic way of investigating and elaborating on the evolution of clusters, especially appropriate for those in developing countries such as China, where the economic structures and practices associated with the corresponding action, network and context are in an ongoing process with discontinuous changes (Li et.al, 2012). In coastal regions of southern China, the emergence and development of industrial clusters since the 1980s can be analysed by applying this framework. Related factors and mechanisms used in achieving industrial upgrading in these clusters can be identified and understood more comprehensively by combining analyses from all three aspects. However, this framework considers action, network and context as a priori and although their interactions could explain cluster evolution, how they emerge from the region and co-evolve with the cluster has not been revealed.

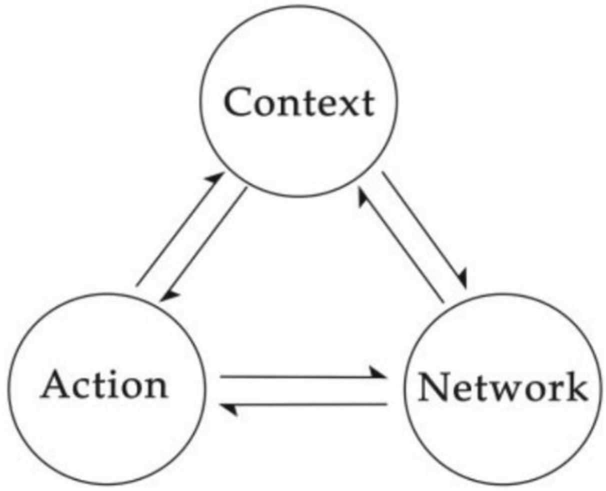


Figure 3-7 Tri-polar analytical framework of cluster evolution (Li et al., 2012)

From the cluster and evolutionary economic geography perspectives, industrial upgrading is one of the "ends" and can be achieved by various "means". Cluster upgrading can be seen as the manifestation of local industrial upgrading that follows the patterns suggested by the GVC studies, but within clusters the key to upgrade is to strengthen innovation capabilities since upgrading and innovation are intertwined (Pietrobelli & Rabellotti, 2004). Innovation is a rather broad concept, and at the regional level "innovation is produced through regional networks of innovators, local clusters and the cross-fertilising effects of research institutions" (Lundvall & Borrás, 1997, p39). The regional system of innovation (RSI) approach provides some insights for understanding how regional actors interact with each other to generate innovation.

3.2.2 Regional System of Innovation

The RSI is said to exist when a production structure and a knowledge infrastructure exist in a certain location and they are systematically engaged in interactive learning (Braczyk, Cooke, & Heidenreich, 1998). It can be established by firms based on their mutual learning processes according to geographical and relational proximity without involving knowledge generating organisations, or a cluster of firms with local supporting institutions, or cooperating with research institutions outside the region for more radical innovations (Asheim, 1998). RSIs have been visualised (see Figure 3-8) comprising two sub-systems, namely the knowledge application and exploitation sub-system and the knowledge generation and diffusion sub-system, differentiating themselves from national systems of innovation (NSIs) (Autio, 1998). Such a schematic illustration was adapted by Cooke (2002) to analyse innovation in the EU under a multi-level governance environment.

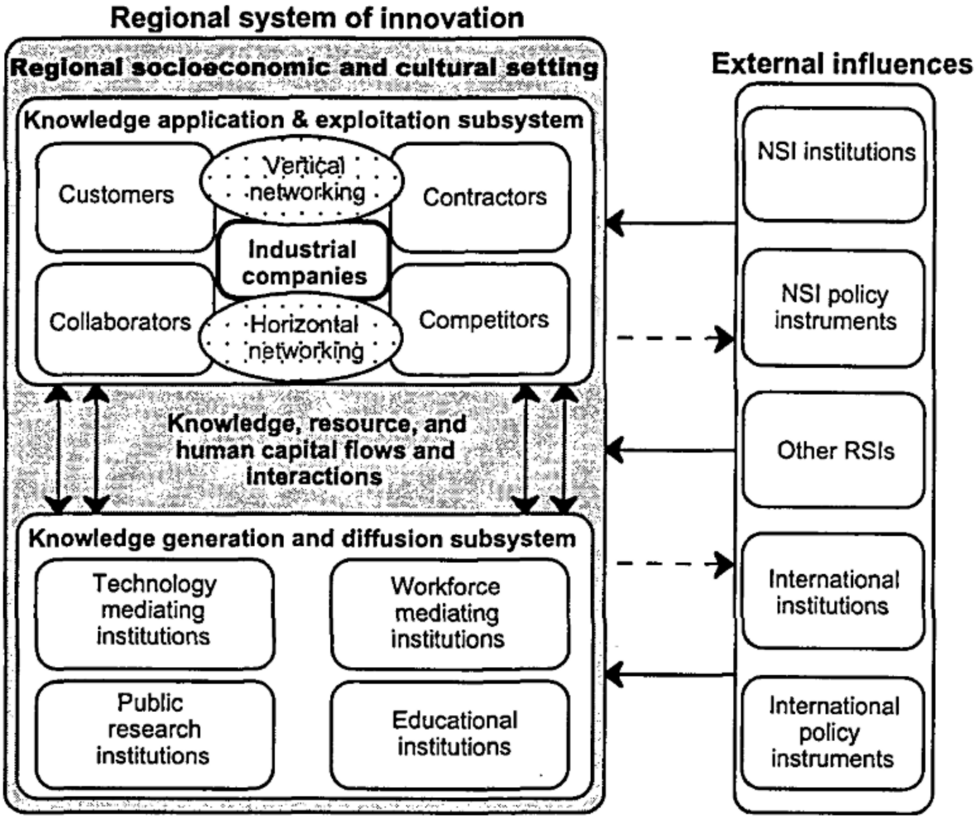


Figure 3-8 Visualisation of RSIs (Autio, 1998)

Cooke has classified RSIs into three types, namely grassroots, network, and dirigste RSI (Cooke, 1998), as well as exploring the conditions and criteria for RSIs at infrastructural and superstructural or cultural level (Cooke, 2001). Asheim (1998) elaborated these RSI types respectively as: territorially embedded regional innovation systems that grassroots innovate mainly through localised, inter-firm learning processes stimulated by combining geographical and relational proximity without directly interacting with knowledge generating organisations; regionally networked innovation systems whereby firms clustered in the region are supported by a regional institutional infrastructure for innovations; and regionalised national innovation systems that can be seen as remote R&D centres of the national authority for specific projects to develop more radical innovations based on formal analytical-scientific knowledge and with limited linkages to local industry. RSIs can also be simplified as a Triple Helix model in terms of university-industry-government relations, considering such tri-lateral networks and hybrid organisations as the key drivers for innovation (see Figure 3-9) (Etzkowitz & Leydesdorff, 2000).

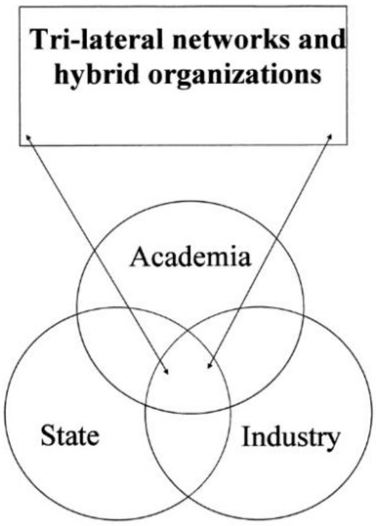


Figure 3-9 The Triple Helix Model of RSI (Etzkowitz & Leydesdorff, 2000)

An ideal-type RSI is depicted in Figure 3-10, with firms and universities in the region being the main actors and interacting with each other for innovation generation and enhancement. Local clusters act as the basis for innovations assets and besides the knowledge generation sub-system and knowledge utilisation sub-system, there exist the regional governance sub-system and the regional culture that affect the innovation process. However, the role played by regional institutions or the institutional environment in the emergence and development of RISs has not been clearly identified and categorised (Doloreux & Parto, 2005). Furthermore, both top-down (macro-to-micro) and bottom-up (micro-to-macro) mechanisms should be incorporated into the analysis of RISs at the meso-level (Dopfer et al., 2004; Iammarino, 2005).

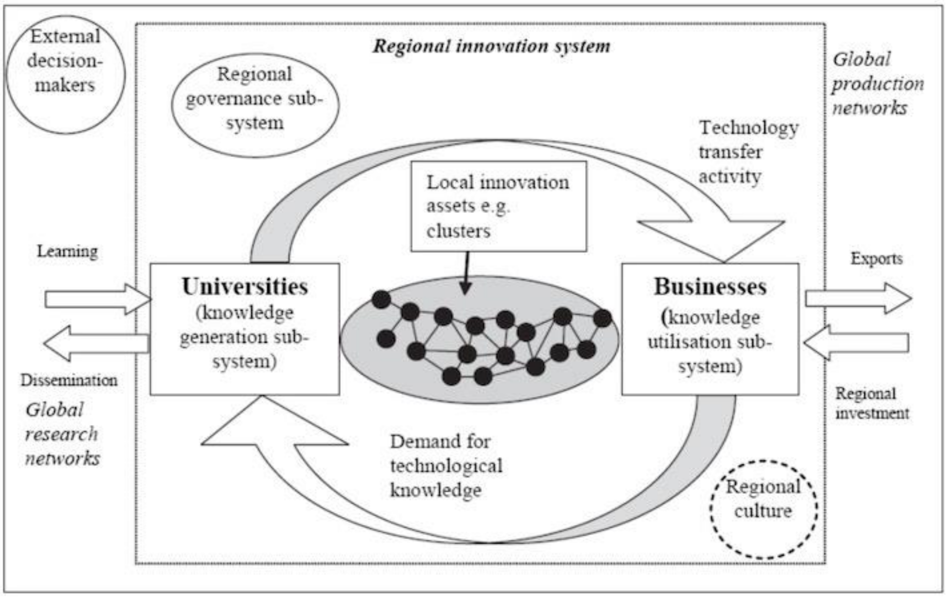


Figure 3-10 An Ideal Type of RSI (Cooke & Piccaluga, 2004)

To address such ambiguity issues of RSIs, a new conceptual model was proposed with linkage to clusters, NSI, public institutions and the external environment (see Figure 3-11). RSIs are built upon different industrial development paths of clusters to support innovation in already established industries and promote emerging industries based on new knowledge (Asheim, 2007). By adding regional policy as the third sub-system and specifying the constitution of each sub-system as well as different types of interactions between them, this model provides a more comprehensive representation for diverse actors and interactive mechanisms (Cooke et al., 2007). The RSI then gradually became an approach used in regional policy making, especially for regions to pursue industrial transformation or upgrading through innovation.

However, it would be risky if policy-makers adopted normative thinking that applied stylised constructs and ignored the importance of bottom-up processes, initial conditions and the context- and time-specific notion of the RSI (Benjamin, Kaplan, & Schroeder, 2013). Moreover, previous literature on RSI and clusters has focused on upgrading the underlying factors and taking the patterns of economic geography as given (Ketels, 2013). In reality, the RSI should also be viewed as an evolutionary process with the dynamic transformations of local industries and regional contexts. Furthermore, although most RSI studies put firms at the centre of the focus, regions are not just the containers where innovation takes place. Instead, they are actually key mechanisms that enable them (Florida, Adler, & Mellander, 2017) and should be further explored.

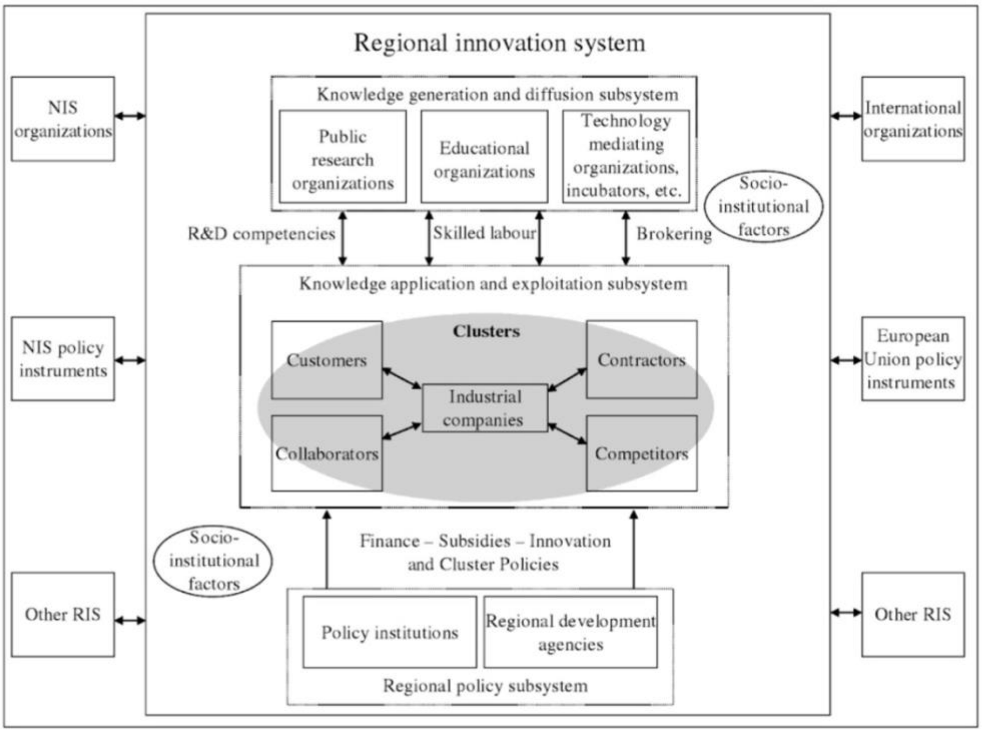


Figure 3-11 NSI, RSI and Clusters (Cooke et al., 2007)

3.3 From the Ecosystem Perspective

For local industrial upgrading, previous research has not addressed the detailed mechanisms, especially from the manufacturing perspective. It has not revealed how these actors and interactive mechanisms relate to or co-evolve with the region's development, or more specially, the enrichment of the local resources. A more comprehensive, integrated and dynamic framework will be needed to analyse industrial upgrading in a region in a longitudinal manner and show how the region can facilitate the upgrading process continuously.

In domains like evolutionary economics and evolutionary economic geography that consider evolution as the key theme, ecological metaphors are always used in analysing changes within the evolution. Nowadays, "ecosystem", borrowed from ecology, has been employed by different theoretical domains as a metaphor for analysing industrial and innovation related issues. Departing from a manufacturing standpoint, I would like to combine and integrate existing literature on industrial and regional evolution (taking the region as a whole rather than separate parts) in order to establish a regional business ecosystem model for better understanding of industrial upgrading process in a specific region.

3.3.1 Industrial Systems

Fundamentally, industrial upgrading is about changes in industrial systems, more specifically the manufacturing systems. As identified from the literature on globalisation and global industrial transfer from section 3.1, the manufacturing activities are finally located in different regions of developing countries. Then local industrial systems are gradually built up, together with the emergence and maturation of a local value chain, which can be summarised as a linear model based on Porter's value chain (see Figure 3-12).

Figure 3-12 Linear Manufacturing Value Chain

(adapted from Sainsbury (2007): the value chain of manufacturers)

This can also be seen as a broad definition of value chain for manufacturing sectors and with the trend of globalisation at the macro level, industrial systems within the global value chain change at the micro level. Manufacturing globalisation is characterised by geographic dispersed industrial systems and the coordination among these systems, which can be defined as "the process of moving from independently managed businesses serving local markets to networks of business serving the businesses' chosen market in a coordinated and optimised way" (Shi, 1998, p. 92). Adapted from Porter's matrix of international strategies for firms that depend on their choices about configuration throughout the value chain (see Figure 3-13), a coordination and dispersion platform for industrial systems to re-structure has been established (see Figure 3-14).

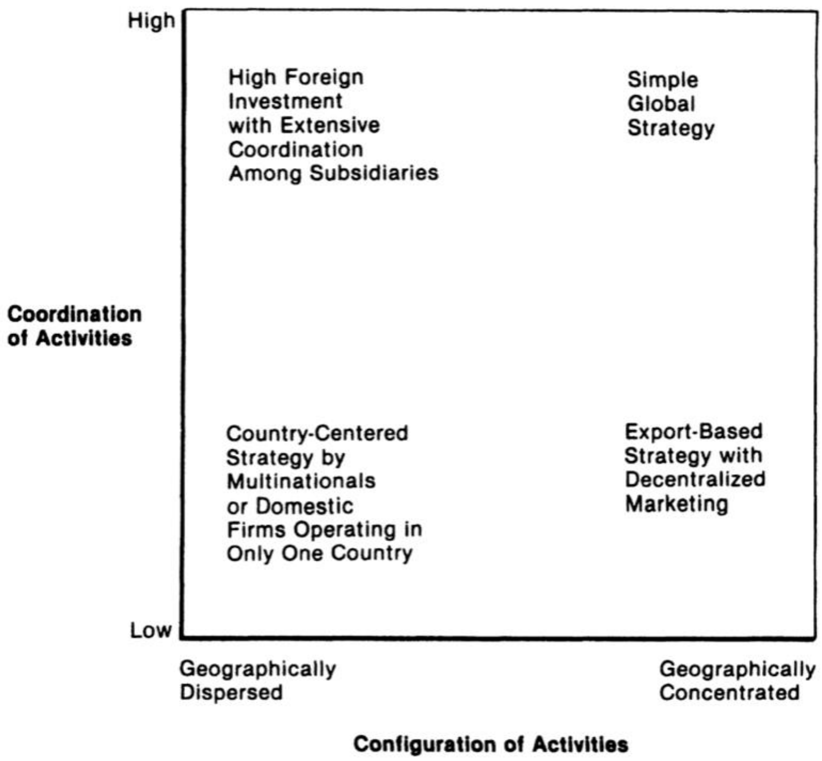


Figure 3-13 Porter's Matrix of International Strategies (Porter, 1986)

Based on case studies of MNCs, such a matrix has been further developed to show the configuration of industrial systems for international manufacturing networks. Figure 3-15 depicts seven typical configuration patterns identified by Shi and Gregory (1998), providing a structured view of international manufacturing networks and their pathways of evolution from industrial systems of home-based manufacturing.

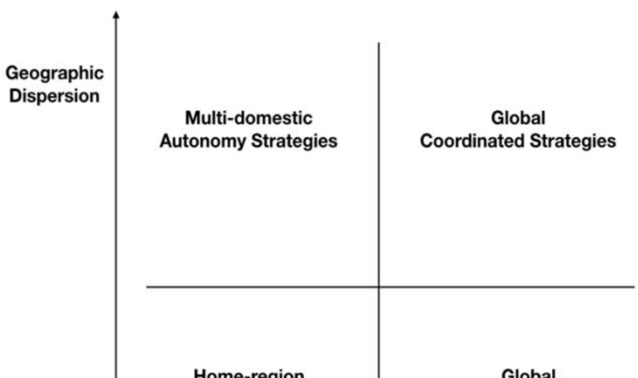


Figure 3-14 The International Manufacturing Platform representing four strategies leading to different network configurations (Shi, 1998)

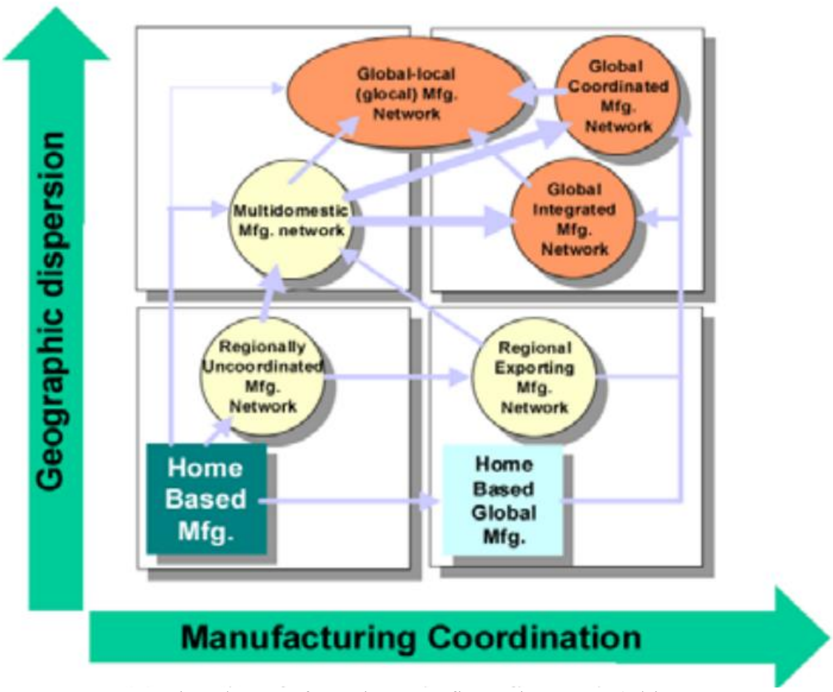


Figure 3-15 International Manufacturing Configuration Map (Shi & Gregory, 1998)

Globalisation has gradually integrated industrial systems into different intra-firm and inter-firm manufacturing networks. As shown in Figure 3-16, intra-firm international manufacturing networks are established and controlled by MNCs while inter-firm supply networks are also constructed with the possibilities of outsourcing non-core manufacturing tasks. Combining extensions on both ownership and geography, a Global Manufacturing Virtual Network

(GMVN) is considered a synthesis that can be used to explore new generations of manufacturing architecture. The “virtual” means that inter-firm relationships are used to form a temporary supply chain (Miscioscia, 2001). The formation of GMVN can be understood as the emergence of new networks between OEMs, CEMs, component suppliers and distributors rather than the traditional relationships between them. This is prominent in the electronics industry, where OEMs and professional manufacturing service providers leverage resources in a collaborative way instead of owning these assets (Shi & Gregory, 2002).

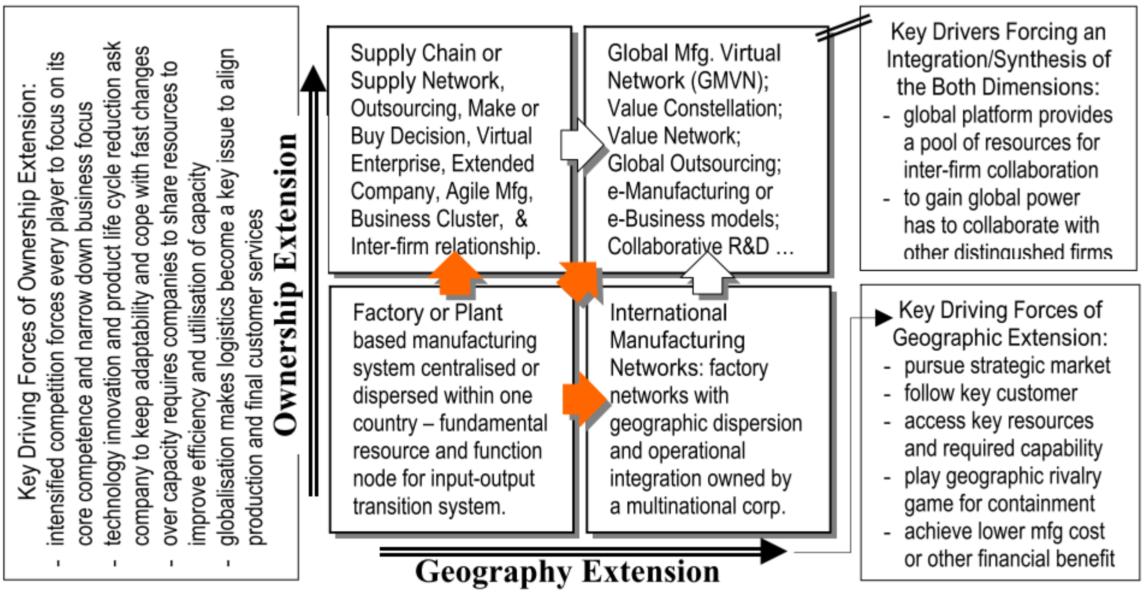


Figure 3-16 Manufacturing System Evolution Matrix and Key Drivers (Shi, 2004)

There are four basic decisions associated with the GMVN (see Figure 3-17(A)), in terms of manufacturing internationalisation or globalisation, value and supply chains, strategic alliance and the synthesis among former three dimensions (Shi & Gregory, 2002). Then, as shown in Figure 3-17(B), these three dimensions can be synthesised to a GMVN by network strategy processes, communication platform and operational mechanisms (Shi, Fleet, & Gregory, 2005).

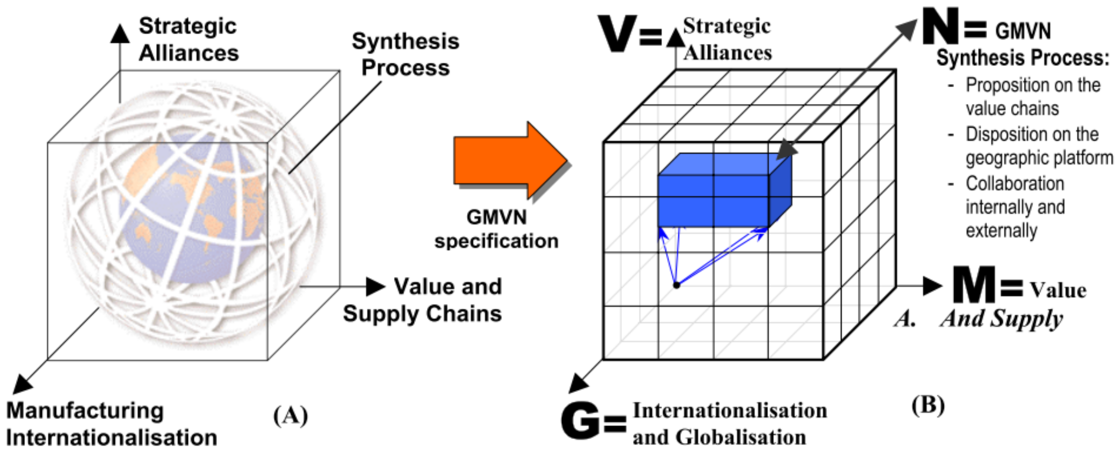


Figure 3-17 Manufacturing System Contexts and GMVN Position (Shi et al., 2005)

The GMVN has benefited developing countries and regions through enhancing the development of local CEMs or EMS providers (and their industrial systems). Within a GMVN, there is same chance for OEMs and CEMs/EMS providers to identify business opportunities and deliver a solution to a specific customer by leveraging and integrating resources, therefore it is possible for CEMs/EMS providers to achieve upgrading and establish own brands. For instance, industrial transfers from western economies and the four Asian dragons to China have nurtured a large number of Chinese CEMs and EMS providers.

3.3.2 Challenges Faced by Industrial Systems

The Shanzhai phenomenon, or the boom in white brand mobile phones in Southern China from 2007, can be seen as one of the consequences brought about by the formation of GMVN. Such a strong globally specialised and collaborated network enabled the Chinese small- and medium-sized CEMs/EMS providers to quickly respond to the changing demands of consumer electronics products and some of them even innovated to lead the market demands (Zhu & Shi, 2010). For instance, in one of my case studies, a local CEM was the largest exporter of MP3 players to the global market in 2008. For consumer electronics, there is growing uncertainty associated with product types and with the strong local manufacturing capabilities, a GMVN for a certain product is not flexible enough to accommodate unexpected changes.

Moreover, the lifecycle of consumer electronics product has shortened, and even well-established industrial systems need to be adjusted according to new generations of products. Although previous research has offered manufacturing strategies under established industrial systems for uncertain products (Hilletofth, 2009) and GMVN has provided solutions for unestablished industrial systems to deliver certain products, it is still not clear how firms can efficiently respond to orders of uncertain product types with uncertain industrial systems. Such a situation was indeed faced by many Chinese firms as the Shanzhai phenomenon proliferated in not only mobile phones but also other electronics goods with short product life cycles. Then their reactions can be summarised as a kind of ecosystem strategy (see Figure 3-18). As reviewed in section 3.3.3, ecosystem research focuses on addressing the uncertainty issue associated with value proposition among actors, which can be applied to understand the new type of industrial systems for uncertain products in a region.

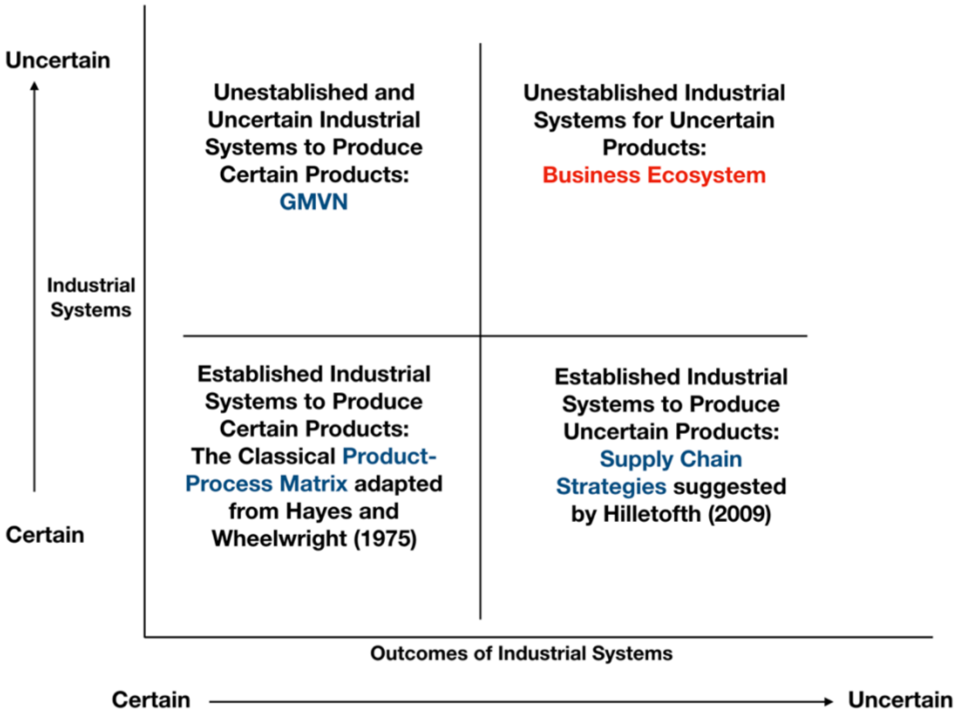


Figure 3-18 Business Ecosystem: for Uncertain Products Manufacturing under Uncertain Industrial Systems

(adapted from Shi, 2015)

3.3.3 Ecosystem Studies and Relationships with Industrial Systems

In recent decades, the surge of "ecosystems" has shown more possibilities in decision-making and setting manufacturing strategies. In business and management research, an ecosystem is always used to describe a network of interconnected organisations that are linked to or operate around a focal firm or a platform (Thomas & Autio, 2012). In regional studies, ecosystem has become a new buzzword in regional innovation and entrepreneurship research. Nowadays, there are three main streams of ecosystem studies: business ecosystem, innovation ecosystem and entrepreneurial ecosystem. Most of the theoretical foundations for this study is drawn from the literature on the former two types.

Firstly, the concept of business ecosystem was initially derived from a biological analogy of the phenomenon that industrial, social, economic and geographical factors are intertwined to form a complex system of interactive community based on common foundations (Moore, 1993). Moore defined a business ecosystem as an economic community with the support from interacting organisations, including suppliers, lead producers, competitors and other stakeholders, as well as individuals (see Figure 3-19) (Moore, 1996).

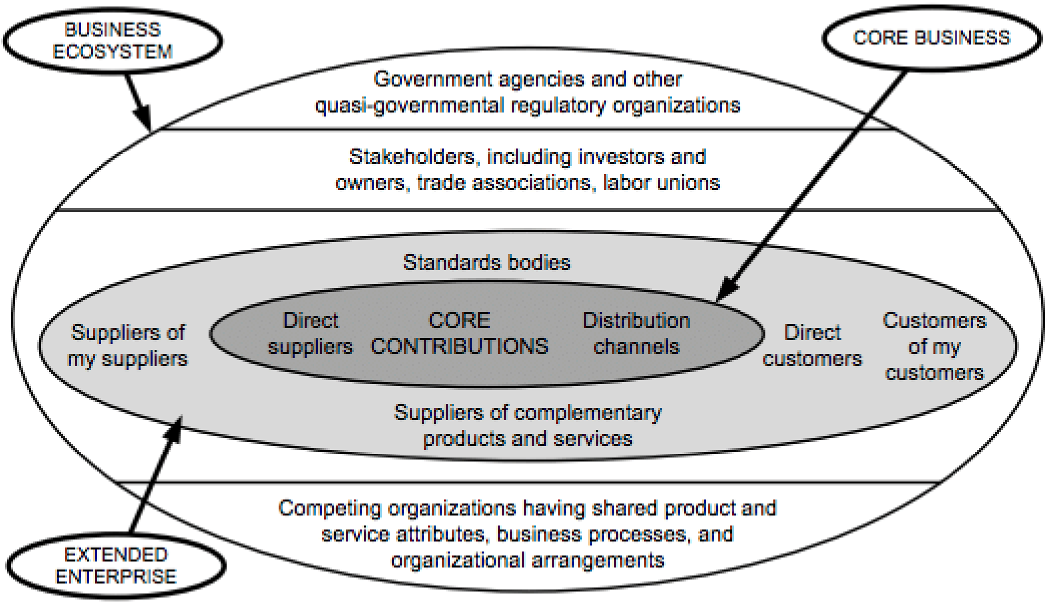


Figure 3-19 The Static Model of a Business Ecosystem (Moore, 1996)

In this sense, a business ecosystem could be seen as a new corporate form fostered by firms to achieve growth in terms of capability extension or new market development (Moore, 1998). Observing such a new corporate form, scholars have identified the associated factors and interactions between them, highlighting keystones, dominators, niche players and hub landlords as four types of ecosystem actors (Iansiti & Levien, 2002) pursuing different strategies and proposing three determinants of ecosystem health as productivity, robustness and niche creation (Iansiti & Levien, 2004a). Drawing from the ecology literature, early conceptualisations of the business ecosystem identified some actors and interactive mechanisms but did not clearly identify its boundary. Rong and Shi further deconstructed the ecosystem by lifecycle stages and configuration patterns, showing coordination and collaboration among actors for the value proposition as the ecosystem evolved (Rong, 2011; Rong & Shi, 2014). Then a "tornado model" was proposed (see Figure 3-20) to understand the business ecosystem as a dynamic community with the mission of creating business value through integrating fragmented resources from the resource pool to an industrial system and re-embedding the industrial system in the pool (Shang & Shi, 2013).

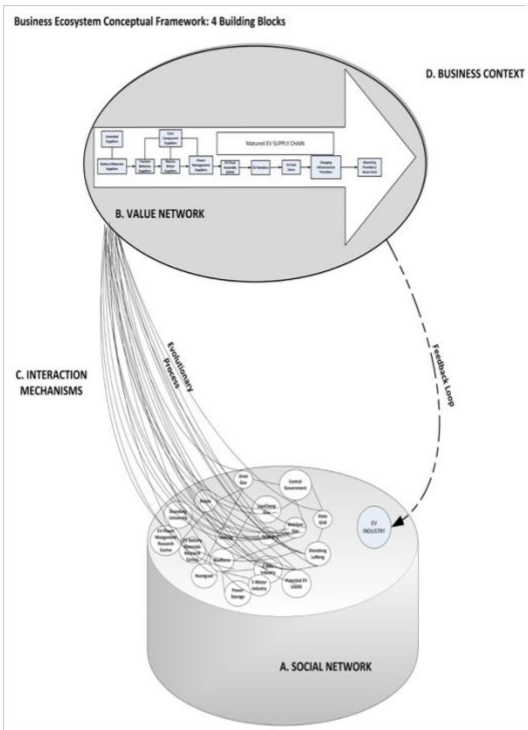


Figure 3-20 "Tornado Model" of a Business Ecosystem (Shang & Shi, 2013)

Secondly, innovation ecosystems are often used to describe the collaborative arrangements of combining firms' individual offerings into a specific value proposition (Adner, 2006). This concept was originated from the research about Silicon Valley, where innovative companies emerged and grew (Lee, 2000; Saxenian, 1994). Then, in 2004, the United States launched a report about sustaining the national innovation ecosystem, emphasising that the nation's technological progress and innovation depend on dynamic innovation ecosystems rather than mechanical end-to-end processes or individual parts (President's Council of Advisors on Science and Technology (U.S.), 2004). Similarly, Japan also adopted an ecosystem approach based on the co-evolutionary dynamics of firms and institutions to sustain national innovation (Watanabe & Fukuda, 2005). To combine the production and the use of innovations, an integrated framework (as in Figure 3-21) was proposed to show the complexity of innovation ecosystems where networks of innovations and communities of people and organisations interact for innovations to be generated and used (Wang, 2009).

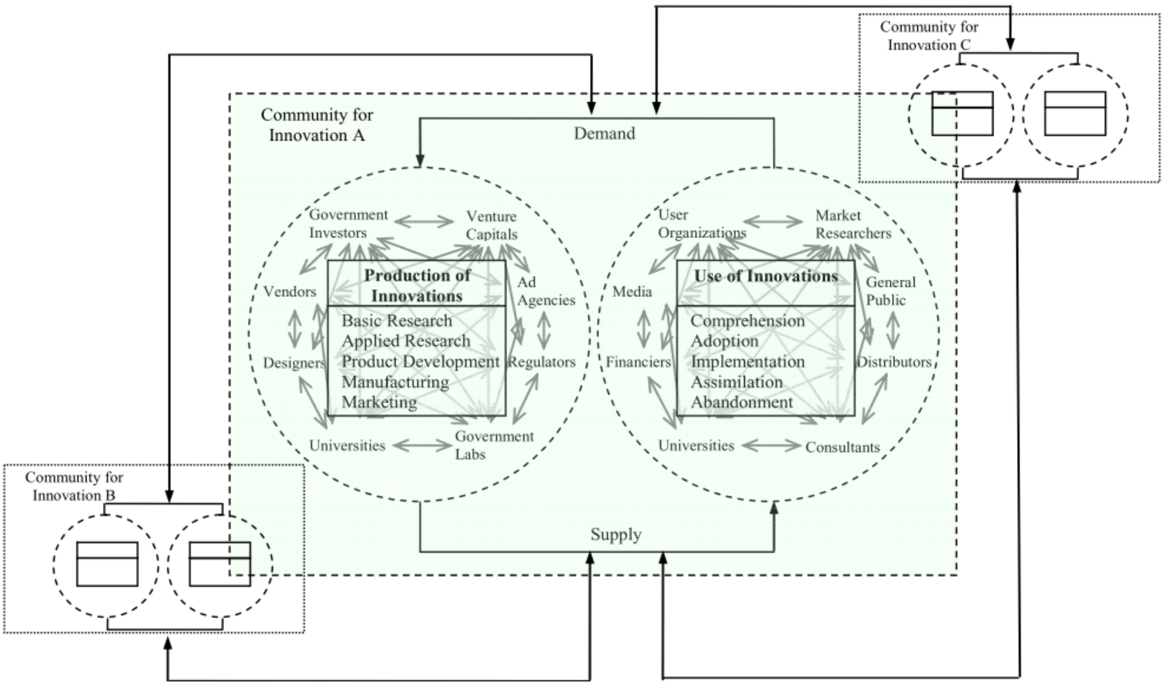


Figure 3-21 An Integrated Framework of Innovation Ecosystem (Wang, 2009)

Based on the input and output flows with respect to a focal firm in the ecosystem, Adner and Kapoor analysed how it related to its suppliers and complementors from the customer's perspectives (Figure 3-22) and examined the value creation structure (Adner & Kapoor, 2010). Then ecosystem was employed as "a wide lens" to offer firms strategic options in commercialising innovations with other actors, especially those complementors (Adner, 2012).

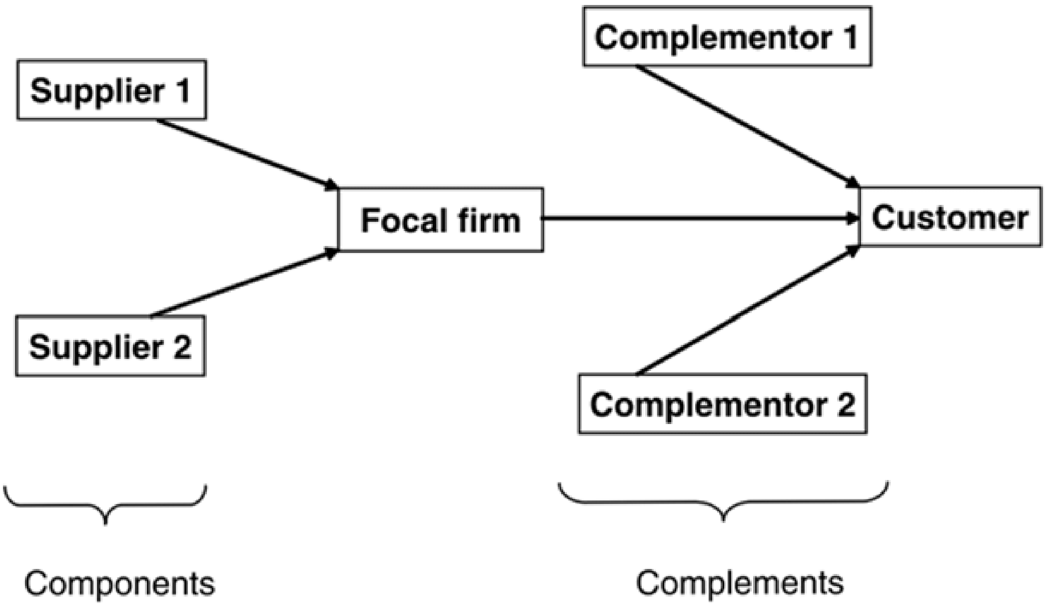


Figure 3-22 Innovation Ecosystem around a focal firm (Adner & Kapoor, 2010)

In contrast to other network constructs in management research, innovation ecosystem refers to a network that covers both producers and users, as well as complementors and customers, and can therefore be defined as a network of interconnected organisations around a focal firm or a platform, focusing on new value creation through innovation (Autio et al., 2014). However, innovation ecosystem research was criticised for over-emphasising technological aspects whilst neglecting the non-technological elements such as strategy, organisation and institution that had the same importance for building up the competency of these innovation ecosystems (Oh, Phillips, Park, & Lee, 2016). At the regional level, a successful practice of innovation ecosystem that considered not only the technological innovations but also other supporting institutions has been carried out in the city of Shenzhen based on abundant local enterprises and resources (World Economic Forum, 2016). Nevertheless, a regional-level global innovation ecosystem rather than regional innovation ecosystem is more appropriate to describe the emergence of innovation ecosystems in China. This is because nowadays, with the advancement of communication technologies, innovation ecosystems should be global, plugging into the knowledge generated *outside* the home country while at the same time fostering the symbiotic relationships between players domestically that will drive innovation *within* the country (Fransman, 2018).

3.4 Summary and Identification of Research Gaps

In sum, then, three main research gaps have been identified from reviewing the existing relevant literature on industrial upgrading and business ecosystems. Firstly, from local and manufacturing network studies, actors and interactions for innovations at region-level as well as configuration mechanisms of regional industrial systems have been identified but the *evolution of the regional resource pool* has not been revealed. The formation and changes of some types of resources in a region are important for local industrial development. Secondly, although different types of industrial upgrading have been identified from the global perspectives while strategies for industrial upgrading through innovation enhancement in a region have been suggested by the local perspectives, neither of them has comprehensively elaborated *regional industrial upgrading per se as a process*. Thirdly, being a continuous and dynamic process, regional industrial upgrading is practiced by industrial systems of firms and their interactions with and impacts on the regional resources have not been fully addressed by any single discipline. A more comprehensive framework is necessary for exploring the *co-evolutionary mechanisms between industrial systems and resources in a region for regional industrial upgrading*. The "tornado model" of a business ecosystem, providing a holistic view of the analysis of interactions between the resource pool and industrial system, is adapted to form the conceptual framework for this research.

As illustrated in Figure 3-23, the conceptual framework of a business ecosystem at the regional level is constructed to incorporate different theoretical domains in a region-based business ecosystem model so as to address the research gaps identified from the literature. First and foremost, a business ecosystem perspective, which possesses co-evolution of participants (Moore, 1996) and adaptability to changes (Teece, 2016), has been applied to analyse industrial dynamics mainly driven by innovation (Rong et.al, 2017). During the development of business ecosystem theories, the constructs and evolution of an ecosystem have been summarised by a dynamic business ecosystem model (Shang & Shi, 2013), together with a 6C framework that aims to interpret the co-evolution of industrial systems and their dynamic environment (Rong et al., 2015). To understand industrial upgrading as a dynamic and evolutionary process in a region, a regional version of the business ecosystem has been developed based on the iterative and co-evolving logic inherited from the dynamic model, with the regional resources pool, regional industrial systems and interactive mechanisms between them as the main constructs.

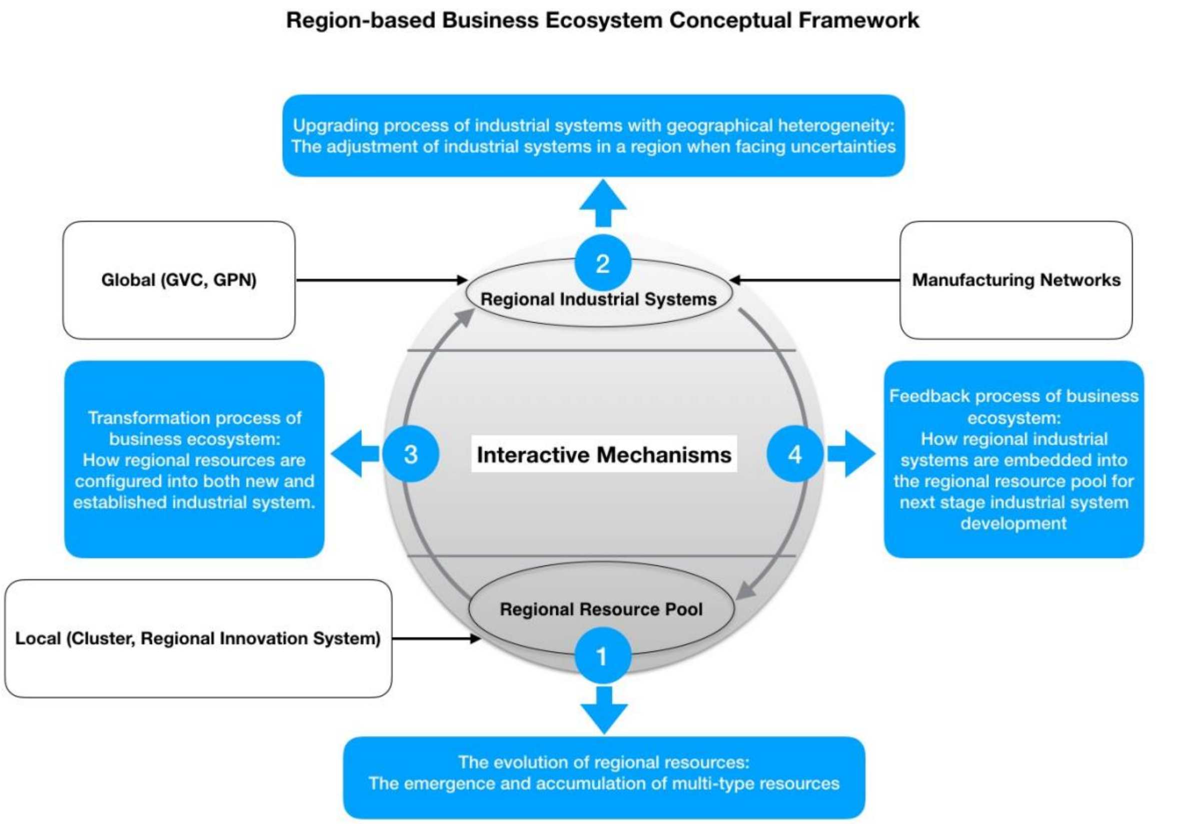


Figure 3-23 Conceptual Framework and Identification of Research Gaps

Regional Resource Pool

In traditional economics, land, labour, capital and enterprise are considered as key resources that are essential for production, namely the factors of production. For individual firms, the resource-based view (RBV) of firms focused on the utilisation of their internal resources to pursue competitive advantages (Barney, 1991) whilst Porter's strategy studies considered more about resources in their external environment (Porter, 1985). Penrose perceived the firm as a pool of resources organised in an administrative framework and the firm growth as an evolutionary process that involves the accumulation of resources (Best & Garnsey, 1999; Penrose, 1959). For a region, the resources are more complex than from a firm's perspective in terms of types and accessibility. From a spatial perspective, resources refer to not only machinery, equipment and financial capital that important for the production process but also other socially constructed entities that depend on collective processes of resource generation and application, such as experience, knowledge, social capital and power (Bathelt & Glückler, 2005). Therefore, the resources necessary for the upgrading process of a region-specific industry can be viewed as a regional resource pool or the resource-based view of a region-based business ecosystem, which comprises the emergence and accumulation of multi-type resources along with the regional industrial development.

When moving towards a more technology-intensive and knowledge-intensive economy through industrial upgrading, there is growing importance of obtaining intangible resources such as knowledge, power and social capital. In addition to acquiring material resources that are crucial for production, the producers or carriers of those intangible resources in a region need to be identified. Based on the understanding of regional resources from literature in economic geography (Martin & Sunley, 2003; Storper, 2013) and resource-based view (Garnsey & Leong, 2008), the phases of regional resource pool evolution are examined with the empirical evidence from Shenzhen.

Regional Industrial Systems

In a region, there exist diversified industrial systems, even within one industry. As discussed in the previous section, when facing growing uncertainties, the studies in supply chains focus on maintaining production for existing markets rather than nurturing new markets whilst business ecosystem theories do address uncertainties associated with new markets (Rong & Shi, 2009; Rong, Shi, & Yu, 2013). Developed from supply chain theories, business ecosystem expands the supply chain network to include the process of co-evolution of industrial systems and their dynamic environment with uncertainties and a wide range of business opportunities (Breslin, 2011; Moore, 2006; Rong et al., 2015).

For industrial systems in a region, value chain and production network literature has classified different types and strategies of upgrading under the context of globalisation and international division of labour but neglect the geography of industrial upgrading (Liu, 2017). Based on the previous experience of joining the global value chain and global production network, manufacturing firms in Shenzhen have already made their own ways to achieve upgrading of their industrial systems over the past few decades. Such processes with geographical heterogeneity are explored to show how industrial systems adjust themselves for production when facing uncertainties from existing markets and emerging markets concurrently.

Interactions: co-evolutionary mechanisms

In a business ecosystem, those fragmented resources can be mobilised with a specific vision and transformed into a new industrial system and in return, the industrial systems will be embedded in the ecosystem's resource pool (Rong et al., 2018; Shang & Shi, 2013; X. Shi & Shi, 2017). On one hand, the transformation process of business ecosystem for the emergence of new industrial systems has been revealed with firm- and industry-level analyses from empirical evidence (Ng, 2016; Shang, 2014). At regional level, the transformation process of the business ecosystem should be further explored to uncover how resources are configured into not only new industrial systems (new sector emergence) but also those established ones (established sector transformation).

On the other hand, the embedding process of the business ecosystem should be paid more attention to since the embedded resources are potential contributors for industrial system development in the next stage. The embeddedness of production networks in the places they inhabit has been emphasised by global production network studies (Dicken & Henderson, 2005; Hess & Coe, 2006), indicating the importance of the embedding process on sustaining the regional industrial development through continuous upgrading.

Chapter 4 Research Methodology

This chapter presents the methodology, including research design, data collection and data analysis methods that have been employed to address the proposed research questions and objectives. The main research questions and objectives are raised at the beginning of this chapter. This is followed by a justification of the methods selected and the development of procedures in data collection and analysis.

4.1 Research Questions

Based on the research gaps identified in the literature review (see Chapter 3), the main research question of this thesis is:

How does a region act as a business ecosystem to facilitate the upgrading of a region-specific industry?

This overarching question can be divided into three sub-questions:

Sub-question 1: What is the evolutionary pattern of a regional resource pool?

Sub-question 2: How to understand the upgrading of a region-specific industry?

Sub-question 3: How does a regional resource pool interact with regional industrial systems to facilitate industrial upgrading?

4.2 Research Design

4.2.1 Philosophical Position and Selection of Research Method

In the social sciences, the philosophical position of the research can be identified according to its ontological, epistemological and methodological concerns (Corbetta, 2003). From a spectrum of positions, Table 4-1 illustrates the options of philosophical position for this research.

Positivism is a research paradigm based on observation and restricted to the observables, advocating that the social world is external and its properties can be measured objectively (Easterby-Smith, Thorpe, & Jackson, 2012). Positivism is based on two fundamental assumptions: that ontologically reality is external and objective; while, epistemologically, knowledge is significant only when it is based on accurate observation and measurement of this external reality (Comte, 1853). From the positivist perspective, the role of research is to test theories and devise rules for reality. The natural sciences usually adopt a positivist research framework by emphasising the importance of empirical testing and measurement to research and theorise deductively.

In contrast, research in the interpretivist paradigm develops new theories in an inductive way (Bryman, 2015). Theory development aims to describe, explain and predict social phenomena (Kerlinger & Lee, 1999). From the interpretivist perspective, knowledge and understanding are socially constructed (Gephart, 2004). The social sciences are interpretivist/constructivist in the sense that understanding the behaviours of entities in society inevitably entails subjective opinions rather than hard ahistorical facts. Inductive methods such as theory building from cases can be used to address complex social issues that intertwine the technical and the social aspects, and then to develop theories effectively from what has been observed (Eisenhardt, Graebner, & Sonensheim, 2016).

Being a context-based exploratory study that aims to understand the continuous industrial upgrading phenomenon taking place in a region and facilitated by a corresponding and socially constructed business ecosystem, the philosophical position of this research is interpretivist. Approaching its research questions with the ontological and epistemological position of interpretivism, the research methods employed are qualitative, involving textual and discourse analysis. In social science research, different methods are distinguished by three conditions (see Table 4-2).

Table 4-1 Ontologies, epistemologies and methodologies in the social sciences

(adapted from (Della Porta & Keating, 2008))

Philosophical Position	**Positivism**	**Neo-positivism and post-positivism**	**Interpretivism/ Social Constructionism (Constructivism)**	**Humanism**
Ontological issues				
Does social reality exist?	Objective; realism	Objective; critical realism	Objective and subjective as intrinsically linked	Subjective
Is reality knowable?	Yes, and easy to observe and measure	Yes, but not easy to observe and measure	Somewhat, but not as separate from human subjectivity	No; focus on human subjectivity
Epistemological issues				
Relationship between the scholar and his/her object	Dualism: scholar and object are two separate things; inductive procedures	Knowledge is influenced by the scholar; deductive procedures	Aims at understanding subjective knowledge	No objective knowledge is possible
Forms of knowledge	Natural laws (causal)	Probabilistic law	Contextual knowledge	Empathetic knowledge
Methodological issues				
Which methodology?	Empiricist, aiming at knowing the reality	Mainly empiricist, recognising context	Relative focus on meanings, context	Focus on values, meaning and purposes
Which method(s)?	Imitating the natural method (experiments, mathematical models, statistical analysis)	Based upon approximation to the natural method (experiments, statistical analysis, quantitative interviews)	Seeking meaning (textual analysis, discourse analysis)	Empathetic interactions between researchers and object of research

Table 4-2 Relevant situations for different research methods (R. Yin, 2018)

Method	**Form of Research Question**	**Requires Control Over Behavioural Events?**	**Focuses on Contemporary Events?**
Experiment	how, why?	yes	Yes
Survey	who, what, where, how many, how much?	no	yes
Archival Analysis	who, what, where, how many, how much?	no	yes/no
History	how, why?	no	no
Case Study	how, why?	no	yes

The main question of this research is a "how" type question, and being an ongoing process, industrial upgrading in a region cannot be controlled by any single researcher. Thus, case studies that focuses on contemporary events, relying on direct observation of the events being studied and interviews of the persons who may still be involved in those events (R. Yin, 2018), were deemed the most appropriate method. Moreover, theory building instead of theory testing and the exploratory nature of this research reaffirms the selection of case studies as the appropriate research method. In order to understand the region-based business ecosystem underpinning and enabling local industrial upgrading processes to take place continuously and figure out how these "invisible hands" work, insights could only be obtained through investigating the interactions between case companies and the regional resources, as well as identifying a series of milestone events that result in the evolution of a regional resource pool and have a direct impact on the upgrading process at different stages.

To build up theory from the case study method, multiple-case study designs are preferred to single-case study designs to satisfy the research criterion of robustness (Herriot & Firestone, 1983). Yin also suggested that case studies can employ an embedded design with multiple levels of analysis in a single study (R. Yin, 1984). Then, patterns can be identified and consolidated through cross-case analysis by viewing the data in diverse ways (Eisenhardt, 1989). Therefore, a multi-level longitudinal case study with embedded settings is designed for building a framework for the region-based business ecosystem in facilitating local industrial upgrading.

4.2.2 Unit of Analysis

According to Yin, the unit of analysis (or the "case"), can be derived from the research question(s) (R. Yin, 2018). Since the research question and sub-questions focus on the region and the region-specific industry, the unit of analysis is the region (Shenzhen) as a whole business ecosystem, with the electronics industry embedded in this ecosystem and firms (or industrial systems) embedded in this industry, leading to three levels of analysis. Firstly, for the main types of resources in the region through its development phases, analysis at the ecosystem level is conducted to show the evolution of the regional resource pool. Secondly, for the changing mainstream manufacturing style applied at different time periods, an industry-level analysis is used to identify the trend experienced by the industry. Thirdly, for the industrial upgrading process, firm-level analyses are used to understand the interactions between the industrial systems and regional resources.

4.2.3 Data Selection

From the practical review in Chapter 2, the development of the electronics industry in Shenzhen has been reviewed and aroused the research interest. Hence, Shenzhen is selected as the region-based business ecosystem with evolution in both resources and the electronics industry to focus on. Milestone events are identified by applying the temporal bracketing strategy (Langley, 1999) to show the phases of regional resource pool development while embedded case companies in the electronics industry are then identified in a theoretical sampling manner whereby "cases are selected because they are particularly suitable for illuminating and extending relationships and logic among constructs" (Eisenhardt & Graebner, 2007).

On the one hand, the selection criteria for the case companies are as follows:

1. Originated from Shenzhen and currently headquarters or manufacturing activities still based in this region.
2. For established firms, they must have more than 15 years history[9] and experienced upgrading at least once (either within the same sector or upgraded to a new sector of the electronics industry).
3. For start-ups with less than 10 years history, they must be in an emerging sector of the electronics industry.
4. All must have specific products that are manufactured using local resources.
5. All must be suggested by industry rankings or recommended by industry experts. [10]

On the other hand, besides the temporal bracketing strategy (Langley, 1999) applied, the selection criteria for milestone events are as follows:

1. Must be initiated by people/organisations in Shenzhen.
2. Must have a direct impact on at least one of the transitions in Shenzhen's development.
3. Must have a direct or indirect impact on the dynamics of Shenzhen's electronics industry.
4. Must be highlighted by published works, including newspapers, reports and books, etc. more than 10 times.
5. Be recommended by more than 5 experts.

[9] Shenzhen is a relatively young city that was officially entitled as a prefecture-level city in 1979 and was established as China's first Special Economic Zone in 1980. The duration of 15 years is not a very long period of time but seems to be a reasonable benchmark for a company that has grown in a city with less than 40 years development.

[10] Industrial rankings for electronics companies in Shenzhen from official and informal sources were collected and some experts, including government officials and professionals that have worked in Shenzhen's electronics industry, were consulted for advice before making the selection of case companies.

Tables 4.3 and 4.4 present the cases selected following the criteria listed above.

Table 4-3 Companies selected for case studies

Case Company	Founded Year	Main Product(s)	Market Segment/Sector
SEG	1986	Display, IC and other components	Electronics component
BYD	1995	Battery, mobile phone	Consumer electronics
ComTech (and its subsidiary IngDan)	1995 (2010)	IC	Electronics component
Netac	1999	USB flash memory disc	Hi-tech device
Rapoo	2002	Keyboard, mouse	Consumer electronics
Lachesis (and its antecedent)	2010 (2000)	Portable ward device (MP3)	Medical device (consumer electronics)

Table 4-4 Events selected for case studies

Case Event	Time	Main Contribution
Establishment of the Shekou Industrial Zone	Late 1970s	Laid the foundation for the city's infrastructure construction and initiated the foreign invested manufacturing activities.
3+1 Trading Mix	Late 1970s – mid 1990s	Initiated the process manufacturing activities in Shenzhen.
The Hi-tech Fair	Since 1999	Triggered the transformation of local industries from low-tech to hi-tech.
The Shanzhai Phenomenon	Mid – late 2000s	Stimulated the transformation of manufacturing activities from mass production of certain products to flexible and customised production of products with uncertainties.
Establishment of the Shenzhen Institutes of Advanced Technology (SIAT)	2006	Facilitated local firms to pursue technological upgrading.
The Maker Phenomenon	Early 2010s	Utilised the resources from the Shanzhai manufacturing for indigenous innovations.

For each case, secondary data from various sources were collected and at least one interviewee was contacted before conducting the fieldwork. For company cases, interviewees identified at the initial stage are founders or experienced managers while for event cases, local government officials and researchers familiar with Shenzhen's development are approached in the pilot study. More interviewees and secondary data sources are subsequently identified according to a "snowball sampling" strategy during the process of field visits and interviews. Generally, interviewees were selected based on two perspectives:

1. They might have stayed in Shenzhen and witnessed its development for more than 10 years[11].
2. They might have directly or indirectly engaged in the upgrading process of Shenzhen's electronics industry in terms of participation in critical events or important company decisions.

4.3 Data Collection

Data collection methods such as archives, interviews, questionnaires, and observations can be combined when conducting case studies (Eisenhardt, 1989). In this research, secondary data was collected mainly from archives and documents while primary data was collected through field visits and interviews.

4.3.1 Data Sources

There are six major sources of evidence in case study research, namely documentation, archival records, interviews, direct observations, participation-observation and physical artefacts (R.

[11] For a city in mainland China, at least one important industrial change will be observed according to the national and regional 5-year plans and the global technological advancement.

Yin, 2018). It is necessary to use multiple sources of data to garner an in-depth and contextual study for such a real-world phenomenon.

Before collecting the primary data through interviews and direct observations, secondary data about the background of case companies and events was located in documentation and archival records. Sources of documentation are mainly formal studies or evaluations related to industrial upgrading in Shenzhen and news clippings and other articles appearing in the mass media or in community newspapers, while archival data in terms of statistics released by multi-level governments, maps and charts of the geographical characteristics of Shenzhen, as well as survey data such as industrial reports produced by different organisations. In addition, other sources such as video clips of documentaries about the focal region and industry of this research and museum visits were also used as supporting materials. The detailed sources of secondary data collection are listed in Table 4-5.

With background information obtained from the secondary data, field visits to the selected case companies and related institutions identified were conducted, together with semi-structured interviews with the informants contacted. The primary data collection took place in three phases, with a pilot study in 2016 (1st phase) and fieldworks in 2017 (2nd phase) and 2018 (3rd phase). All primary data was collected in Shenzhen and the surrounding area such as Dongguan. Tables 4-6 to 4-8 present the primary data sources.

Table 4-5 Sources of secondary data

Documentation	*Studies*	"The Research about the Evolution and Development of Shenzhen's Industrial Structure"《深圳产业结构演化与发展研究》
		"China's Economic Zones: Design, Implementation and Impact"
		"Regional Development for Pearl River Delta" 2013, 2014, 2015《珠三角区域发展报告（2013）》《珠三角区域发展报告（2014）》《珠三角区域发展报告（2015）》
		"Industrial Development of Hong Kong and Pearl River Delta Opportunities & Strategies"
		"The Localisation and Differences in Economic Development under Globalisation -- Comparative Study based on Three Economic Development Paths in Guangdong"《全球化背景下经济发展的本地化与差异性——基于广东经济发展三种不同模式的比较研究》
		"Shenzhen Electronics in Thirty Years (1980-2010)" 《深圳电子三十年》
		"Guangdong Manufacturing Development in Forty Years" 《广东制造发展四十年》
		"Guangdong Economic Reform in Forty Years -- Logics behind Regional Reforms " 《广东经济改革四十年——地方改革的逻辑》
		"Chronical of Shenzhen Special Economic Zone (1978-2015)" 《深圳经济特区年谱（1978-2015）》
		"Chronical of Shenzhen Special Economic Zone (1978-2018)" 《深圳经济特区年谱（1978-2018）》
		"Regional Powerhouse: The Greater Pearl River Delta and the Rise of China"
		"Learning from Shenzhen -- China's Post-Mao Experiment from Special Zone to Model City"
		"Study on Competitiveness of Enterprises Cluster" 《企业聚群竞争力——珠江三角洲企业聚群竞争力提升战略研究》
		"The Development Pattern, Transformation and Upgrading on Pearl River Delta Industrial Cluster" 《珠三角产业集群发展模式与转型升级》
		"The Space of Innovation in Pearl River Delta of China: Corporation Organization and Interaction" 《珠三角创新空间：企业组织与网络》
		"Explorations of the Forerunner -- Guangdong's Reform and Opening Up in Forty Years"《先行者的探索——广东改革开放40年》
	News Articles	Articles related to "Shenzhen Electronics" (all available dates)
		Articles related to "Shenzhen Development" (all available dates)
		Articles related to "the Pearl River Delta (PRD)" (all available dates)
		Articles related to "Industrial Upgrading in China" (all available dates)
		Articles related to "Electronics Indsutry Upgrading" (all available dates)
		Articles related to "Shenzhen Manufacturing " (all available dates)
		Articles related to "PRD Manufacturing " (all available dates)
Archives	*Statistics*	"Guangdong Statistical Yearbook" (all available years)
		"Statistical Yearbook of China's Electronics and Information Industry" (all available years)
		"Shenzhen Statistical Yearbook" (all available years)
	Reports	"The Research Report of Transformation and Upgrading Strategies in Shenzhen's Electronics and Information Industry"《深圳电子信息产业转型升级策略研究》
		"The Research Report of the Experience, Problems and Solutions in Shenzhen's Innovation Development"《深圳城市创新发展经验、问题与对策研究》
		"The Research Report of the Technological and Industrial Development in Shenzhen's Electronics Components (2014)"《深圳市电子元器件技术与产业发展研究报告（2014）》
		"The Research Report about the Establishment of Shenzhen's Comprehensive Innovation System"《深圳市综合创新生态体系建设研究》
		"The Research Report of Establishing Shenzhen's Innovation-oriented Research Institutes"《深圳建立创新型研究院体系研究》
		"Shenzhen Technological and Innovation Development Report (2016)"《深圳市科技创新发展报告（2016）》

(to be continued)

Extensive Sources	*Documentaries*	The People’s Republic of The Future (Bloomberg Businessweek Presents) Hello World Season 1 (21) Inside China's Future Factory: https://www.youtube.com/watch?v=eLmaIbb13GM&t=0s&list=PLqq4LnWs3olVtd-fSbmz8a0KhoBCB8JW4&index=22 Hello World Season 1 (22) China's High-Stakes Robot Wars: https://www.youtube.com/watch?v=qrhvZhPaxQ4&list=PLqq4LnWs3olVtd-fSbmz8a0KhoBCB8JW4&t=0s&index=23 Hello World Season 1 (23) Inside China's High-Tech Dystopia: https://www.youtube.com/watch?v=ydPqKhgh9Mg&index=24&t=0s&list=PLqq4LnWs3olVtd-fSbmz8a0KhoBCB8JW4
		Shenzhen Stories (1-8) https://www.youtube.com/watch?v=TlyWG-QMP84 https://www.youtube.com/watch?v=IJK3yI9JbTo https://www.youtube.com/watch?v=QA2PAh7jBC4 https://www.youtube.com/watch?v=tqu0E88dWcs https://www.youtube.com/watch?v=aLyK3sjkSx8 https://www.youtube.com/watch?v=3Q-eO9EMemg https://www.youtube.com/watch?v=Tt8a6Mrm06s https://www.youtube.com/watch?v=CXG5b-5_2-I
		Shenzhen: Forging China’s Modern Identity (Shenzhen: The Migrant Experiment) https://www.youtube.com/watch?v=HC9qUlt8RLc
		Shenzhen: The Silicon Valley of Hardware (Full Documentary) | Future Cities | WIRED https://www.youtube.com/watch?v=SGJ5cZnoodY&t=8s
		Inside the world's craziest gadget market https://www.youtube.com/watch?v=ezSd6_2_ts0
	Museums	Shekou Reform and Opening Museum
		Shenzhen Museum
		Shenzhen Industrial Museum

Table 4-6 Sources of primary data (1st phase)

	Organisation	Date	Interviewee (Position)	Duration of Interview
1st Phase	Huawei	07/07/2016	Vice President of Public Affairs	45 mins
	Foxconn	08/07/2016	Marketing Director, President of the FIT Branch	55 mins, 30 mins
	BGI	08/07/2016	Vice President, Operation Director	38 mins, 59 mins
	Topray Solar	12/07/2016	President, Vice President	66 mins
	Songshan Lake Robotics Industrial Park	13/07/2016	Director of Public Relations	104 mins
	Shenzhen Qianhai Financial Holdings	13/07/2016	Director of Fund Management	30 mins
	Shenzhen Innovation Fund	14/07/2016	Senior Investment Manager	56 mins
	SIAT	18/07/2016	Director of Graduate Studies	90 mins
	Huawei	19/07/2016	Supply Chain Manager	70 mins
	Shenzhen Science, Technology and Innovation Commission	19/07/2016	Deputy Director	59 mins
	Shenzhen Development and Reform Commission	19/07/2016	Deputy Director	64 mins
	Tencent	19/07/2016	Senior Product Manager, Senior Strategy Analyst	30 mins, 40 mins
	Han's Laser	20/07/2016	Senior Manager	45 mins
	Netac	21/07/2016	Founder	35 mins
	N/A	22/07/2016	Former Deputy Mayor of Shenzhen and Former Vice Provincial Governor	40 mins

Table 4-7 Sources of primary data (2nd phase)

2nd Phase	Green Pine Capital	23/03/2017	Business Partner	55 mins
	Netac	24/03/2017	Deputy General Manager, IP Manager	60 mins
	China Merchants Shekou Industrial Zone Holdings	29/03/2017	Deputy General Manager	65 mins
	Midea	30/03/2017	Strategy and Investment Director, Government and PR Manager	85 mins
	BBK Electronics	31/03/2017	Vice General Manager, Head of the General Manager Office	60 mins, 40 mins
	DJI	31/03/2017	Director of Public Relations, Executive Assistant to CEO, Services Strategy Manager	72 mins, 75 mins, 60 mins
	ARM Shenzhen Office	31/03/2017	Director of Investment	48 mins
	China Merchants Shekou Industry Research Institue	03/04/2017	Director, Deputy Director, Project Manager	30 mins, 45 mins, 45 mins
	OPPO	06/04/2017	Senior Investment Manager	30 mins
	Green Pine Capital	06/04/2017	Founder	35 mins
	BYD Headquarter	08/04/2017	PR Manager	55 mins
	Mindray	09/04/2017	Vice General Manager in Domestic Sales and Marketing, Senior Manager in Shenzhen Branch	50 mins
	Lachesis	10/04/2017	Intelligent Hardware Project Director	47 mins
	Information Office of Shenzhen Municipal Government	11/04/2017	Director, Deputy Director	65 mins
	Hungfung Brothers	18/04/2017	CEO	44 mins
	ComTech	01/09/2017	Vice General Manager	83 mins
	IngDan	04/09/2017	Senior Manager	99 mins
	Lachesis	05/09/2017	Founder	138 mins
	Infinity Intelligent	06/09/2017	General Manager	143 mins
	Dongguan Xiegang High-end Equipment Manufacturing Association	06/09/2017	President	118 mins
	N/A	12/09/2017	Senior Professor in Innovation Cluster Research	53 mins
	Guangdong Academy of Social Sciences	15/09/2017	President, Senior Researcher	134 mins, 52 mins
	Shenzhen Academy of Social Sciences	17/09/2017	Vice President	80 mins

Table 4-8 Sources of primary data (3rd phase)

3rd Phase	Tencent	20/04/2018	General Manager of the InternetPlus Partnership Department	51 mins
	BYD Electronics	20/04/2018	Senior Engineer, Senior Assistant in President Office, Government Affairs Directos	45 mins, 32 mins, 37 mins
	BYD Electronics (Factories)	25/04/2018	Production Line Manager, Engineer	47 mins, 33 mins
	Okata	26/04/2018	General Manager	63 mins
	Rapoo	27/04/2018	Senior Manager, PR Manager	115 mins, 39 mins
	Shenzhen Electronics Industry Association	20/06/2018	Manager	41 mins
	SEG Headquarter	21/06/2018	Senior Manager in Strategic Management Department	84 mins
	SEG Electronics Market	22/06/2018	Vice General Manager, Vendor 1, Vendor 2, Vendor 3, Vendor 4	76 mins, 29 mins, 34 mins, 26 mins, 54 mins
	SEG Maker Space	23/06/2018	Maker, Manager	58 mins, 32 mins
	Yihua Computer	20/07/2018	Strategy Consultant, Senior Manager	92 mins, 36 mins
	N/A	22/07/2018	Former Deputy Mayor of Shenzhen	132 mins
	Huawei	23/07/2018	Director of IoT Sector, Director of Supply Chain Strategic Planning	110 mins, 92 mins
	N/A	24/07/2018	Former Governor of Futian District	124 mins
	Seeed Studio	27/07/2018	Founder and Chairman	56 mins

Interviews were mainly conducted during the site visits. A project brief introducing the objectives of the research and the interview agenda had been sent to each interviewee at least one week before the interview. During the interviews, the interviewees were encouraged to provide more information about what they considered important to this research. Some interviews were recorded with the consent of the interviewees to minimise errors from manual recording. Interview notes were summarised and sent back to the interviewees within one week after the interviews for them to check the accuracy. Some interviews were conducted for more than one round to obtain more comprehensive information about the case company or event, with either the same interviewees or new personnel being referred to. In total, 72 in-depth semi-structured interviews were conducted, together with additional secondary data collected from site visits, including exhibition hall displays, leaflets, internal documents and presentation slides. During all data collection phases, the University of Cambridge's formal rules on ethical considerations in social science research were strictly applied.

4.3.2 Data Collection Protocol

There were four stages of data collection (see Figure 4-1). In the first stage, tasks were mainly associated with collecting and scanning secondary data. With the focal region and industry identified from the practical review, case companies and case events were not clear before collecting the secondary data. After scanning of the secondary data collected, potential case companies and events were listed following the selection criteria. In the second stage, during the first phase of primary data collection (i.e. the pilot study), information from interviews were combined with the first-round screening of secondary data obtained. Case companies and events were narrowed down according to the interviewees' feedback and secondary data implications. Then, in the third stage, more interviews were conducted and more secondary data were collected. After the second-round screening of secondary data and information provided by the interviewees, the case companies and events were confirmed as those listed in Tables 4.3 and 4.4. Finally, in the fourth stage, interviews were conducted to fulfil the data sets for the case companies and events.

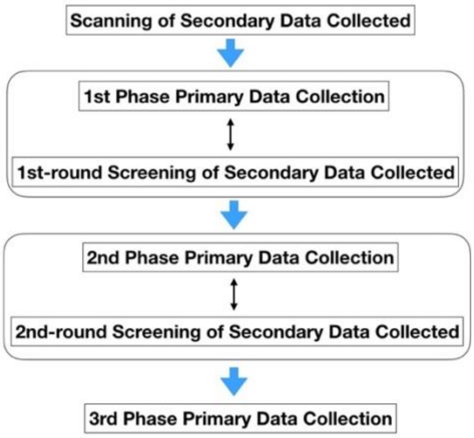


Figure 4-1 Data collection procedure

Since interviewees might provide information related to either companies or events (sometimes both), the data collection protocol was structured as following:

Table 4-9 Data collection protocol

Questions	Data to be collected	Data sources
Case Companies		
Development path of the company	□ Phases of firm development (by product) □ Main Transitions □ Successful or unsuccessful upgrading □ Global and local trends in the electronics industry	□ Official websites □ Exhibition halls □ Presentation slides □ Internal archives □ Third-party reports □ Semi-structured interviews
Local resources used in the upgrading process	□ Internal and external factors for the company to pursue upgrading □ Changes in the local environment: resource renewal and strengthening related to the upgrading process	□ News articles □ Local policy documents □ Semi-structured interviews
Milestone Events		
Identification of key events for regional and industrial development	□ Phases of industrial development of Shenzhen (by industrial structure, product and technology) □ Regional development plans	□ Chronical records □ News articles □ Industrial reports □ Government documents □ Documentaries □ Semi-structured interviews
Triggering factors and mechanisms	□ Main local players □ Interactions between players	□ Chronical records □ News articles □ Semi-structured interviews
Industrial and social impacts	□ Changes in existing sectors □ New sector emergence □ Related social changes. e.g. lifestyle, culture	□ News articles □ Publications □ Semi-structured interviews

4.4 Data Analysis

For case study analysis, the general analytic strategy for this research is "working the data from the ground up". Such an inductive strategy can lead to grounded theory building with evidence from the data collected. There are three stages of data analysis (see Figure 4-2) with operational details as explained in the following worked example.

Firstly, the region's industrial development is perceived as a process with six milestone events forming the basis for the regional resource pool. These events are analysed in terms of three phases, namely Preparation (before the event takes place), Launch (when the event happens) and Follow-up impacts (after the event is initiated). All participants and their interactions with each other are listed according to those three phases and visualised with a three-dimensional diagram as shown in Figure 4-3.

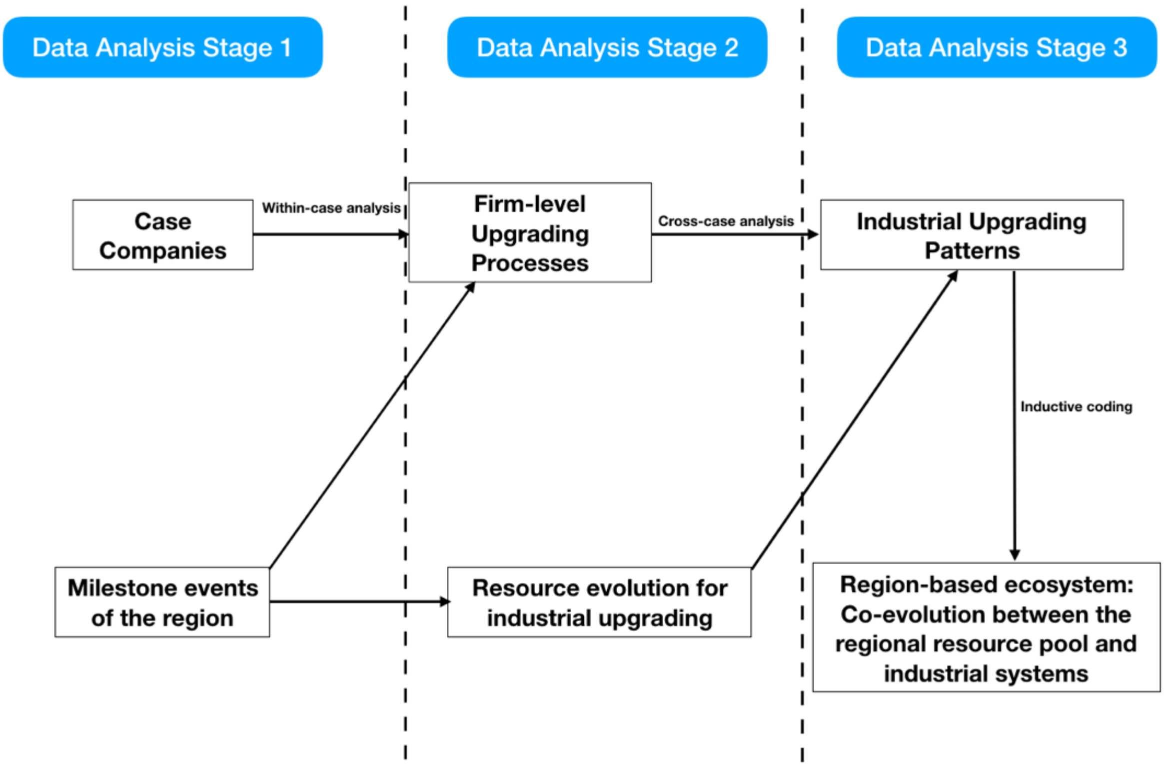


Figure 4-2 Data analysis procedure

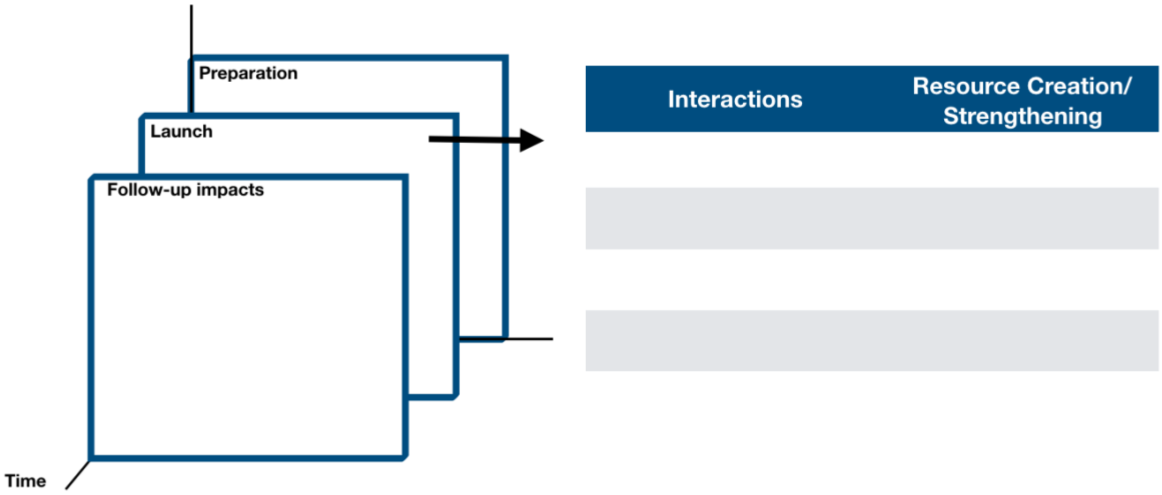
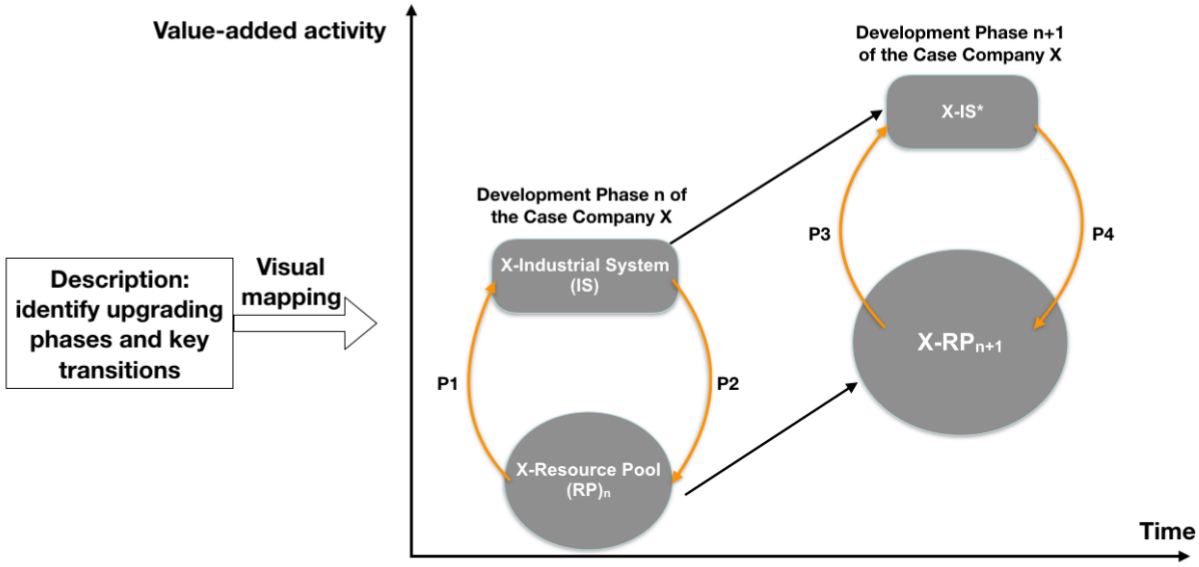


Figure 4-3 Analytical Framework for Milestone Events

Then the interactions between each two participants in the resource pool are categorised according to the classification of interactions in ecology. New resources created and/or existing resources strengthened after the interactions are highlighted to show the changes in regional resources.

The general perception of industrial upgrading is the progression from OEA, to OEM, ODM and then OBM, whereas more specifically, it can be attributed to the changes in industrial systems of firms within the industry. Within-case analysis are conducted for the upgrading process of each case firm and corresponding industrial systems following the procedures shown in Figure 4-4.



Process	Main Driver(s)	Main Interaction(s)	Impact(s)
P1			
P2			
P3			
P4			

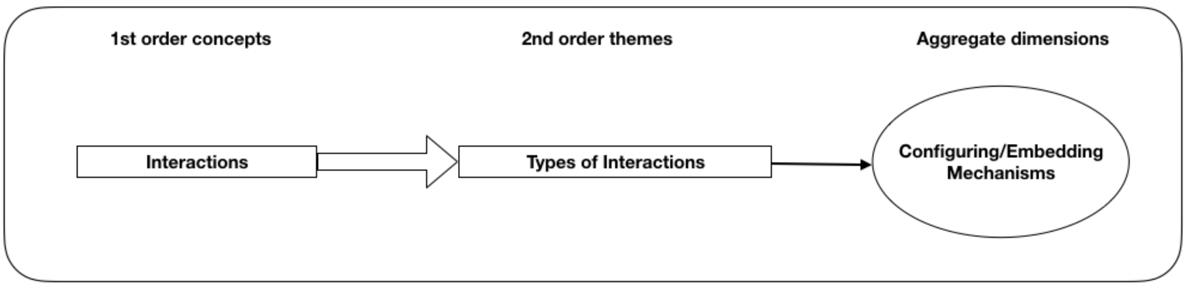


Figure 4-4 Analytical Framework for Case Companies

For each firm case, the upgrading phases in terms of products and technologies, as well as the key transitions between phases identified from data collected, are presented in the case description. Then all descriptive information is organised and visualised in a diagram showing the value-added activities from low to high conducted by the firm chronologically, together with a table presenting the interactions between industrial systems and the resource pool. In the table, detailed analyses for changes in the industrial systems at each stage are summarised, among which mechanisms for new sector emergence with a new industrial system configured from resources and existing sector transformation with an established industrial system reconfigured by resources, are revealed.

Secondly, with milestone events and firm-level upgrading processes analysed, synthesis of the events for the regional resource pool evolution and cross-case analysis for the regional industrial upgrading are conducted.

Table 4-10 Table for the Synthesis of Milestone Events

Events	**Resources Used**	**Types of resources used**	**Resources Created/Strengthened**	**Types of Resources Created/ Strengthened**	**Regional Resource Pool**
3+1					
CMSK					
CHTF					
Shanzhai					
SIAT					
Maker					

For milestone events synthesis, Table 4-10 is used to better understand the evolution of regional resources that involves both new resources created and existing resources strengthened. All these resources form the basis of the regional resource pool where each case firm can leverage resources from and also have feedbacks onto it.

The cross-case analysis of firm-level upgrading processes aims to show the generic mechanisms for industrial upgrading in a region from the empirical evidence of case companies. According to the conceptual model and analytical framework, there are eight types of mechanisms between the regional resource pool and industrial systems, which can be grouped into either configuring mechanisms from resources to industrial systems or embedding mechanisms from industrial systems to the resource pool. Thus, Table 4-11 is applied to extract the generic mechanisms for the upgrading of the electronics industry in Shenzhen.

Table 4-11 Table for Cross-case Analysis of Case Companies

Configuring from existing/new resources to established/new industrial systems (ER-NIS, ER-EIS, NR-NIS, NR-EIS) **OR** **Embedding of established/new industrial system to the resource pool and induce new resources/strengthen exiting resource** **(EIS- NR, EIS-ER, NIS-NR, NIS-ER)**	**Case firm 1**	**Case firm 2**	**Case firm 3**	**Case firm 4**
Interactions from empirical evidence				
Generic Mechanism(s)				

Finally, the evolution of regional resources and the upgrading process of the region-specific industry are integrated to show the co-evolution between regional industrial systems and resource pool enabled by the region-based business ecosystem. Then the initial conceptual framework is refined with more consolidated constructs to form the conceptual model of a region-based business ecosystem for industrial upgrading in an evolutionary manner.

Application of the Gioia Methodology

For interpretive research, Gioia methodology provides a systematic approach to develop new concept and articulate grounded theory via inductive coding (Gioia, Corley, & Hamilton, 2012). From the raw data collected, a primary map[12] is generated for each case firm's upgrading path. First-order concepts are captured from the detailed interactions for events and upgrading to take place.

For case firms, the primary maps are integrated into secondary maps (as shown in Figure 4-4), highlighting the established sector(s) transformed and new sector(s) emerged throughout the firm's upgrading path. The new and existing regional resources leveraged by the firms for upgrading are also taken into account. Then the types of interactions in the first-order concepts are coded as second order themes, which can be further aggregated into either configuring or embedding mechanisms of the ecosystem.

[12] Primary maps consist of all related information collected from secondary and primary data sources, some of them are in Chinese version.

Chapter 5 Case Studies

5.1 Embedded Milestone Events

5.1.1 "3+1" Trading Mix

Since the "3+1 Trading Mix" manufacturing (subsequently "3+1" manufacturing) was initiated in late 1970s, factories applying this strategy proliferated in the PRD, especially in Shenzhen. Although "3+1" manufacturing contributed significantly to the local economy, it was mainly associated with low value-added production and was not a sustainable means of long-term industrial development. After prevailing for around 15 years, "3+1" manufacturing gradually faded away in Shenzhen.

Event Description

The successful introduction and implementation of the "3+1" manufacturing can be traced back to the establishment of Special Economic Zones (SEZs) in southern China. Mr. Wu Nansheng, Party Secretary of CCP (Chinese Communist Party) Guangdong Provincial Committee, first proposed the idea of a free trade zone in Shantou in 1979 to revitalise the local economy. His idea was endorsed by the First Secretary of the Guangdong Provincial Committee, Mr. Xi Zhongxun, who then lobbied the central government to delegate more power and flexibility to Guangdong. This lobbying proved successful when a formal proposal was approved by the central government, and on 26th August 1980, Shenzhen, Zhuhai, Shantou and Xiamen SEZs were set up and the "Regulations of SEZs in Guangdong Provinces" was launched. After the SEZ of Shenzhen was established, Mr. Wu served as the first Mayor and Party Secretary of Shenzhen Municipality and pioneered the economic reforms in Shenzhen SEZ by introducing foreign investment and implementing marketized development strategies.

Mr Wu was succeeded by Mr. Liang Xiang, who led a series of projects that contributed to the development of local infrastructure and the electronics industry during his tenure from 1981 to 1986. He devised the "Ant Theory" to develop the "3+1" manufacturing, which stated that only after the first "ant" (foreign investor, especially enterprises from Hong Kong) had tasted some sweetness would other "ants" (foreign investors) be attracted to invest in Shenzhen. Preferential policies such as lower taxation and cheaper land-use fees were launched to benefit foreign investors that set up branches in Shenzhen for "3+1" manufacturing. The year 1981 witnessed the emergence of the local electronics industry and Mr. Liang spearheaded the construction of local infrastructure by assigning land of 300 thousand m_2 for the establishment of an electronics industrial zone. In the following year, Shangbu Industrial Zone was established, where later emerged the well-known Huaqiangbei electronics cluster. The Electronics Building was completed in the Shangbu Industrial Zone, which was the first 20-storied office building in Shenzhen. Mr. Liang also took the lead role in setting up the Shenzhen SEZ Outline Plan for Socio-Economic Development in 1982, which guided the construction of basic urban infrastructure, including road, water lines, electrical networks and modern office buildings (what at that time would have been considered "skyscrapers") that further attracted investors and enhanced the development of local industries. For instance, the International Trade Centre Building was constructed at the speed of one storey every three days, a feat impossible elsewhere in China at that time. Subsequent constructors of the National Trade Building achieved the pace of "a three-storied building a day", known as "Shenzhen Tempo". In 1983, the Planning and Development Coordination Committee for Shenzhen's Electronics Industry was jointly set up by the municipal government, the Provincial Electronics Bureau and the National Ministry of Electronics Industry in order to facilitate the establishment of local electronics firms. During the same year, the National Ministry of Electronics Industry set up its Shenzhen office to examine and approve local projects, which accelerated the implementation of "3+1" manufacturing in electronics products. By the end of 1985, more than 3500 "3+1" manufacturing projects had been carried out in Shenzhen, most of which were related to the production of electronics goods.

Mr. Li Hao was appointed Mayor of Shenzhen in August 1985 and he also took the role of Municipal Party Committee Secretary in 1986. During his tenure, Shenzhen underwent dramatic changes in pursuit of export-oriented industrial development with higher efficiency. Soon after taking office, Mr. Li issued the decision to establish the Foreign Exchange Regulator in Shenzhen to deal with the problem of double-track prices in foreign exchange and the existence of a black market. This institution was legitimised by the State Administration of Foreign Exchange in 1987 and it greatly facilitated import and export trading in Shenzhen, especially benefiting those electronics manufacturers that produced with imported materials to export their products to foreign customers. During the same year, the Municipal Investment Management Centre was established to monitor more than 100 state-owned enterprises in Shenzhen. Such a reform strategy was appreciated by the Central Government and promoted across the whole country soon afterwards. In addition to this reform of state-owned enterprises, Mr. Li also advocated to enhance the development of private enterprises by leading the government to launch the "Decisions about Strengthening Technological Works" and the "Interim Provisions on Encouraging Technicians to Set Up Private Technology Enterprises" to support technological start-ups in Shenzhen.

Li Youwei, the successor to Mr. Li Hao as the Municipal Party Committee Secretary, proposed the developmental strategy known as "Second Undertaking" for Shenzhen in 1995. After more than ten years of "3+1" manufacturing, a number of social and environmental problems had become evident, such as rising production costs and severe pollution that needed to be solved. The "Second Undertaking" aimed to reorganise the industrial structure and shift Shenzhen towards a modern city with not only economic prosperity with hi-tech industries but also a better and cleaner (greener) living environment. The first step was to drive out the "3+1" manufacturing sites that offered low value-added and were great polluters. From the end of 1994, local government no longer approved "3+1" manufacturing projects and those factories within the urban area of SEZ were gradually transferred to the Longgang Industrial Zone in the peripheral area. The space released was used to accommodate technology start-ups and introduce foreign hi-tech firms.

Event Analysis

Before “3+1” manufacturing was implemented, local government officials played the essential role in preparing all the requisite factors, including capital, production sites and certain institutions (see Figure 5-1). When these factors were in position and started interacting with each other, “3+1” manufacturing was launched. As Figure 5-2 shows, the government, foreign enterprises and local grassroots were the three main “biotic” actors whilst local infrastructure and authorities established by the government could be seen as “abiotic” actors that, once formed, provided a stable environment which those “biotic” actors were able to exploit.

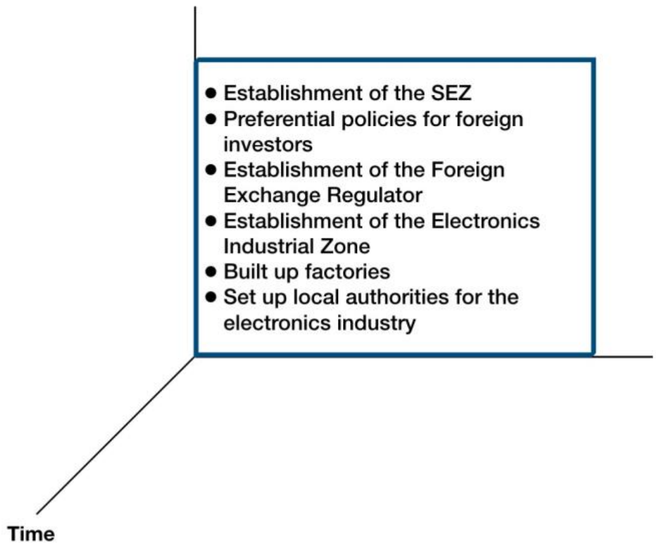


Figure 5-1 Preparation for "3+1" Manufacturing

When “3+1” manufacturing was launched, local electronics firms mushroomed and eventually fell into one of two types: joint ventures with foreign enterprises and indigenous firms. These two types of firms took the form of initial industrial systems of the local electronics industry. The interative mechanisms between those actors’ implementation of “3+1” manufacturing are summarised in Table 5-1. The interaction between local government and foreign enterprises was beneficial to both sides since foreign capital and production lines were introduced to Shenzhen and foreign companies were able to use local labour and land for production at low costs. Authorities and institutions set up by the government regulated the local electronics industry and enhanced the development of local electronics firms.

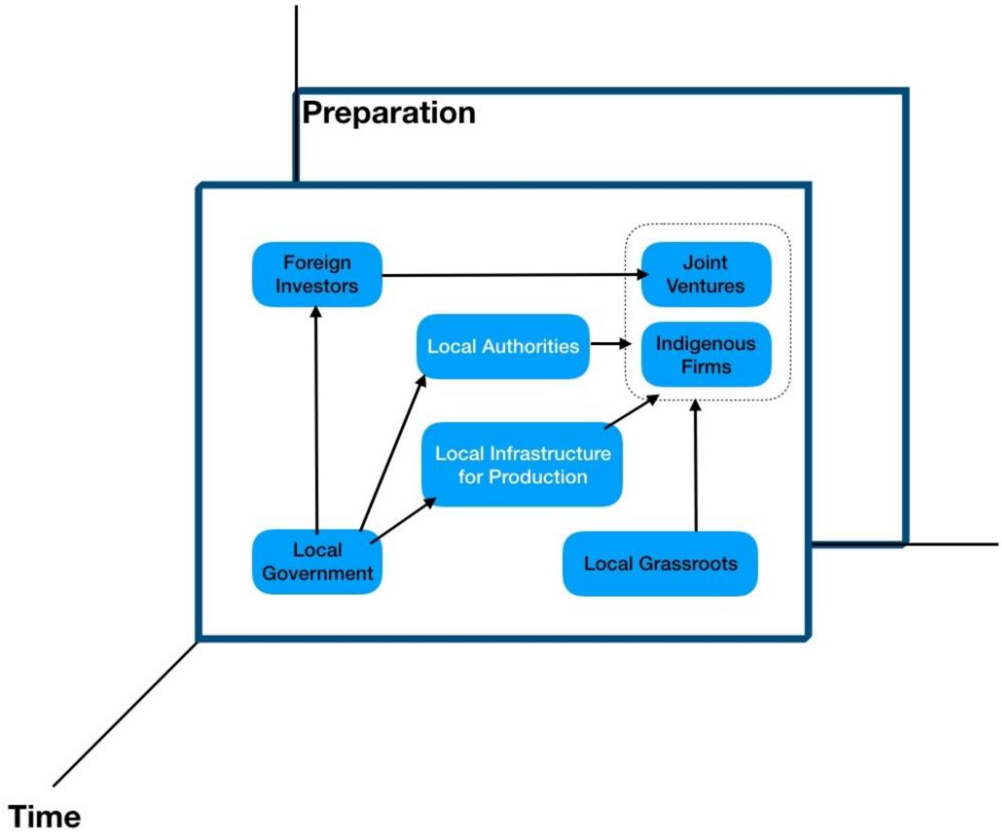


Figure 5-2 Launch of "3+1" Manufacturing

These firms also benefited from new factories and other infrastructure such as transportation facilities constructed in the urban area of Shenzhen. Local grassroots workers worked in these firms, gradually improving their skills through practice and, after accumulating sufficient knowledge and experience, some of them started their own businesses and became local electronics enterprises.

Finally, as local government decided to shift local industries towards high-end manufacturing, "3+1" manufacturing was gradually squeezed out. Although some electronics firms still applying "3+1" manufacturing tried to sustain their production after the government ceased to support it, they were not able to afford the increasing costs incurred from environmental charges and rents. As a result, they either transferred their production lines to peripheral areas and continued “3+1” manufacturing or actively sought ways of upgrading.

Table 5-1 Interactions for the launch of “3+1” Manufacturing

Interactions	Type	Resource Creation/ Strengthening
Local government introduced foreign enterprises to invest into the “3+1” manufacturing	Mutualism	Creation: foreign capital, production lines, joint ventures
Local government set up authorities to organise and govern firms within the electronics industry	Commensalism	Creation: new authorities
Local grassroots worked for firms within the electronics industry	Mutualism	Strengthening: more skilled labour
Electronics firms used infrastructure constructed	Commensalism	Strengthening: increased scale of production and productivity

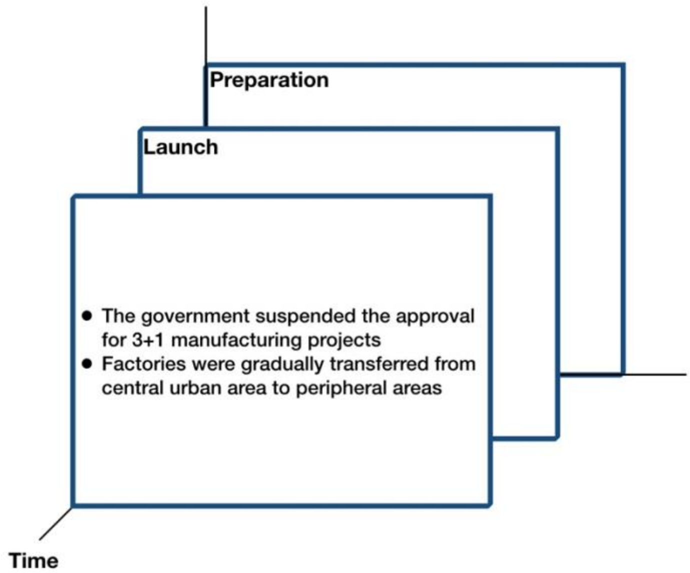


Figure 5-3 Fading out of "3+1" Manufacturing

5.1.2 The Shekou Industrial Zone

The Shekou Industrial Zone was the first internationally accessible economic development zone in China. Developed by the China Merchants Group (CMG) in late 1978 (now known as the CMSK), it has played a pivotal role in China's economic reform path. It introduced foreign companies into Mainland China to set up exclusively foreign-owned branches, for instance Sanyo Electronics from Japan, which built the first modernised factory in the zone. With production lines established, a wide range of electronics products were manufactured, including radios, recorders, calculators and loudspeakers.

Event Description

Before China's reform and opening-up, Shenzhen had been a small fishing village and administrative seat in Bao'an county, in which the Shekou Peninsula acted as a customs office. At the beginning of 1979, the proposal of Shekou Industrial Zone, drafted by the CMG on behalf of the Guangdong Provincial Revolutionary Committee and the Ministry of Transport, was approved by the Central Government. Three months later, Shenzhen was designated as a municipality to replace Bao'an county. Then in July, Shenzhen was assigned the task of developing an Export Special Zone and the infrastructure project broke ground in Shekou (known as the "First Blast", when the sea was filled with the stones from the demolished hills) by the CMG, from which sprung up the Shekou Industrial Zone, a kind of "test tube" experiment with foreign ingredients injected into the traditional Chinese economic system. Figure 5-4 illustrates the location of Shekou and the gradual development around the industrial zone.

In 1981, Mr. Yuan introduced the first private branch exchange (PBX) to Shekou to set up the first microwave communication station in Shenzhen and made the first cross-border call to CMG's Hong Kong office. This move bridged Shekou with the outside world and enabled foreign investors in Shekou to communicate with their headquarters or home countries more efficiently, thus raising more opportunities.

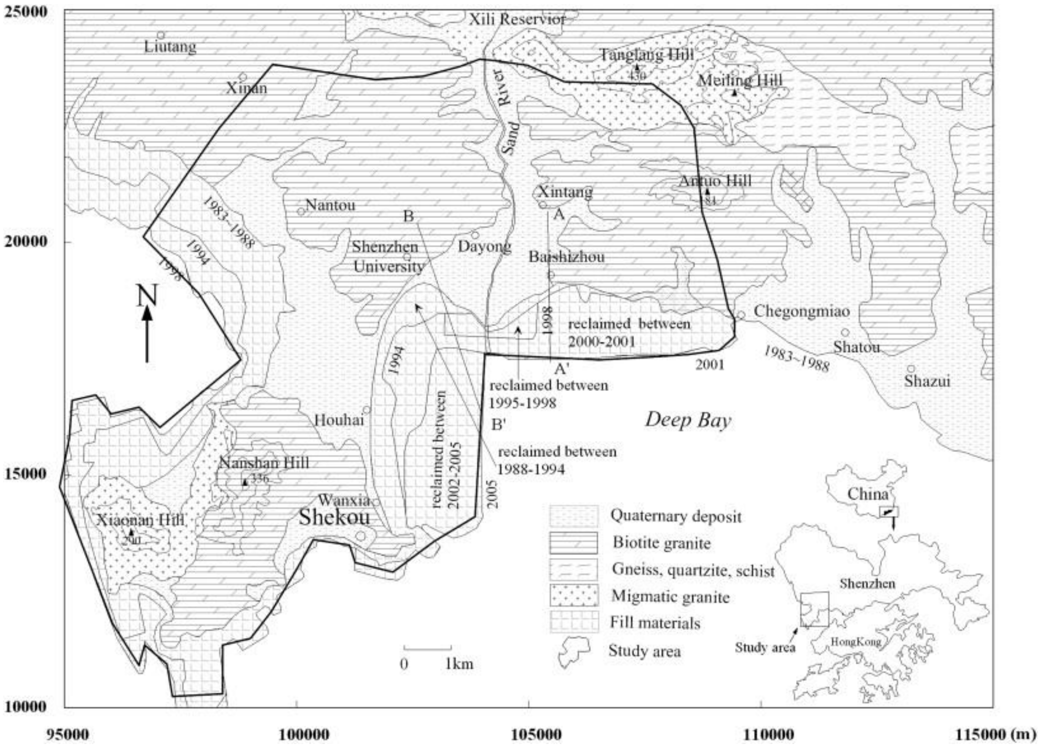


Figure 5-4 The Map of Shekou Peninsula (Hu & Jiao, 2010)

Luks Group from Hong Kong was allowed to set up its wholly-owned branch in Shekou in 1982 for TV production, mainly in the design, manufacturing and distribution of TVs and TV kits. In the following year, Luks set up another joint venture company engaging in TV manufacturing in Shenzhen, namely Shenzhen Huafa Electronics Company Ltd., which was listed on Shenzhen Stock Exchange in 1992. The Sanyo Electric Machine (Shekou) founded in 1983 was another foreign-owned plant in Shekou Industrial Zone and was the first Japanese company to operate on Mainland China since 1949. Since the CMSK leveraged resources of China Merchants from Hong Kong to develop the industrial zone in Shenzhen and enjoyed a high level of independence in decision-making and self-governance, innovations in terms of not only business models but also institutional structures occurred in Shekou. During his tenure, Mr. Yuan witnessed Shekou grow from an industrial zone covering 2.14 km^2 with an investment of HK$60 million to an industrial kingdom worth over 20 billion yuan by the

1990s[13]. Within Shekou, the Nanshan Development (Group) Incorporation, established by Mr. Yuan, was China's first Sino-foreign joint venture that implemented a shareholding system. Moreover, Mr. Yuan also initiated the China Merchants Bank and the Ping'an Insurance Company, the first joint-stock commercial bank and joint-stock insurance company respectively.

In July 1985, Kaifa Technology (Shekou) Co., Ltd. was founded in Shekou Industrial Zone and introduced the first production line of magnetic head stacks for computers. It was then incorporated to Shenzhen Kaifa Technology Co., Ltd, moving out of Shekou to Caitian Industrial Park and was listed on the Shenzhen Stock Exchange in 1993. Today, it has grown to be a leading EMS company that offers services including manufacturing, supply chain, logistics, R&D, and system solutions, covering a wide range of electronics products. In addition to indigenous EMS companies like Kaifa, foreign giant Flextronics set up its first Chinese branch in Shekou in 1987. It was among the first batch of US companies that invested in China and brought to Shekou a production line with a capacity of 1 million computer mainboards per year. Another Sino-US joint venture by Chinese Academy of Sciences and Analogic Corporation was incorporated into Shekou one year earlier. Known as Anke Hi-Tech Co., Ltd, it was among the first group of hi-tech enterprises certified by the Chinese government and engaged in activities related to the medical electronics sector. As a pioneer in the medical equipment industry, Anke is now described as the breeding ground for Chinese medical device firms because most entrepreneurs and technicians in this sector have at some stage in their careers been employees of Anke (such as, for example, the founders of the national flagship Mindray, established in 1991).

The Shekou Industrial Zone was under the direct control of the Administrative Committee set up by the CMG and also managed by the Administrative Bureau of Shekou District set up by the Shenzhen Municipal Government (see Figure 5-5). This was known as the separation of

13 http://www.chinapictorial.com.cn/en/features/txt/2015-10/14/content_706143_2.htm

government functions from business management, with the Administrative Committee playing the role of managing business performance within the zone whilst the Administrative Bureau acted as the local government. Such institutional innovation was sustained until 1992, when the Industrial Zone was merged into Nanshan District.

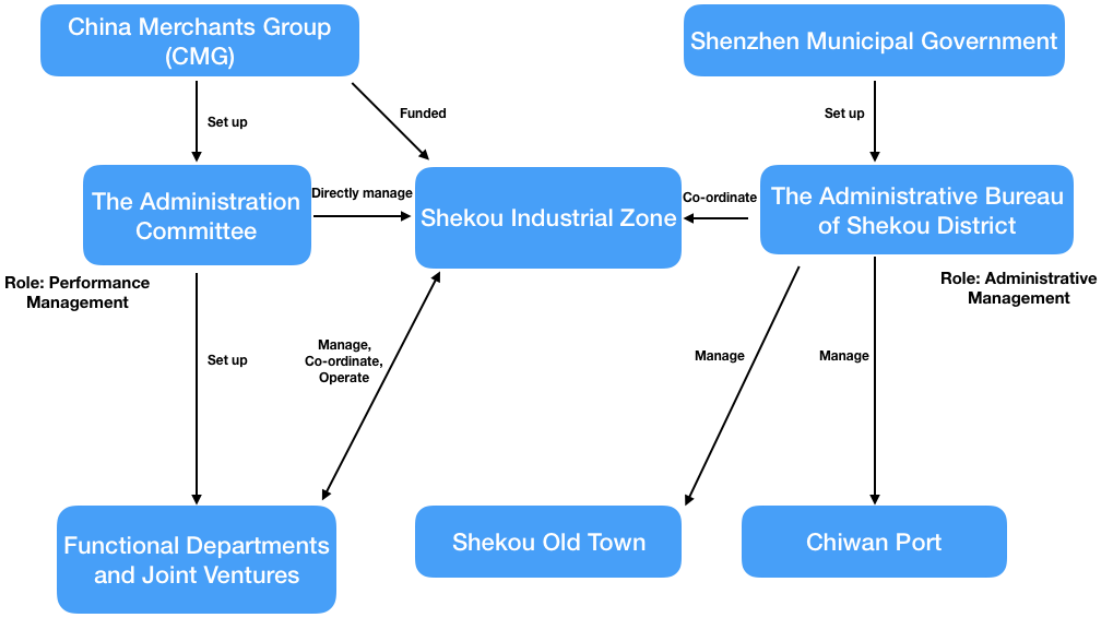


Figure 5-5 The Administrative Structure of Shekou Industrial Zone

(Source: Shekou Reform and Opening Museum)

In 1992, the boundary between the Industrial Zone and Shenzhen city was removed. Although the CMSK still had control over Shekou through its properties, the autonomy of the Industrial Zone no longer existed. The CMSK then integrated the unique advantages of the former China Merchants Property Development and Shekou Industrial Zone and strategically positioned itself as “China's leading city and industrial park developer and operator”, with three pillar businesses: industrial park development and operations, residential community development and operations, and cruise industry development and operations. It formed the unique “Front Port-Middle Industrial Park-Back City” mode.

Event Analysis

The Shekou Industrial Zone was the first area in mainland China that officially opened up to the outside world, even before the Shenzhen SEZ. Developed by the CMG in Hong Kong under Mr. Yuan Geng's leadership, it promoted institutions that imitated practices in Hong Kong society such as a contract labour scheme, more pay for more work ("overtime") and freedom of speech in terms of an independent press, the "Shekou Bulletin". All these measures can be traced back to the revitalisation of the CMG in Hong Kong and the support from the central government in Mainland China (see Figure 5-6).

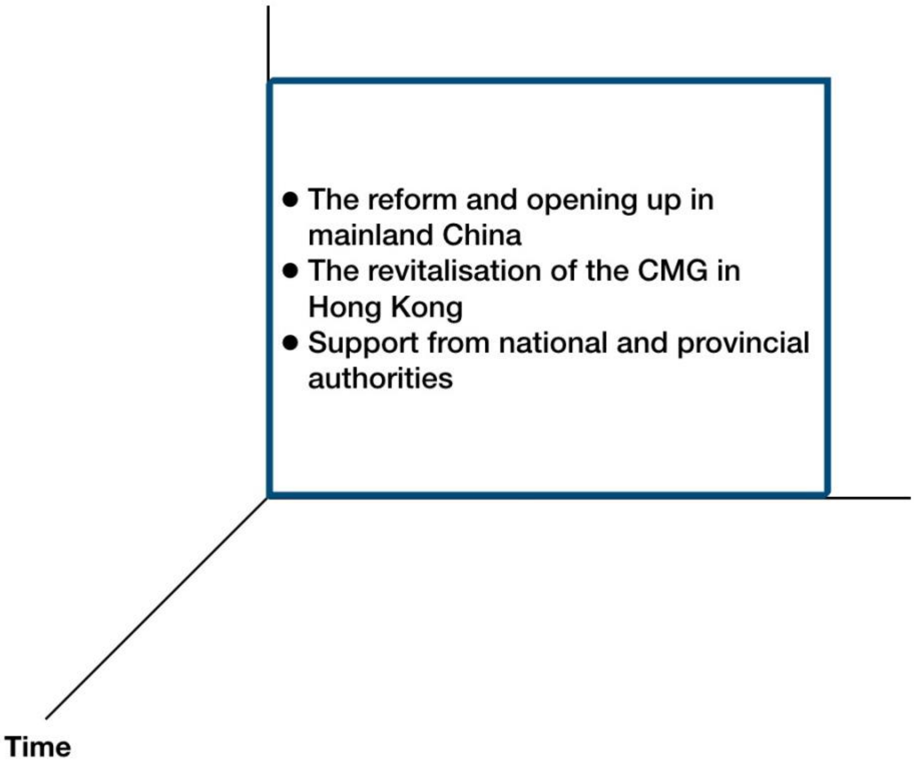


Figure 5-6 Preparation for the Shekou Industrial Zone

In June 1978, Mr. Yuan was assigned by the national Ministry of Transport to inspect the CMG in Hong Kong. After his observations and an investigation in Hong Kong lasting two months, a duty report was sent back to the Ministry for discussions about how to utilise the CMG's resources. In October of that year, the Ministry of Transport submitted the document "Request for utilising China Merchants Hong Kong sufficiently" to the Central Committee and the State

Council. The request was approved and one month later Mr. Yuan led the CMG to locate its office at Connaught Road Central in Hong Kong. At that moment, the CMG restarted its business activities, including developing secondary industries. However, because of the high production costs in Hong Kong, it chose to locate the production site in the neighbouring Bao'an District in Shenzhen, which then became the initiative of establishing the Shekou Industrial Zone. Backed by the Deputy Prime Minister Li Xiannian and Gu Mu, the Shekou Industrial Zone was initiated with the headquarters and infrastructure constructed from early 1979.

During the period 1979 to 1984, basic facilities, including water and electricity supply, land and waterway traffic, telecommunication and land consolidation, were installed in in the Shekou Industrial Zone. As a pioneer, such infrastructure construction came to be known as the "Shekou Mode", which was then adapted by the Shenzhen municipality. Based in Hong Kong, the CMG took advantage of access to the latest information in the global market and Mr. Yuan took every opportunity to expose the Shekou Industrial Zone to foreign enterprises. Gradually, foreign investors were attracted to come and set up branches or form joint ventures with the CMG in the Industrial Zone.

In addition to the industrial development, Mr. Yuan also endeavoured to take a further step in reforming the management system within the zone. He focused on transforming the mentalities of migrant workers and administrators towards being more outward-looking and socially minded by providing them with training programmes introduced from Hong Kong. Moreover, employees were recruited through relatively transparent application and interview processes, which differed to most work unit appointments in Mainland China at that time. The Shekou Industrial Zone, under the CMG's administration, provided an outstanding example for changing governmental roles and had huge implications for possible governmental restructuring throughout China (O'Donnell, Wong, & Bach, 2017). Figure 5-7 presents the main actors and their interactions when the Industrial Zone was launched, among which the CMG in Hong Kong and foreign enterprises played the key role in setting up the industrial systems within the zone. Such systems included branches of foreign firms and Sino-Foreign joint ventures, supported by the CMG's management team and infrastructure construction.

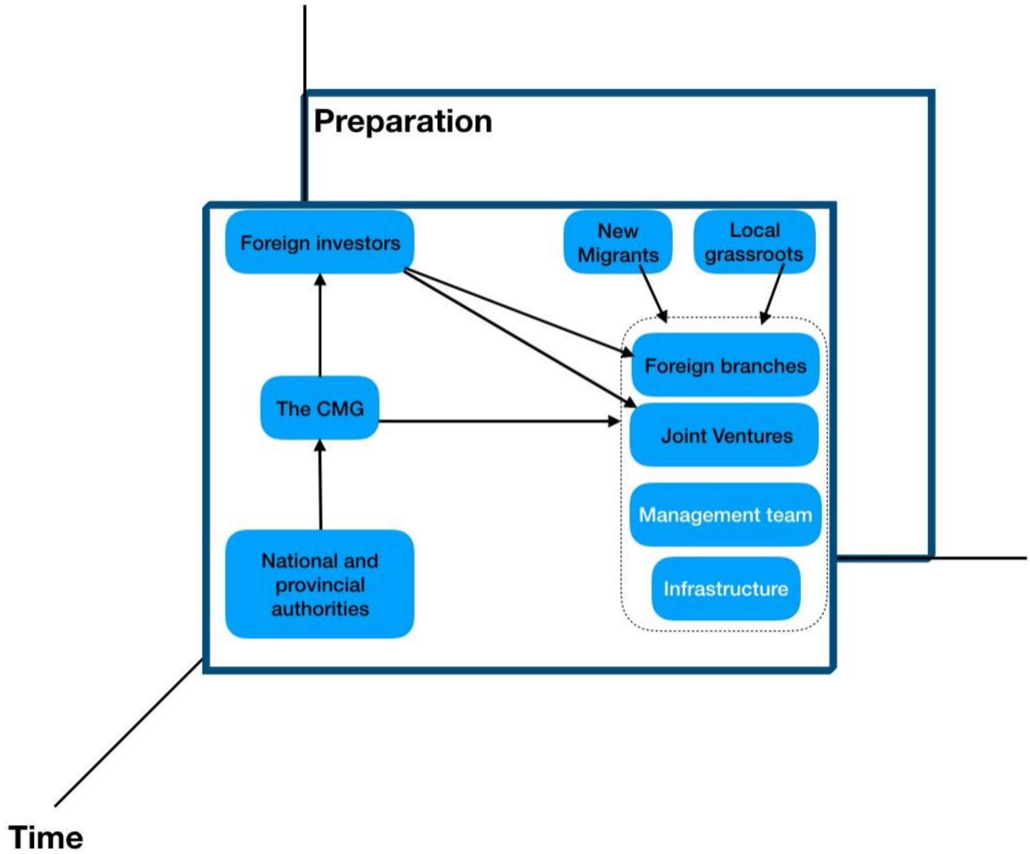


Figure 5-7 Launch of the Shekou Industrial Zone

There were mainly five groups of interactions during the launch of Shekou Industrial Zone under the control of the CMG (see Table 5-2). By reactivating the CMG in Hong Kong, the Central Government delegated power to Mr. Yuan to establish the Industrial Zone in Shekou. In addition to infrastructure construction, which benefited not only the Shekou area but also the whole of Shenzhen, such an experimental field also enjoyed considerable autonomy, triggering reforms not only in industrial systems but also social systems. Firms located within the Industrial Zone and those people working in organisations under the CMG gradually adapted to the new systems that were decidedly distinct from other places in mainland China and became more open-minded. Foreign enterprises attracted to the Industrial Zone also took advantage of cheaper labour and land costs and, in return, they brought to Shekou advanced production and management know-how.

Table 5-2 Interactions for the launch of Shekou Industrial Zone

Interactions	Type	Resource Creation/ Strengthening
The Ministry of Transport revitalised the CMG in Hong Kong	Commensalism	Creation: access to latest information
The CMG constructed infrastructure in the Industrial Zone	Commensalism	Creation: new facilities Strengthening: better conditions
The CMG promoted the Shekou Industrial Zone and attracted foreign enterprises to invest	Mutualism	Creation: foreign production lines, management styles
New migrants and local grassroots sought job opportunities in the Industrial Zone	Mutualism	Strengthening: more skilled labour
The CMG employed various strategies to motivate staff within the Zone	Commensalism	Creation: professional management team Strengthening: higher productivity and efficiency

However, such radical reforms within Shekou encountered a number of challenges, largely of an ideological and institutional nature. It was then merged into Shenzhen municipality and became a street office precinct under the Nanshan district (see Figure 5-8). Although there was no longer the same autonomy in Shekou as when the CMG fully controlled it, its legacy in terms of an innovative and open-minded culture left a lasting legacy for other firms emerging from the Shekou Industrial Zone.

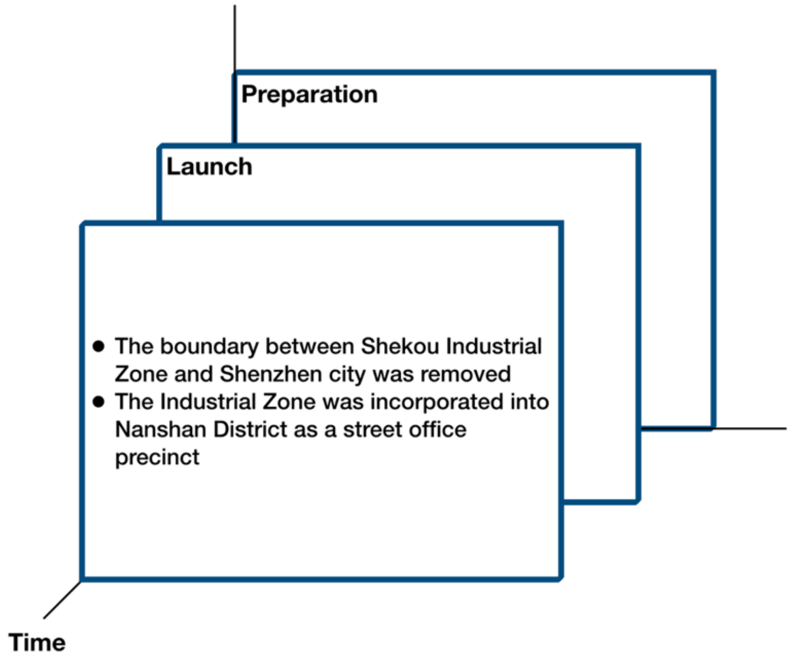


Figure 5-8 Termination of the Shekou Industrial Zone (CMSK) under the CMG

5.1.3 The First Hi-Tech Fair

In 1999, the first China Hi-Tech Fair (CHTF) was held in Shenzhen. Retrospectively, that time can be seen as marking the watershed between low-end manufacturing and the move to high-tech industrial development in the city. Since then, it has become an annual event in Shenzhen and is now the largest and most influential fair in Mainland China for international technological and economic exchange. Referred to as "the No.1 Technology Show in China", the annual CHTF acted as "a window into technologies and hi-tech products of China and the world, a channel for advanced international tech products into the Chinese market and a platform for in-depth cooperation and exchanges in international tech and economic affairs"[14].

Event Description

Before the debut of the first CHTF, there was only one annual large-scale event in Shenzhen, called the "Lychee Festival". As its name implied, this fair mainly promoted local agricultural products and most participants took the chance to exchange market information. In a delegation tour to Dalian in April 1998, officials of the Shenzhen Municipal Government paid a visit to the Dalian International Garment and Textile Festival and they were impressed by the impact of such an event in attracting business opportunities from throughout China and all over the world. Then they started planning for a city event on a similar scale but for technology-oriented exchanges in order to promote Shenzhen on the world stage. However, at that time there were limited local facilities that could be used for holding such a large event and some infrastructure projects needed to be completed within a year so as to launch the festival in the following year. After lobbying the national authorities in Beijing to support this event, the Municipal Bureau of Science and Technology assumed responsibility for constructing the exhibition hall and attracting capital from all over the world. The incumbent director of the Bureau, Mr. Li Lianhe, led the project team to build a new exhibition hall and travelled to 26 countries to visit potential investors. In addition to their efforts, the Shenzhen Capital Group Co., Ltd ("SCGC") was

14 Source: http://www.chtf.com/english/chtf2015/OverviewOfCHTF/

established by the Municipal Government as a limited venture capital company, which then participated in the CHTF as the very first local venture capitalist.

After six months, the exhibition hall was completed and sponsorships from the national Ministry of Foreign Trade and Economic Cooperation, Ministry of Science and Technology, Ministry of Industry and Information Technology, and the Chinese Academy of Sciences were obtained. On 5th October 1999, the first CHTF was officially launched in Shenzhen and the incumbent Premier Zhu Rongji delivered a speech at the opening ceremony and announced that:

"To enhance the economic and technological co-operations between China and other countries, the Chinese government decided to hold the CHTF in Shenzhen every year." [15]

During the first CHTF, there were several highlights. First and foremost, technology companies established by local grassroots workers presented their ideas and products to investors at the fair and gained capital and resources for further development. For instance, Tencent rented a booth to display its online messenger OICQ and successfully attracted venture capitalists to invest in it. Without the 2.2 million USD obtained from IDG and PCCW, Tencent would not have been able to grow into a technology giant in the following years. Acknowledging the great impact of the first CHTF on the company during a public speech, Tencent founder Pony Ma said:

[15] Source: https://www.chinadaily.com.cn/regional/2015-11/02/content_22313793.htm; http://topics.gmw.cn/2010-08/25/content_1227808.htm

"We had been desperately searching for capital in order to maintain the operation of Tencent and we even thought about selling our QQ software. Fortunately, we obtained our first venture capital fund through the platform provided by the first CHTF."[16]

Second, an important by-product emerged at the first CHTF, namely the emergence of local venture capital firms. "Venture capital" was a new source of funds in Mainland China and in addition to those who managed to secure funds from foreign venture capitalists via the fair, there were still local technology start-ups with growth potential waiting to be funded. Then the state-owned venture capitalists such as the SCGC started investing in these companies and, at the same time, many private venture capitalists emerged and participated in assisting the development of local technology firms.

Event analysis

The CHTF was established mainly by the Shenzhen Municipal Government in order to pursue economic growth from technological innovation when Asia had yet to step out of the shadow of the financial crisis in the late 1990s. It was a challenging task for the Municipal Bureau of Science and Technology because of the short preparation period (about 487 days, as Mr. Li mentioned). During this period, the project team made every effort to get the approval from national authorities to co-host the event and get the necessary infrastructure and facilities built, as well as attracting foreign investors to participate in the event (see Figure 5-9).

The first CHTF was held in the newly constructed exhibition hall with space of 20,200 m^2 from 5th to 10th October 1999. During these six days, 2856 companies and 955 investors from 26 countries and regions participated in the fair and the turnover through the fair reached 6.49 billion USD[17]. Figure 5-10 presents the interactions among the actors during the launch of the

16 Source: http://news.ifeng.com/gundong/detail_2010_10/13/2766554_0.shtml
17 Source: http://www.chtf.com/liaojiegaojiaohui/lijiehuigu/chtf1/

1st CHFT. It can be seen as a stage set up by the local government while various actors play different roles and interact with each other.

Figure 5-9 Preparation for the 1st CHTF

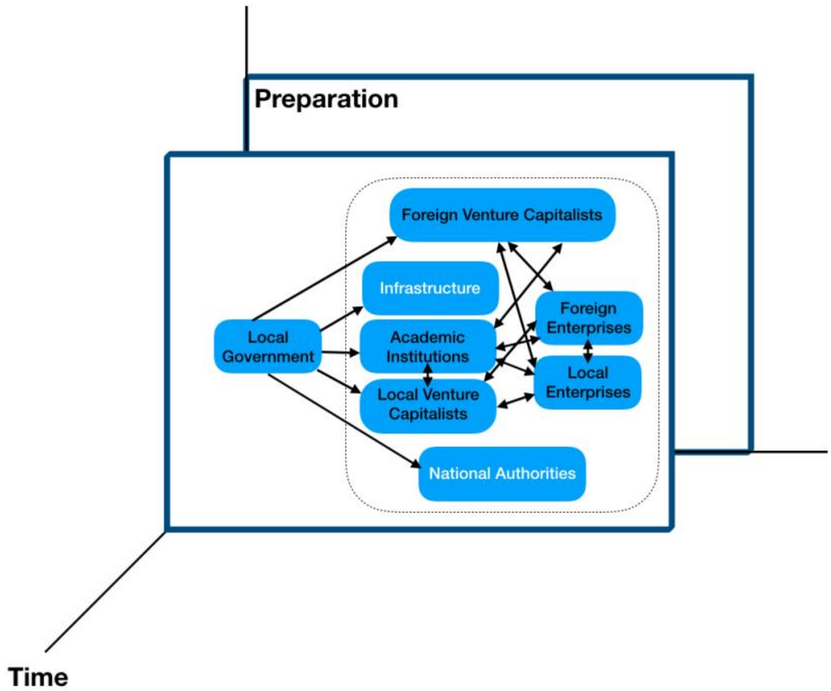


Figure 5-10 Launch of the 1st CHTF

The interactions and related mechanisms are presented in Table 5-3. The launch of the 1st CHTF indicated that the role played by the municipal government was not only pivotal but also appropriate. The government laid the foundations in terms of different kinds of resources for the fair and provided exhibitors the environment with free trading and exchange without too much direct intervention during the fair. As the former deputy mayor of Shenzhen Municipality, Dr. Tang, said:

"The role played by the government should be 'planting the tree to attract the phoenix' in terms of providing a regulated market environment for companies to compete fairly and cultivating indigenous innovations by these companies through some guiding mechanisms[18]."

Table 5-3 Interactions for the launch of the 1st CHTF

Interactions	Type	Resource Creation/ Strengthening
Local government lobbied national authorities	Commensalism	Creation: a state-level event
Local government constructed the infrastructure for the CHTF	Mutualism	Creation: new exhibition hall and facilities
Local government attracted and introduced foreign investors	Mutualism	Creation: venture capital first appeared in mainland China
Local government invited academic institutions to participate	Mutualism	Creation: some institutions started locating research branches in Shenzhen
Foreign venture capitalists invested in exhibitors	Mutualism	Strengthening: firms received investments were able to develop and expand e.g. Tencent
Local venture capitalists invested in exhibitors	Mutualism	Strengthening: firms received investments were able to develop and expand and the local venture capitalists learned from practicing
Trade talks between academic institutions and investors	Mutualism	Creation and strengthening: research projects located and commercialised in Shenzhen
Collaborations and competitions between exhibitors	Mutualism/ Competition	Strengthening: stimulated local firms to improve their products and technologies
Venture capitalists competed for the same company's project	Competition	Strengthening: enabled local venture capital firms to learn from their rivals and grow

18 Here the guiding mechanisms can be traced back to the policies launched by the Shenzhen Municipal Government in 1995 to motivate local firms to set up own research and development departments.

The 1st CHTF can be seen as a successful undertaking by the municipal government in "attracting phoenix" by strengthening and renewing tech resources essential for the city's development. This event also helped to bring in the concept of "venture capital", triggering the emergence of private venture capitalist firms and gradually formed the venture capital (VC) industry in Shenzhen. Those established foreign VC giants who participated in the fair offered samples for local emerging VC firms to learn from and there were also many investment opportunities brought by the exhibitors for local VC firms to practice.

5.1.4 The "Shanzhai" Phenomenon

"Shanzhai", a Chinese term originally meaning "mountain villages away from the society with rule of law", first emerged as a phenomenon in the electronics industry in the mid-2000s with the meaning of manufacturing cheap and counterfeit mobile phones to compete with expensive and branded products. Then the term was extended to describe all imitation products appearing in our daily lives. In this section, the underlying mechanisms triggering the emergence of the "Shanzhai" phenomenon in Shenzhen and its impacts on the upgrading of the local electronics industry will be considered.

Event Description

Shenzhen has always been linked to the "Shanzhai" phenomenon and was even referred to as the city of "Shanzhai", not just because they share the same initials ("SZ"), but more importantly because the phenomenon itself first appeared in the city's Huaqiangbei (HQB) area. HQB is a subdistrict of Futian District in Shenzhen and runs 1.5 km from south to north and about 1 km from east to west. Since the company SEG (refer to case 5.1.1) settled in this area in 1988, the trading market of components gradually expanded and developed. By the end of 2006, the market covered a space of more than 300 thousand m^2 and achieved annual turnover of more than 20 billion RMB. There were more than 18 specialised malls in HQB for various types of electronics components, accommodating vendors from different regions and forming networks based on their social relationships.

As Mr. Li, who was the Governor of Futian District, within which the HQB area falls, said:

"In early years, because of the embargo set by Coordinating Committee for Multilateral Export Controls (CoCom), electronics components could only be imported into Mainland China through smuggling or military enterprises. Most smuggled products were sold via the vendors at the HQB market."

In another interview, a local manufacturer of electronics components also mentioned that when they started their businesses in electronics, they could only sell parts smuggled or dismantled from worn-out products. Such trading activities of foreign made components enabled many local grassroots to make their first earnings, which they used to set up their own businesses and learn to manufacture similar goods. From then on, local supply chains of electronics components were gradually established and became more diversified.

In early 2000s, with the booming mobile phone market and some technological innovations such as the USB flash drives (refer to case 5.1.3), vendors in the electronics market and corresponding supply chains behind them reacted quickly and started providing components and accessories for these popular consumer electronics. Initially, these vendors followed the wholesale strategy of producing and selling large quantities of homogeneous products mainly to organisational rather than individual buyers.

For functional phones, there were clusters of retailors of different brands for the mainland market and suppliers of all components necessary for each handset. However, with faster changes in technologies and demands, the lifecycle of a certain type was shortened. Then, in HQB, there emerged mobile handsets without brands but with the same functions as those famous brands, at much lower prices. These functional phones were actually copycats, made simply by integrating all components that could be easily obtained in HQB following the same industrial design (ID) and mechanical design (MD) of those branded products. With lower costs and higher efficiency in design and manufacturing, these counterfeit mobile phones soon grabbed a slice of the market share and kicked off the “Shanzhai” phenomenon.

The proliferation of such fake products in Shenzhen drew the attention of the local government. After an investigation, it realised that the lack of a test centre for telecom network access had driven local manufacturers to get rid of the time-consuming application process by producing phones without brands. To address this issue, the government requested China's Ministry of

Industry and Information Technology in Beijing for the permission to build a test centre in Shenzhen. In 2004, Shenzhen's test centre for telecom access was authorised and, subsequently, local enterprises were able to obtain approval and establish their own mobile phone brands more efficiently. By the end of February 2005, there were 90 authorised brands of functional mobile phones in China, half of which were owned by Shenzhen enterprises.

However, the "Shanzhai" phenomenon was not eliminated by this move; indeed, it became even more vigorous, especially after MediaTek (MTK) launched its Turnkey solution in 2004 and Apple released its "iPhone 2G" in 2007. The MTK's modulated integrated circuit (IC) solution enabled brand mobile phone companies to save money and time on their own R&D for investments in the integration of motherboards and software programming (Zhu & Shi, 2010). Previous research has also revealed the actors participating in the "Shanzhai" mobile phone development and how the Shanzhai firms operated (see Figure 5-11).

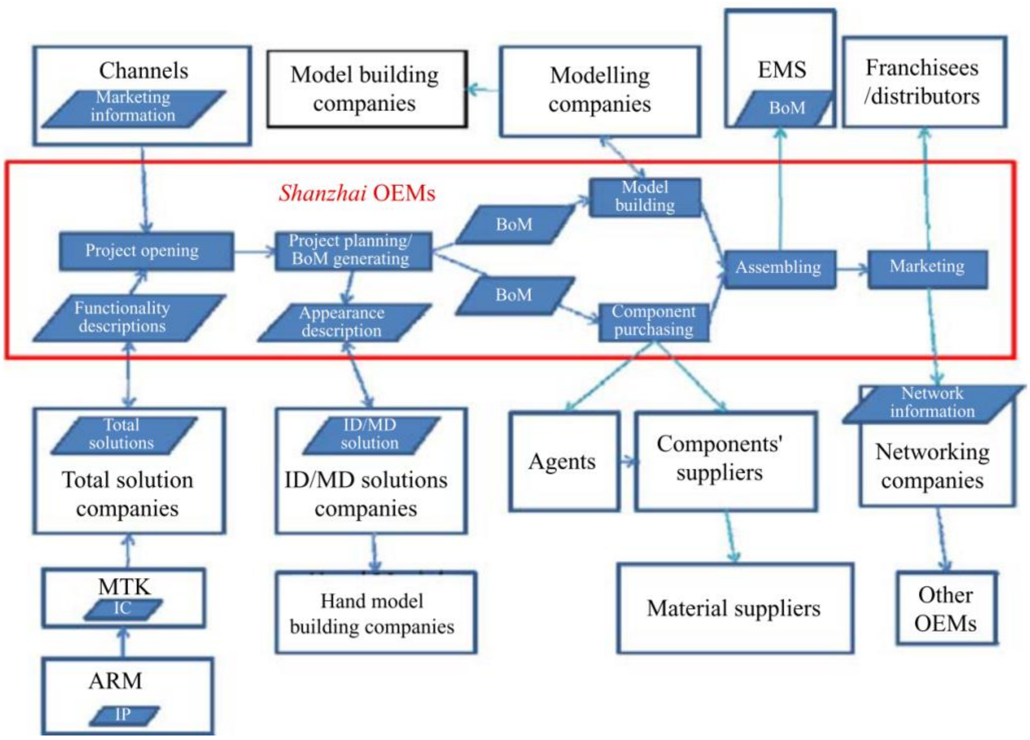


Figure 5-11 Participants of Shanzhai mobile phone development (Zhu & Shi, 2010)

In October 2007, the State Council removed the government's control over mobile phone licences and such regulatory change contributed to the legitimacy of "Shanzhai" manufacturing activities and their legal standing (Lee & Hung, 2014). More Shanzhai manufacturers for mobile phones mushroomed in Shenzhen and altogether produced more than 150 million handsets in that year.[19] The Shanzhai Phenomenon was officially acknowledged on 2 December 2008 when the China Central Network Television (CCTV) reported on the Shanzhai culture during its news broadcasting. Such region-specific culture could be described as a network of retailors and vendors at the HQB electronics market, component manufacturers with factories, design houses for IC solutions, and integrators with assembly lines. Except for chips, all the other components for a smart phone could be found in Shenzhen within half an hour.[20] Then Shanzhai manufacturers began diversifying their products to include other consumer electronics, for instance tablets and wearable electronic devices. Without their own R&D, they chose to follow the "gongban" (public board) and "gongmo" (public mould) issued by design houses and integrated different components into various consumer electronics products. Such production-ready boards designed for consumer electronics manufacturers can be seen as the core of Shanzhai manufacturing (Lindtner, Greenspan, & Li, 2015), and its potential for wider industrial applications laid the foundation for the development of local "makers" in the following years.

Event Analysis

The "Shanzhai" phenomenon was spontaneous and controversial but inevitable under the context of HQB in the 2000s. After development of more than two decades, the flourishing electronics market attracted manufacturers supplying diversified components. At the same time, the domestic demand for functional mobile phones continued to rise but most branded products were too expensive and considered luxury goods by migrant workers in Shenzhen. Moreover, large OEMs such as Foxconn catered predominantly to established global brands

19 Source: Book "Shenzhen Electronics in Thirty Years (1980-2010)"

20 Shenzhen is also the largest consumer market for chips and the place that established chip manufacturers locate their retail stores and warehouses, leading to fierce competition in chips and enabling local mobile phone manufacturers to bargain with different brands. Source: Book "Shenzhen Electronics in Thirty Years (1980-2010)".

and left those less well-known brands with smaller quantities to other local manufacturers. As a result, these local OEMs started assembling handsets with components brought from local suppliers and selling these white label mobile phones at a much lower price via their vendors at the HQB. This was the official start of the Shanzhai Phenomenon. At this stage, the local government did not intervene directly in the market although it realised that burgeoning Shanzhai mobile phones might have a detrimental impact on the image of local manufacturing. Instead, it started improving the local system for IP protection by establishing the Municipal IP Bureau and a test centre for the network access of mobile phones in 2004 so as to facilitate local brands to emerge and grow. As Mr. Li, the first director of the Municipal IP Bureau, put it:

"With the growth of local enterprises such as Huawei, independent innovations were initiated by growing number of private firms and Shanzhai copycatting would discourage them to invest in R&D. Realising the potential risks of Shanzhai manufacturing to local firms with innovation capabilities, local government decided to impose IP protection."

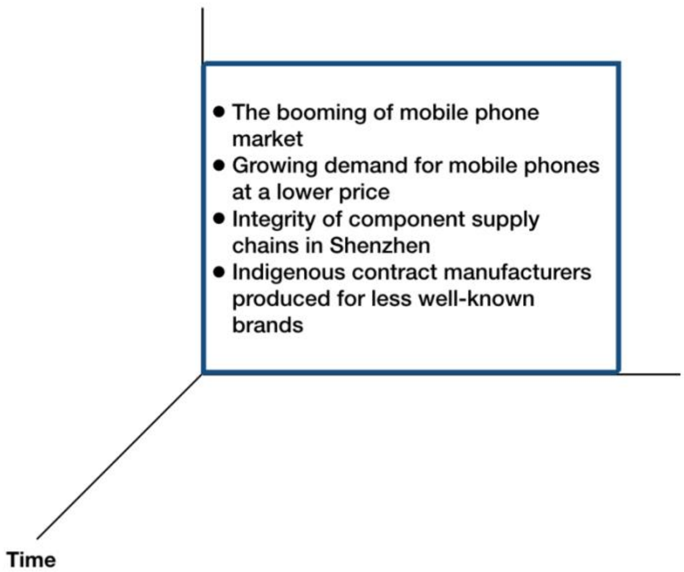


Figure 5-12 Triggering conditions for the Shanzhai Phenomenon

As shown in Figure 5-12, the Shanzhai phenomenon was mainly triggered by these factors and HQB was the place that all of them clustered and interacted with each other. Indigenous or localised design houses (mainly from Taiwan) provided “gongban” (public board) for mobile phones and other consumer electronics. Local components suppliers then produced “gongmo”(public mould) that were compatible with the “gongban” and Shanzhai firms assembled the products according to “gongban” and “gongmo”. For Shanzhai mobile phones particularly, Turnkey solution providers such as the MTK offered design houses the ability to develop “gongban” based on its integrated chips with more functions. Design houses purchased components from local suppliers and manufactured “gongban” for local Shanzhai firms. These firms then searched “gongmo” from component suppliers for casing and other accessories compatible with the “gongban” they had chosen. After obtaining the necessary components, they assembled these parts into Shanzhai products and sold them through vendors at the HQB market. From 2005 to 2007, the Shanzhai Phenomenon exploded and attracted not only local consumers but also some foreign buyers from other developing countries. During this period the government tolerated both the manufacturing and consumption of Shanzhai products on the one hand, but on the other hand started establishing institutions to improve the local IP protection system and support local brands that were facing challenges from Shanzhai competitors. Figure 5-13 shows the main actors in the Shanzhai phenomenon and their interactive mechanisms are summarised in Table 5-4.

It is important to note that from the emergence to the explosion of the Shanzhai phenomenon, several significant changes took place in the electronics industry of Shenzhen. Firstly, indigenous design houses were induced by the MTK’s Turnkey solution and grew rapidly in the city. They continuously developed various types of “gongban” that were key for component manufacturers and Shanzhai firms to organise their production. Secondly, local manufacturers of electronics components became more specialised and flexible. To gain orders from design houses and Shanzhai firms, they should be able to provide quality components at competitive prices and sometimes customise specific parts as required. Thirdly, local Shanzhai firms were actually integrators of different components rather than traditional manufacturers of mobile phones applying a vertical integration strategy. This lowered the entry barriers for local grassroots firms to enter the mobile phone market and therefore made it much easier for them to become Shanzhai players and boost the phenomenon further. Fourthly, design houses and integrators learned to collaborate with each other to deliver products that followed fast-changing market trends and satisfied consumer demand. Moreover, multi-media functions such as ı ... ere gra

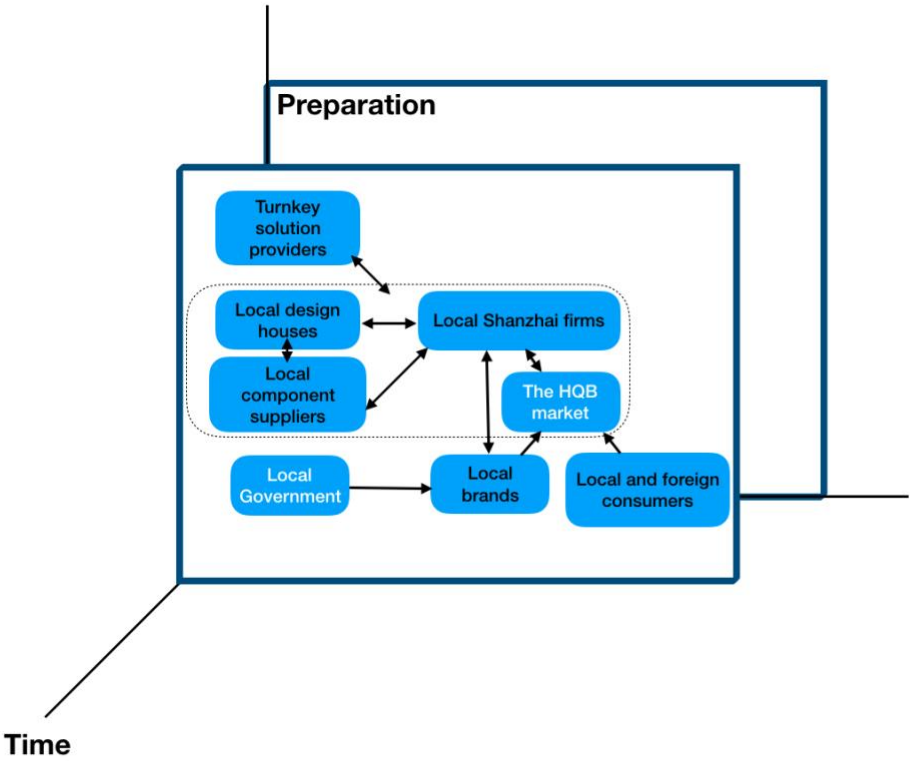


Figure 5-13 Main actors and their interactions behind the explosion of the Shanzhai phenomenon

After the license control on mobile phones was removed in 2007, many Shanzhai firms established their own brands and launched branded products. This gradually blurred the boundaries between local brands and Shanzhai brands but without their own R&D and following the Shanzhai assembly, these Shanzhai firms produced mobile phones with lower quality and their products were sometimes associated with infringement issues. From 2008 onwards, with the rise of 3G technology and smart phones, the Shanzhai functional mobile phone gradually lost its popularity. Shanzhai manufacturing could not be easily applied to smart phones because local suppliers were not ready to produce components with much higher quality requirements. Firms started from Shanzhai manufacturing could only achieve expansion and further development if they began investing in R&D and brand marketing. Figure 5-14 shows the reasons for the gradual decline of Shanzhai manufacturing of handsets.

Table 5-4 Interactions for the Shanzhai phenomenon

Interactions	Type	Resource Creation/ Strengthening
Local design houses applied MTK's Turnkey solution	Mutualism	Creation: new technology Strengthening: network effect and continuous improvement of the
Local design houses purchased components from local suppliers and produced "gongban"	Mutualism	Creation: new standards Strengthening: more specialised component manufacturers
Shanzhai firms integrated/assembled components into products following "gongban" from design houses and "gongmo" from local suppliers	Mutualism	Strengthening: more flexible and efficient production
Design houses collaborated with Shanzhai firms in the development of new Shanzhai products	Mutualism	Strengthening: collaborative manufacturing and innovation
Shanzhai firms competed with branded companies	Competition	Strengthening: local brands invested more in own R&D
Local government indirectly supported local brands by establishing institutions	Commensalism	Creation: Test centre for Internet access, Municipal IP Bureau
Local and foreign customers purchased Shanzhai products from vendors at the HQB market	Mutualism	Strengthening: expansion of the Shanzhai market

Although the Shanzhai phenomenon in mobile phones seemed to fade away after 2010, it has left a legacy that was crucial for the region's industrial development, especially the later emergence of "makers" and their indigenous innovations in Shenzhen. Firstly, local components were highly specialised after experiencing Shanzhai manufacturing and highly sensitive to new market trends. Once a new generation of electronics products was launched, they could quickly adapt components they supplied to fit in new products. Secondly, local design houses and SMEs became accustomed to the "gongban" and "gongmo" style of manufacturing after Shanzhai, which enabled them to efficiently develop a wide range of new products following the latest trends and conduct manufacturing activities with standardised modules. Thirdly, all these local players that had been fragmented were connected through Shanzhai manufacturing and they formed a network with comprehensive resources that could be leveraged for prototype development when new ideas or innovations emerged.

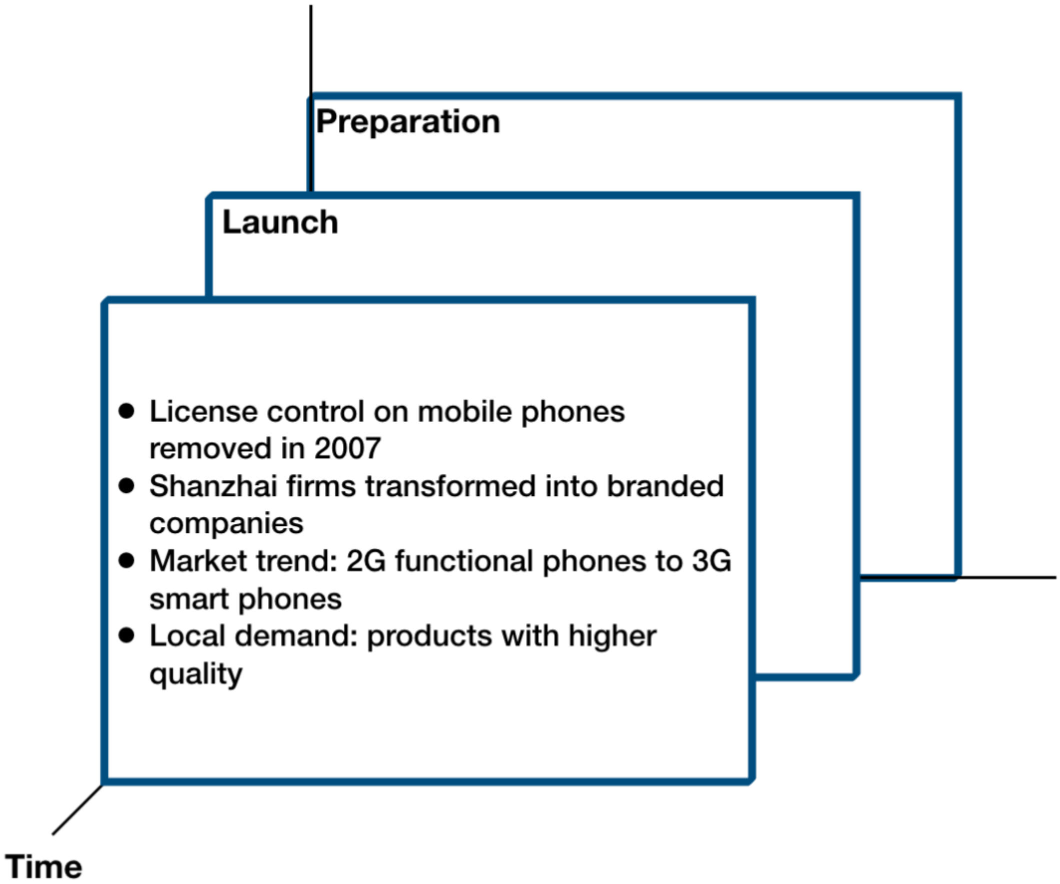


Figure 5-14 Main reasons for the declining Shanzhai mobile phone market

5.1.5 The SIAT (Shenzhen Institutes of Advanced Technology) of the Chinese Academy of Sciences

In 2006, the Shenzhen Institutes of Advanced Technology (SIAT) was co-founded by the Shenzhen Municipal Government, the Chinese Academy of Sciences (CAS) and the Chinese University of Hong Kong (CUHK) in Shenzhen. It was positioned as a state-level industrial research institute with vision and mission to help local companies to deal with technological barriers. It also acted as an academic institution offering postgraduate programmes with not only professional training but also practical applications through collaborations with local firms in order to make them better work for local industries after graduation.

Event Description

From the early 1980s, the electronics industry grew rapidly Shenzhen and the surrounding cities within the Pearl River Delta. After two decades of development, local firms gradually faced more technological challenges in products and production processes whilst there was a lack of research institutes in Shenzhen to help those who were not able to conduct independent R&D. In the early 2000s, the Chinese Academy of Sciences (CAS), which functioned as a national scientific think tank, launched a structural reform programme and tried to disseminate its branches all over Mainland China in order to commercialise research findings based on different industrial bases. At that time, Shenzhen had accumulated resources and manufacturing capabilities from the electronics industry and was on the way to pursuing the transformation of local firms from low-tech to hi-tech. In Hong Kong, there had been a critical mass of scientists and researchers from abroad since the 1987 handover, but they lacked the opportunities to conduct large-scale practical research due to local restrictions. In 2004, Prof. Yangsheng Xu of the CUHK suggested the CAS to incorporate the research capabilities of academic institutions in Hong Kong with the needs in the mainland to sustain long-term economic growth in both regions. According to its geographic proximity to Hong Kong and its record of rapid industrial development, Shenzhen was an ideal place for collaborations between Hong Kong and the mainland to take place. The Municipal Government of Shenzhen and the CAS decided to collaborate according to their mutual benefits and with the support from the

Chinese University of Hong Kong (CUHK), a new institution called the Shenzhen Institutes of Advanced Technology (SIAT) was officially formed on 22nd September 2006. The SIAT was the first national-level industrial research institute located in Shenzhen, aiming to enhance the innovation capability of established industries and promote the development of emerging industries in the Pearl River Delta region.

However, although the SIAT had been titled, there was still no physical entity. Given the land for the infrastructure construction by the Municipal Government, a team of five from the CAS, led by Prof. Jianping Fan (also the President of the SIAT), was given the mission to kick off the SIAT's operations. Initially, they located their office within Shekou, where the previous industrial zone had left facilities that were ready for use. During the period of the site's construction, the SIAT started recruiting staff and seeking opportunities. In October 2006, its first commercialised a project in cooperation with local robotics company Siasun to integrate their technologies, and the sterilisation robot for containers was launched in Yantian Port. The SIAT also attended the 8th Hi-tech Fair (CHTF) in that year and initiated the showcase of robotics, which then became a permanent exhibition at the annual CHTF. By showing its applications of advanced technologies from scientific research, the SIAT successfully attracted collaborators and dozens of investors during the fair for commercialisation of its technologies and prototypes. Since then, the SIAT has continuously assisted local firms in technological upgrading. For example, the Midea Group, a local giant in the household appliance sector for decades, jointly established a lab with the SIAT for emulation techniques.

In 2009, the site construction was completed and the SIAT was able to enrol postgraduate students in the new campus. In the same year, the Shenzhen Robotics Association (SRA) was established by the SIAT, with more than 20 member organisations. The SRA could be seen as China's pioneer industrial association in such an emerging industry and played an important role in facilitating local robotics development. Based on the SRA, forums about the technologies and applications of industrial robots were organised by the SIAT to enhance mutual learning and communication between local robotics firms. In addition to development in the robotics sector, the SIAT also started exploration in the biomedical sector. Sub-institutes[21] were gradually established within the SIAT, covering aspects including health and medical devices, robots, new energy and new materials, and cloud computing. Currently, there are national-, provincial- and municipal-labs located for different types of research in the SIAT and more than 1000 partnerships with firms have been formed.

Event Analysis

Shenzhen Municipal Government initiated the transformation of local industries from low to high value-added from the late 1990s with the launch of the annual Hi-tech Fair and policies enhancing local technology development. The proportion of output from hi-tech products in Shenzhen's total industrial output continuously increased and local companies such as Huawei and BYD electronics emerged and developed rapidly with their own R&D. However, the government realised that without a well-established institution for scientific research in Shenzhen to complement the R&D within hi-tech firms, it would not be easy to sustain the technological upgrading of local industries for the long-term development of the city. When a delegation from the CAS investigated Shenzhen in August 2005, local officials shared the concern and they reached the consensus of building a research institute. By the end of this year, representatives from the CUHK visited the CAS and showed their interest in supporting the establishment of such an institute by offering the necessary technologies, talents and capital. Then, in 2006, with the policy document "Decision on the Implementation of Independent Innovation Strategy and Building Innovation-Oriented City" taking effect in Shenzhen, the idea of establishing a new research institute was finalised and became a cooperative project among the Municipal Government, the CAS and the CUHK.

[21] Currently nine sub-institutes: Advanced Integration Technology, Biomedical and Health Engineering, Advanced Computing and Digital Engineering, Biomedicine and Biotechnology, Advanced Technology, Brain Cognition and Brain Disease, Perceptiveness Research, Synthetic Biology, Advanced Electronics Materials.

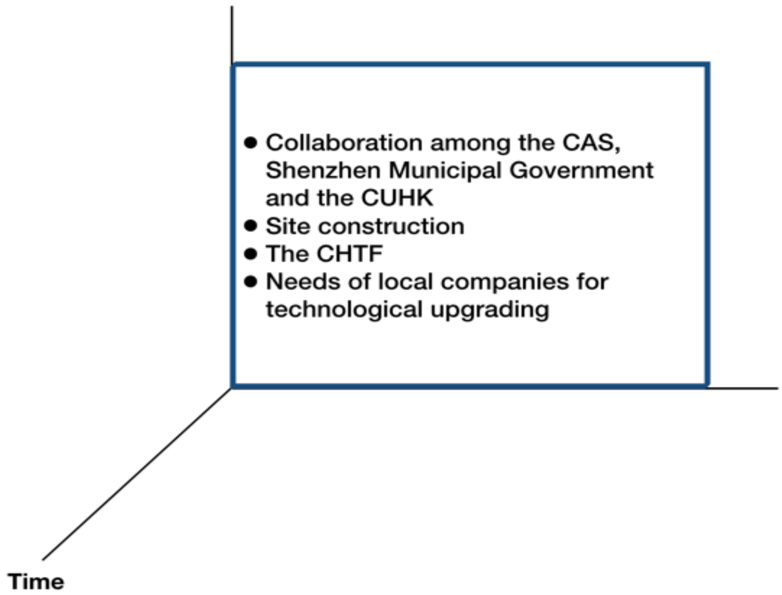


Figure 5-15 Preparation for establishing the SIAT

As shown in Figure 5-15, during the preparation stage for SIAT's establishment, the local government played a pivotal role in matching the appropriate resources with industrial needs. With the SIAT acting as a platform, research capabilities from the CAS in Beijing and from the CUHK in Hong Kong were gradually transferred to and localised in Shenzhen to the benefit of local firms.

It took three years for the site construction to be completed and, during this period, the SIAT started its operations in mainly three areas. Firstly, it actively headhunted and introduced talents from abroad to the SIAT to build up diversified research teams in hi-tech areas. Secondly, it presented research outcomes to the public through platforms such as the hi-tech fair and attracted potential investors and collaborators for commercialisation. Thirdly, it played the leading role in the formation of industrial associations such as the SRA, gathering local firms together to enhance synergies, as well as accommodating scientific research to better serve their practical needs. During this stage (see Figure 5-16), the government was no longer steering the development of the SIAT and, instead, the internal management team was using different strategies to utilise local resources.

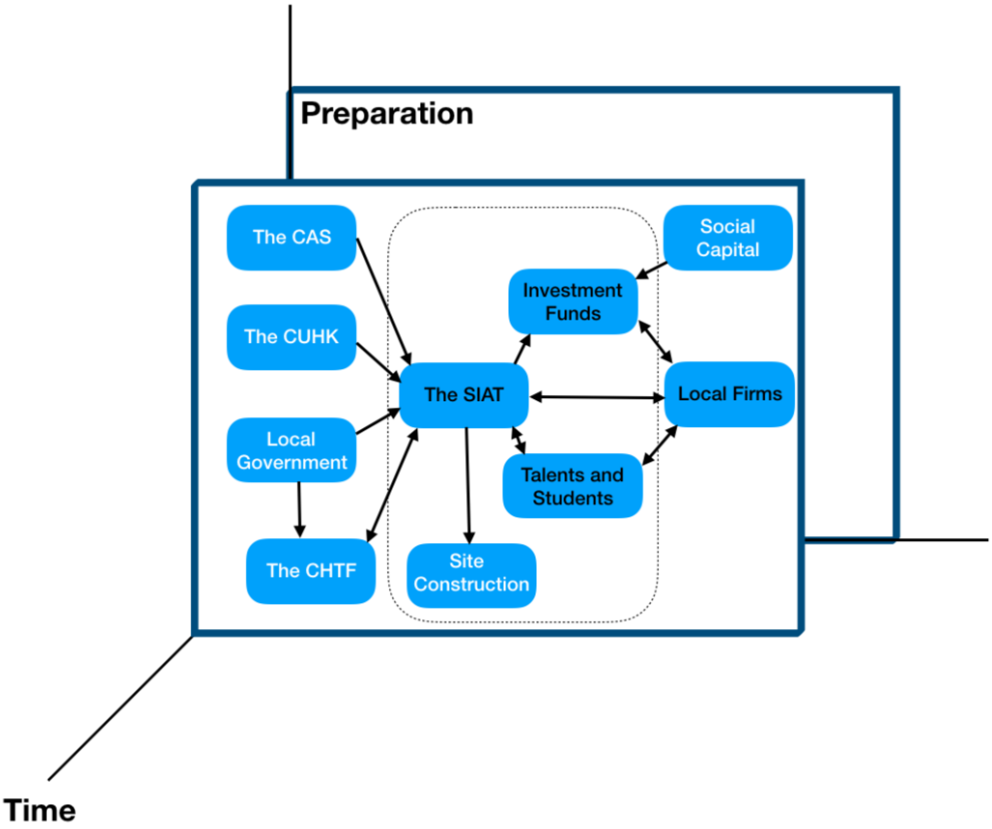


Figure 5-16 Launch of the SIAT

Speaking of the location of SIAT (Shenzhen), Prof. Xu of the CUHK and founder of the Institute of Advanced Integration Technology under the SIAT, said:

"Shenzhen is a migrant city with an inclusive and dynamic culture. Together with the supply chain integrity, here emerged diversified technological innovations."

After joining the SIAT, he put effort into building up the team for robotics research and participated in the organisation of the SRA. With assistance from the SIAT's scientific research in robotics and support from the SRA, local SMEs that stepped into robotics manufacturing grew rapidly and gradually specialised in segments such as medical robots and service robots.

For example, the Shenzhen Silver Star Intelligent Technology Co., Ltd collaborated with the SIAT in the R&D of robot vacuum cleaners and launched its own branded product KV8 in 2009, opening up the domestic market for cleaning robots. Later, they continued developing new generations of household intelligent robots in the jointly established lab.

From 2009 onwards, the SIAT relocated to the newly built campus and further integrated resources for innovation according to local industrial needs. In addition to the SRA, the SIAT also took the lead in forming industrial associations in low-cost health terminalss, Beidou Navigation Satellite System applications and marine research.

As Prof. Fan, the President of the SIAT, said in an interview[22]:

"We insisted on serving local industries for their upgrading with our technological capabilities and building platforms for research and practices in hi-tech areas, especially advanced manufacturing equipment and intelligence system for robotics."

Since he predicted that robots would be widely used in our daily life during the CHTF in 2006, the SIAT has greatly enhanced the technologies of industrial robots. Not only local robotics firms benefited from such technological advancement but also many manufacturing firms were assisted by the SIAT in applying robotics in their manufacturing processes to improve productivity. Moreover, the SIAT have trained more than 7000 postgraduate students in the past decade and about 60% of them went on to work for local firms after graduation23. Local enterprises and venture capitalists who were interested in hi-tech sectors approached the SIAT for collaborations and some investment funds were established for hi-tech start-ups. The SIAT also acted as an incubator for hi-tech start-ups and some spin-off companies have grown to

22 Source: http://www.uestcrobot.net/?q=node/236
23 Source: http://www.sznews.com/news/content/2018-11/05/content_21193528.htm

become leaders in niche markets. For instance, United Imaging, which was supported by the SIAT in its nascent stage of product development, has now become a leading firm in medical imaging systems with independent design, R&D and manufacturing capabilities.

Table 5-5 Interactions for the operation of the SIAT

Interactions	Type	Resource Creation/ Strengthening
Collaboration among the CAS, the CUHK and the Shenzhen Municipal Government	Mutualism	Creation: a state-level research institute
The SIAT formed investment funds with social capital	Mutualism	Creation: funding for practical research
The SIAT recruited talents from all over the world and trained postgraduate students	Mutualism	Creation: professionals in new research domain
Graduates from the SIAT worked for local firms	Mutualism	Strengthening: more skilled labour
The SIAT assisted local firms in technological upgrading	Commensalism	Strengthening: higher value-added manufacturing
The SIAT incubated hi-tech start-ups	Mutualism	Creation: new firms in emerging sectors

Table 5-5 summarises the interactions associated with the operation of the SIAT, from which local resources were enriched. Being a public industrial research institute, the SIAT has brought Shenzhen positive externalities in terms of new types of resources for innovation and facilitated the upgrading of local firms. It differentiated itself from other research institutes in mainland China by its different roles it has played in Shenzhen (as shown in Figure 5-17).

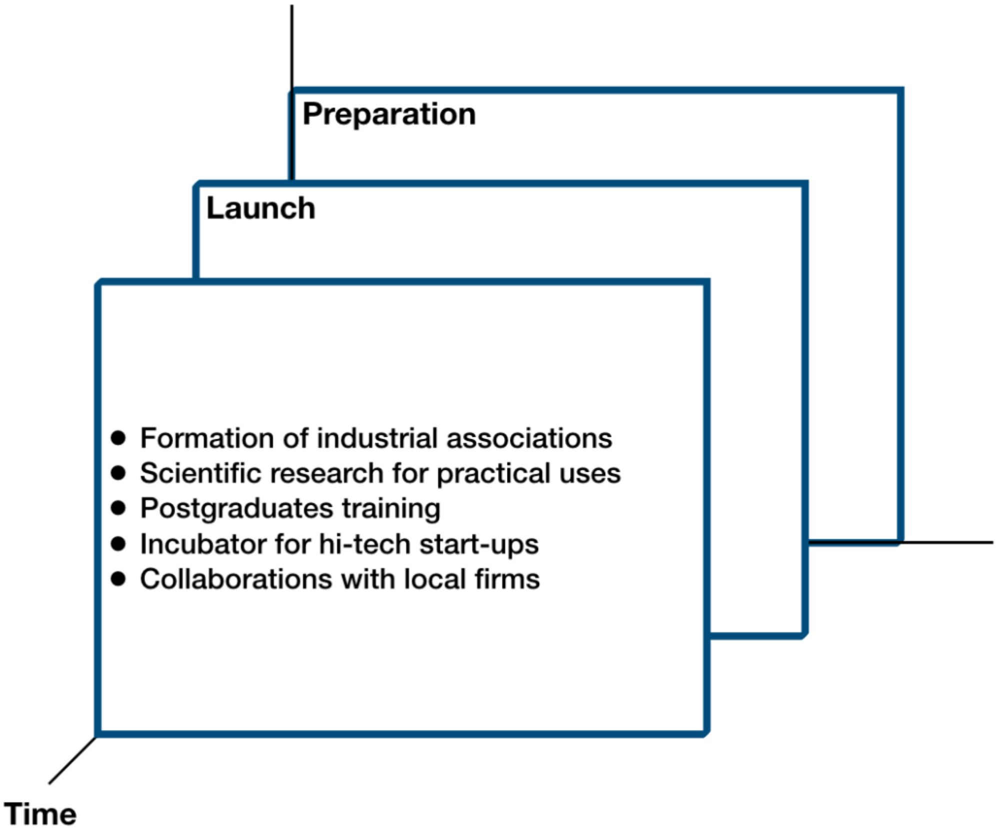


Figure 5-17 Different roles of the SIAT

5.1.6 The "Maker" Phenomenon

From "maker for makers" to "open factory for factories"

"Maker" is an imported concept and the maker culture refers to a technology-based extension of the combination of DIY and hacker culture that results in new device creation and existing device improvement[24]. It was introduced to Shenzhen in the early 2010s and then quickly spread to other mainland cities. With the legacy from the Shanzhai phenomenon in terms of comprehensive local resources that could be flexibly leveraged, Shenzhen soon become a city with many innovative makers. The city's "Shanzhai" image gradually transformed into indigenous innovation with the reinforcing maker culture.

Event Description

In early 2015, Chinese Premier Li Keqiang visited the Chaihuo ("firewood" in Chinese) Makerspace in Shenzhen and stressed the importance of grassroots innovation in enhancing the national economy:

"I'd like to add a piece of firewood to your business, to advocate more people to be makers!"[25]

After the Premier declared his approval of makers, many makerspaces or hackerspaces sprang up in mainland China. Being the pioneer in organising maker activities, Shenzhen has continuously collected and accumulated "firewood" spontaneously since the late 2000s.

24 Source: https://en.wikipedia.org/wiki/Maker_culture

25 Source: http://english.gov.cn/premier/news/2018/07/21/content_281476231348794.htm

As discussed in 5.3.5, the bursting of the "Shanzhai" phenomenon around 2008 attracted many young talents with innovative ideas to come and start their own business in Shenzhen. At that time, the HQB electronics market acted as a treasury of various components waiting for innovators to discover and transform them into cutting-edge products. The founder of Chaihuo makerspace, Eric Pan, was one of these young hunters. After graduating with a Bachelor's in Electronics and Information Engineering, he worked as a technician in the manufacturing department of Intel. The routine job with clear career development path was not challenging enough for him and after working for a few years, he resigned his post and started exploring new opportunities in different mainland cities. In Beijing, he was stimulated by the application of electronics components and automation technologies in contemporary art and started thinking about pushing the use of electronics to a wide range. Curiosity drove him to learn about the "open-source hardware" from the online forum established by Arduino, an Italian "open-source electronics platform based on easy-to-use hardware and software"[26]. Later he visited the HQB electronics market in 2008 and was amazed at the variety of components and the Shanzhai manufacturing system, which motivating him to set up his own business in Shenzhen able to utilise the local resources. Eric and his partner started developing electronic parts based on the open-source blueprints and raw materials from the HQB market, then selling them via a self-established e-commerce website. When he named his company "Seeed Studio" and positioned it as a "maker for makers" by providing electronics parts to innovators all over the world in 2010, the number of indigenous makers in Mainland China was small. As Eric himself put it:

"We started from processing semi-finished products in small to medium scale simply for our own survival. Then we gradually built up relationships with our customers in different places."

In order to promote the maker culture and encourage local grassroots with extraordinary ideas to participate in and make prototypes with the latest technologies, he founded the Chaihuo

[26] Source: https://www.arduino.cc/en/Guide/Introduction

Makerspace in 2011. Being the first makerspace in Shenzhen, it soon attracted enthusiastic grassroots workers to become members and start their own creative works with equipment such as 3D printers and laser cutters provided by Chaihuo and open-source hardware offered by the Seeed Studio. By 2012, Seeed had grown to become the largest domestic open-source hardware manufacturer and in order to further expand its influence, Eric and his team applied to Maker Media[27] in the US for the organisation of Maker Faire in Shenzhen. After obtaining authorisation, the Chaihuo Makespace took the lead in organising the city's first Maker Faire and it was successfully launched in April 2012, with 40 local and 30 foreign makers registered for the exhibition[28]. Since then, it has become an annual event, together with the Hi-tech Fair (CHTF), and can now be seen as two bigname events for Shenzhen by showing how this city has nurtured indigenous innovations in a bottom-up way.

In addition to the Chaihuo Makerspace and the Maker Faire, there were also other maker activities emerging in Shenzhen. HAX, the world's most active hardware accelerator or incubator, located its branch in HQB in 2012. There are two stages of its venture capital-based programme and all activities for the first stage, ranging from sourcing, supply chain, prototyping and industrial design etc. are supervised by the HAX's professional team in Shenzhen. On its website, Shenzhen is mentioned as "a unique production ecosystem in the world, taking advantage of the economies of scale where 90% of the world's electronics are made"[29]. SEG, the initiator of the HQB, also established a makerspace, "SegMaker", located on the floor above the world's largest electronics trading market. It provided not only co-working space for start-up teams but also a Fablab (Fabrication Laboratory) equipped with all the necessary facilities for makers to process electronics components they had purchased from the market downstairs. Moreover, every weekend SegMaker invited experts from various fields to give public lectures in software/hardware technologies, market trend analysis, business

[27] The Maker Media has a city-facing Maker Faire programme that provides tools and resources to help applicants to make a Maker Faire event. Source: https://makerfaire.com/global/

[28] Source: https://makezine.com/2012/04/05/makerfaireshenzhen/

[29] Source: https://hax.co

model review/discussion, etc., and organised salons for sharing professional knowledge and skills. Ms Law, a maker from Hong Kong who chose to settle in SegMaker, said:

"Shenzhen is the best place for us to stay. We can get anything we need from the HQB market and meet makers and professionals with various backgrounds through different kinds of activities here."

By sharing her experience in HQB, she concluded by saying that:

"I like it here because it is more like an ecosystem rather than a zoo; everyone can pursue their targets following the law of the jungle."

She also pointed out the importance of urban villages in Shenzhen for makers to organise off-line networking activities, which enhanced the connectivity and creativity of the local maker community.

The burgeoning maker phenomenon drew the attention of the government. In 2014, Premier Li Keqiang proposed mass entrepreneurship and innovation at the Summer Davos Forum and viewed it as the new engine for China's economic growth:

"When reform and innovation fuels the massive wave of entrepreneurship by the people and at the grassroots level on the land of 9.6 million km$_2$ of China, the enormous power of the diligent and resourceful Chinese people will be fully unlocked and the engine driving China's sustained economic development will constantly regenerate itself and remain powerful…In particular,

we need to step up reforms to remove restraints on innovation by individuals and companies." [30]

Following this speech, a number of preferential policies were launched at different levels to support hi-tech start-ups and makerspaces. In Shenzhen, there were special funds set up by the Municipal Science and Technology Innovation Commission in subsidising local makerspaces. The processes of administrative approvals for start-ups were also streamlined and power was delegated to lower levels. By the end of 2015, the number of makerspaces in mainland China had increased to more than 2300 and the term "maker" had become a top ten "buzzword" of the year. But along with the pros, a number of cons which became apparent in subsequent years need to be critically examined.

Event Analysis

The emergence of the maker phenomenon in Shenzhen was triggered by several factors (see Figure 5-18) in the early 2010s. First and foremost, the mature HQB electronics market with comprehensive supply chains had laid solid foundations for the resources that were most attractive to makers. Then, the legacy of the "Shanzhai" phenomenon in terms of flexibility and agility in specialised components manufacturing had been inherited by local open-source hardware manufacturers such as Seeed. Finally, in Shenzhen there existed many old factory sites leftover from traditional electronics manufacturing and, after refurbishment, these compounds were transformed into creative industrial zones and became ideal places to accommodate makers and their teams. For example, the OCT Loft where Chaihuo Makerspace is located had been factories for TV production. In addition to these main drivers, local grassroots played an essential role in differentiating the maker culture in Shenzhen to others as, in Eric's words:

30 Source: http://english.www.gov.cn/premier/speeches/2014/09/22/content_281474988575784.htm

"People here are more focused on not only making some fun projects but also in turning them into real products, to commercialise as a start-up"[31].

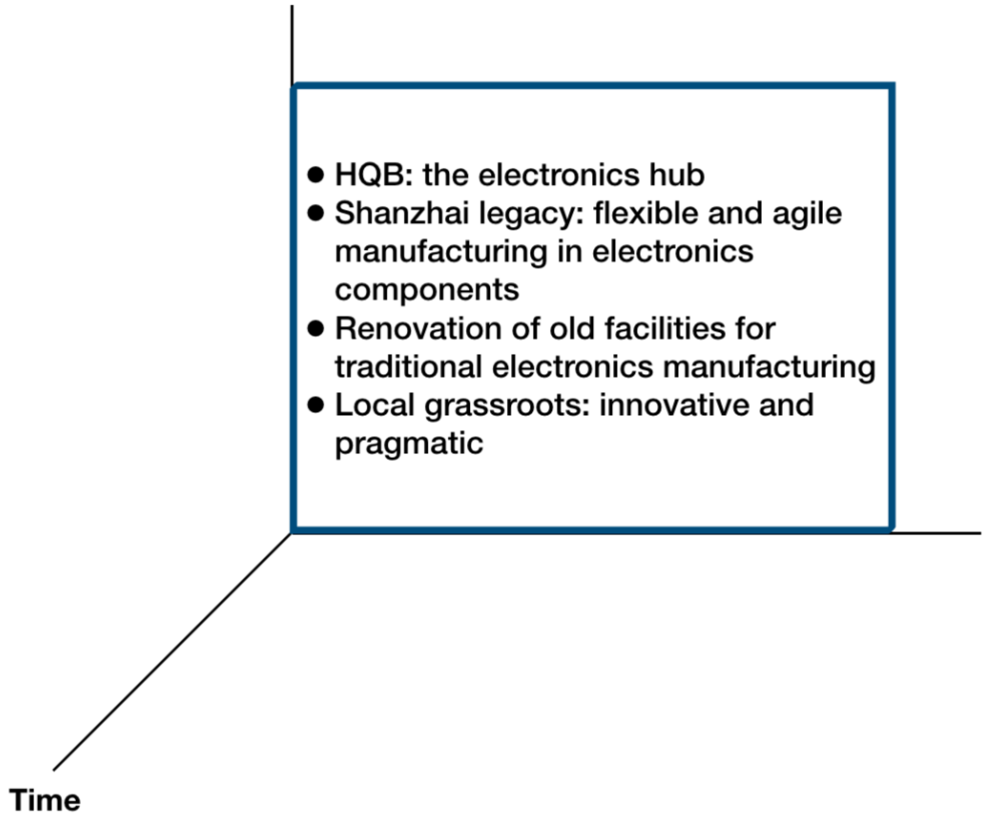


Figure 5-18 Triggering conditions for the maker phenomenon

The Premier's visit to Chaihuo in 2015 marked the take-off of makers and makerspaces in Shenzhen and other mainland cities. The main actors and their interactions that boosted the maker phenomenon are summarised in Figure 5-19 and Table 5.3.6-1.

[31] From an interview with Eric Pan conducted by Lyn Jeffery. (Source: https://boingboing.net/2013/06/11/made-in-china-eric-pan-and-op.html)

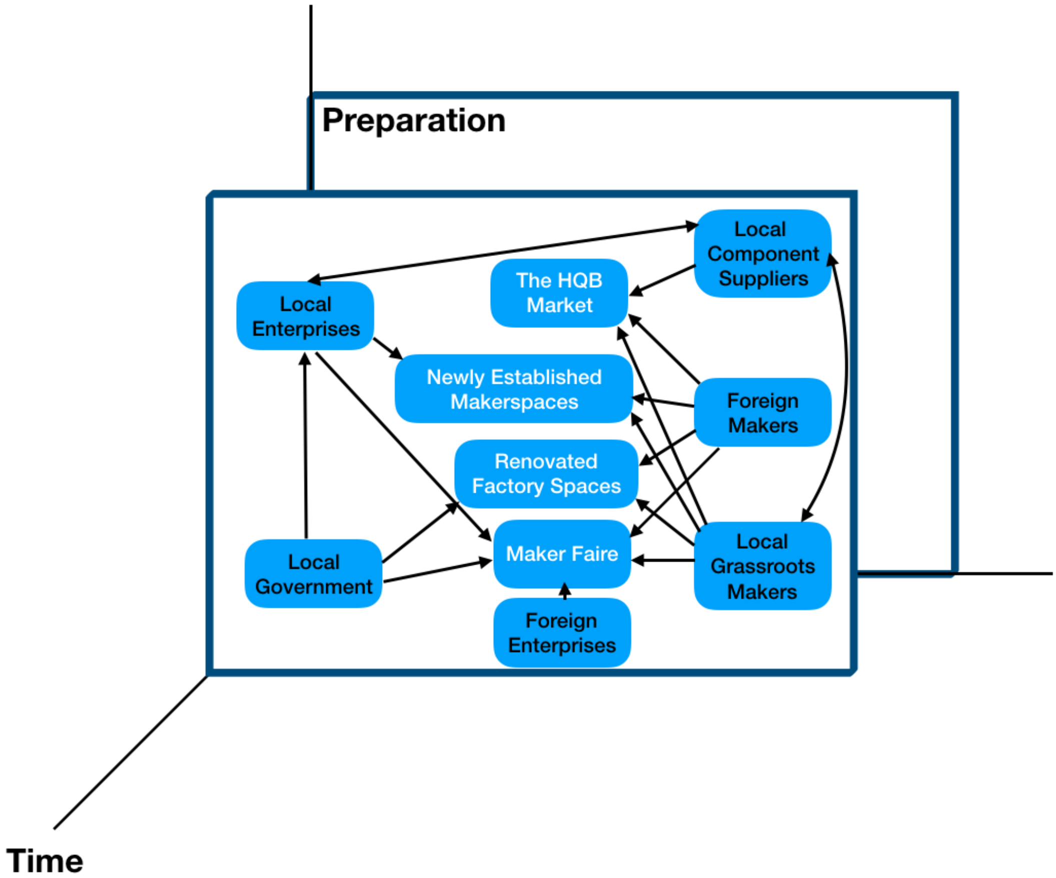


Figure 5-19 Actors and their interactions for the maker phenomenon

The maker phenomenon brought to Shenzhen domestic and foreign makers, makerspaces with diverse functions and the annual maker faire with trendy themes. It can be seen as a bottom-up process according to Chaihuo's experience while the government has played a supportive but not dominant role. It launched beneficiary policies to encourage grassroots workers to realise their ideas and consolidated infrastructure for maker activities to take place. During the interview, Eric noted that:

"The Government's policies are more like 'the icing on the cake' and to a great extent help us to spread out the influence on the wider public."

Following the government's advocation, local enterprises actively engaged in setting up makerspaces and promoted the maker culture by organising regular forums, salons and the fairs. All these activities gathered makers together and enabled them to share and exchange ideas with each other, which might result in new synergies or collaborations and further improvements on the prototypes. Since 2015, the Maker Faire has attracted world leading hardware producers to participate and exposed local grassroots makers to the latest open-source platforms and broadened their horizons.

Table 5-6 Interactive mechanisms for the maker phenomenon

Interactions	Type	Resource Creation/ Strengthening
Local government launched policies to support local hi-tech enterprises and indigenous innovations.	Commensalism	Creation: government funds/subsidies for makers and makerspaces
Local enterprises built up new makerspaces for local and foreign makers to use.	Commensalism	Creation: new infrastructure and facilities
Local government refurbished abandoned factories for creative industries.	Commensalism	Strengthening: revitalisation of old facilities
Local enterprises (in particular Seeed and its subsidiary Chaihuo) took the leading role in organising the Maker Faire.	Commensalism	Strengthening: promote local maker culture and expand its influence
Local and foreign makers purchased and customised components from local suppliers via the HQB market for their prototypes	Mutualism	Strengthening: diversity and flexibility of local components manufacturing
Exchange of ideas between makers through the maker faire.	Mutualism	Creation: potential collaborations for new innovations Strengthening: potential improvements on existing prototypes
Local and foreign enterprises sought new opportunities (new products/technologies) via the maker faire.	Mutualism	Creation: technical support from local or foreign giants e.g. Microsoft, Intel, Arm Strengthening: potential financial support to local innovations

In 2017, Chaihuo Makerspace opened up a new maker hub called "x.factory", with space over 1000 m^2 including workshops for the processing of different materials. It was positioned as the "open factory for factories", aiming to not only enable makers to realise and commercialise their ideas from prototyping, to engineering samples and then small-batch production and finally to large-volume manufacturing, but also to provide a sharing platform for maker professionals (makerpros) to find collaborators through various events[32]. Differing from Chaihuo Makerspace, which utilised the renovated factory space, x.factory was invited by the local real estate giant Vanke Group to locate in its newly established complex named "Design Commune". This implied that local enterprises within classic industries such as real estate had begun to upgrade by incorporating more diverse elements such as makerspaces into the community they built. In Shekou, besides renovating the old industrial zone, the China Merchants Group also established the "Design Society" complex which acted as a platform to facilitate the mutual inspiration between cultures and industries. It co-hosted Shenzhen's 8th Maker Faire with Chaihuo and x.factory in 2018 by bringing design and art elements into the local maker community. There are many other ongoing projects associated with the "gentrification" of the city, some of which caused concerns among local makers who feared inflated rental prices. Considering the importance of urban villages in enhancing the maker culture, since 2019 the municipal government has decided to redevelop urban villages rather than remove them in order to accommodate more young workers and makers.

With the maker culture penetrating into more aspects throughout the city's development, Shenzhen endeavours to attract more talented "makers" from other places and cultivate more local "maker pros". As Eric Pan mentioned during an interview at x.factory, Shenzhen is on the way to replacing the stereotype of "Shanzhai" with growing indigenous innovations:

"Shenzhen is a young city with people coming from everywhere and changing very fast…ten years ago no one knew what 'maker' stood for but now anyone could be a maker… thanks to the supportive environment in Shenzhen for start-ups and innovations (known as "Shuang

32 Source: https://www.xfactory.io

Chuang" in Chinese), we are able to disseminate the maker culture and utilise local (electronics and hardware) resources for innovations according to industrial needs. "

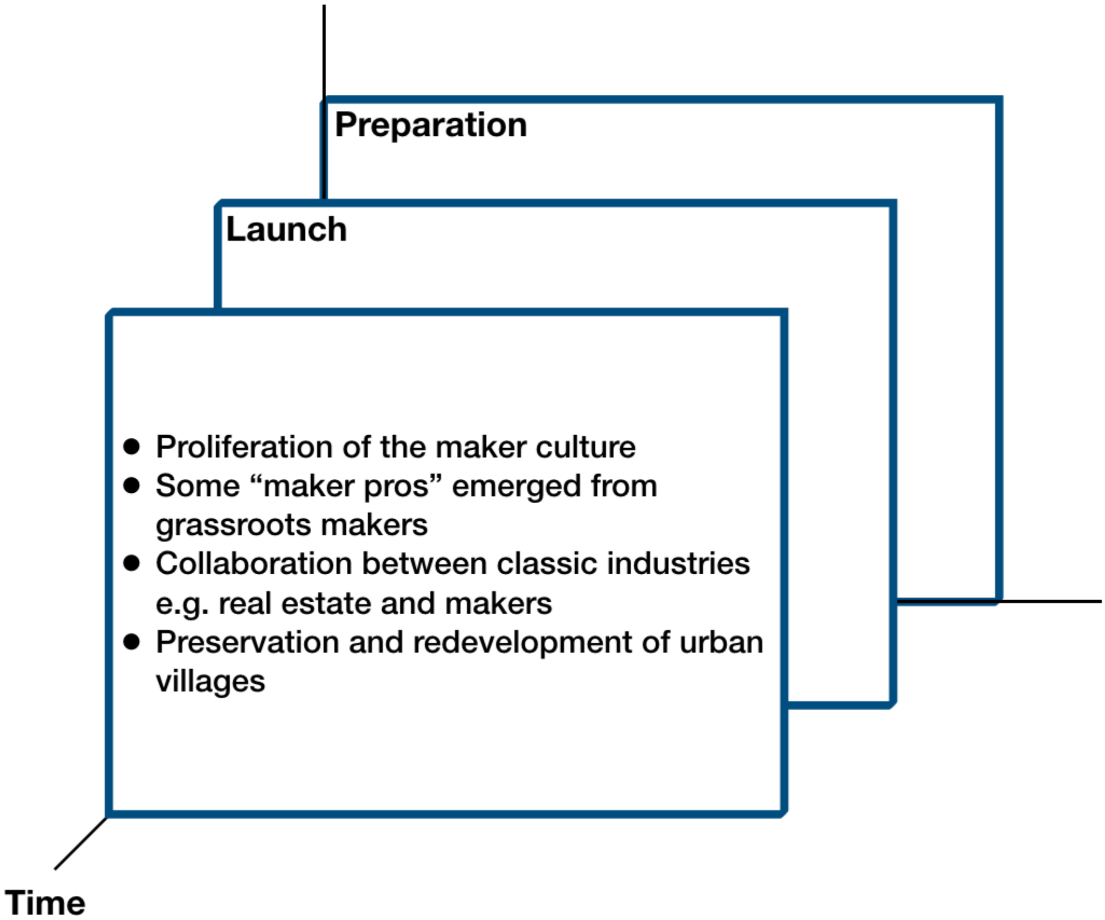


Figure 5-20 Follow-up impacts of the maker phenomenon

5.2 Synthesis of Milestone Events

Events	Resources Used	Types of resources used	Resources Created/Strengthened	Types of Resources Created/ Strengthened	Regional Resource Pool
3+1	Local government, foreign enterprises, local grassroot workers, local firms	-Policy -Capital -Production	Foreign capital, production lines, joint ventures, new authorities, skilled labour, productivity	-Capital -Production	-Policy -Capital -Production
CMSK	National authority, company, foreign enterprises, grassroot workers	-Policy -Capital -Production	Access to latest market information, new facilities, foreign production lines, foreign management styles, professional management teams	-Production	-Policy -Capital -Production
CHTF	Local government, national authorities, foreign investors, research institutions, local venture capitalists, local grassroot innovators, firms	-Policy -Capital -Research -Production	A state-level event, new exhibition halls and facilities, the emergence of venture capitalists, branches of research institutes, research projects	-Intermediary -Capital -Research	-Policy -Capital -Production -Intermediary -Research
Shanzhai	Local design houses, local firms, vendors and manufacturers	-Production	New technology, new standards, new institutions, improvement of the local manufacturing capabilities, more specialised component suppliers, more flexible and efficient production systems	-Production -Intermediary	-Policy -Capital -Production -Intermediary -Research
SIAT	Local government, research institute, social capital	-Policy -Research -Capital	A state-level research institute and postgraduate school, professionals in new research domains, new firms in emerging sectors, talents cultivated for local firms	-Research -Education -Production	-Policy -Capital -Production -Intermediary -Research -Education
Maker	Local government, local firms, grassroot innovators	-Policy -Production	Government funds/subsidies for makers and makerspaces, new infrastructure and	-Policy -Production	-Policy -Capital

Table 5-7 Synthesis of event cases

5.3 Embedded Company Cases

5.3.1 Shenzhen Electronics Group (SEG)

Overview

Shenzhen Electronics Group (SEG), was the first large-scale group corporation that engaged in technology, production and trade in Mainland China. It was jointly founded by the National Ministry of Electronics Industry, Guangdong Provincial Electronics Bureau and 117 Electronics companies in Shenzhen in 1986. Located in Huaqiangbei, SEG and its neighbour Huaqiang Group (provincial SOE) both played important roles in the early development of the local electronics industry. Initially SEG focused on manufacturing by forming partnerships with foreign enterprises. In 1988 SEG then set up the first electronics components market in China, known as SEG Electronics Market. From the 1990s to the 2000s, with the booming ICT industry, especially the flourishing mobile phone market, the SEG Electronics Market led Huaqiangbei to become the world's largest electronics market, with various component suppliers, contributing to the "Shanzhai" manufacturing of white brand mobile phones. In recent decades, SEG actively has engaged in technological innovation by setting up Maker Spaces and attracted innovators from all over the world to come and start their business with the access to the most comprehensive electronics resources. By the end of 2017, SEG had achieved an annual revenue of 3 billion RMB and a profit of 430 million RMB from its subsidiaries, among which Shenzhen Seg Co., Ltd and Shenzhen Huakong Seg Co., Ltd. were listed on the Shenzhen Stock Exchange. In the following section, the detailed process of SEG's development will be shown and critical transitions will be highlighted.

Development Paths and Transitions

<u>The Electronics Components Market</u>

In early 1980s, the National Ministry of Electronics Industry (NMOEI) sent out a team to assist local government officials to set up the local electronics industry. Mr. Fuyuan Ma, one of the team members who conducted fieldwork and investigations in Shenzhen, was selected to take the leading role. First and foremost, he endeavoured to integrate more than 100 local electronics firms that were scattered across Shenzhen into large corporation in order to pursue economies of scale. Then in 1986, SEG was established and Ma was appointed the first chairman. Besides being the chairman of SEG, Ma also assumed the role of President of Shenzhen Electronics Industry Association, established in the same year, as well as the Director of the Shenzhen Office of the NMOEI. With scale effects, SEG achieved a total output of 2 billion RMB in 1987, among which sales revenue accounted for three quarters.[33]

Although China initiated the opening up and reform strategy in the late 1970s, there was still limited autonomy for electronics enterprises to plan for production and related BOM (Bill of Materials). They were not allowed to directly import electronics components and it was time consuming for them to get the approvals from multi-level authorities. Such rigid control hindered the development of the electronics industry in Shenzhen and in order to flexibly obtain components and deliver orders on time, in 1986 Ma decided to lead SEG to establish a local market of diverse electronics components for domestic firms. After obtaining support from the municipal government, SEG refurnished and transformed the ground floor of its office building located at Huaqiangbei St into an exhibition and sales hall. Within this 1400 m^2 space, SEG set up more than 100 stalls and assigned them to component manufacturers from all over Mainland China and Hong Kong to sell their products. On 18th March 1988, SEG Electronics Market, the first electronics components trading market in China, was officially opened to the public, triggering the development of Huaqiangbei to become China's largest electronics component market.

From late 1980s to early 1990s, SEG Electronics Market greatly facilitated the development of local enterprises in electronics because "many grassroots, especially those from Chaozhou-Shantou region in Guangdong, started their career in electronics by selling components at vendors in SEG Electronics Market," as told by Mr. Kang, an experienced manager of the

33 Source: http://www.hqbpc.com/html/hd/513.html

market, and "then they started their own business by setting up factories with earnings from sales and became new suppliers of components." Although increasing numbers of enterprises settled in the trading market, SEG continued to expand the space of exhibition and sales hall to 8000m2, yet it was still insufficient for accommodating all of them. Then, in 1996, SEG made the decision to demolish the old office building and construct a skyscraper instead. They spent four years on this construction project and in 2000, SEG Plaza was completed, standing 356m tall, with a total of 71 stories above ground and four stories underground. The floors from the 1st to the 7th were taken up by the SEG Electronics Market, expanding the space to more than 50,000m2.

CRT (Cathode Ray Tubes) Manufacturing

When SEG was formed, it owned factories located in the urban area of Shenzhen city, in which manufacturing activities were taken place. In contrast to the popular "3+1" manufacturing that was totally controlled by foreign enterprises, SEG engaged in fully or partly self-owned production. In the late 1980s, the manufacturing of colour TVs was booming in China and there were 17 TV manufacturers in Shenzhen alone, producing 27 million colour TVs in 1988, a figure that accounted for one quarter of the national output in that year. However, there was a shortage in the supply of CRTs (Cathode Ray Tubes), a key component of colour TVs, a factor which hindered the development of the TV sector. To overcome the challenge of soaring prices of CRTs in the international market, SEG introduced production lines from Japanese company Hitachi in 1989. With joint investment of 149 million USD, the SEG-Hitachi factory was established with the production space of 150 thousand m2 and a production capacity of 16 million colour tubes per year. From 1989 to 1993, SEG-Hitachi continuously improved its production techniques in CRTs and was able to create its own practical design.

In addition to the joint venture with Hitachi, SEG also invested in another company called Zhongkang Glass, which produced glass bulbs for CRTs in 1990. Being a complementor of SEG-Hitachi, Zhongkang was also a Sino-foreign joint venture and introduced technologies as well as equipment from the US and Japan. Three years later, Zhongkang started launching glass bulbs with an annual capacity of 43 million sets. In 1998, the Korean giant Samsung invested in Zhongkang and formed SEG-Samsung, gradually transferring its production lines of CRTs to Shenzhen. However, entering the 2000s, the popularity of CRT displays declined as LCD (Liquid Crystal Display) technology emerged. Samsung successfully eliminated its CRT production lines and switched to LCD production with capacity released whilst SEG was then burdened by the over-capacity of CRTs and the fast-shrinking CRT TV market. However, CRTs were still used in some consumer electronics products and SEG sustained production and even invested in product and process upgrading in 2004 and 2005, resulting in growing sales revenue in 2006. However, the profitability from CRT production continued to decline and heavy losses finally drove SEG-Samsung to shut down all its factories in 2007.

Semiconductor Chips Manufacturing

SEG also played an important role in initiating semiconductor manufacturing in Shenzhen, especially in IC (Integrated Circuit) [34] production, assembly and test. Since the mid-1980s, ULSI (Ultra-Large-Scale Integration) - chips of more than 1 million transistors – had been applicable. Broadly, the manufacturing of ICs can be separated into two parts: front-end fabrication and back-end packaging. Being Shenzhen’s largest state-owned electronics corporation, SEG was assigned the mission of carrying out localised IC production by the municipal government.

In 1988, SI Semiconductor Co., Ltd (SI) was established as a Sino-US joint venture between SEG and the Asian branch of American company IBDT, and production lines of 4” ICs were introduced. However, because of a lack of core technologies and experience in the IC sector, SI failed to secure sufficient orders in a highly competitive market, generating continuous losses over eight years. After its US partner quit the partnership in 1996, SEG tried to revitalise SI by reorganising its production plan and assets. Without further investments, the SI team, led

[34] An integrated circuit (also referred to as an IC, a chip, or a microchip) is a set of electronic circuits on one small flat piece (or "chip") of semiconductor material that is normally made of silicon.

by Mr. Minglu Cao, raised capital from loans and borrowed retired equipment from other domestic companies. With effort and dedication, they successfully increased the capacity of front-end 4" ICs from 4 thousand to 12 thousand pieces per month and that of back-end packaging from 20 to 120 million transistors per month. In 2000, SI was capable of producing 20 thousand pieces and packaging 200 million transistors. Since then it has become one of the leading IC manufacturers in China and has continued to upgrade its manufacturing processes and IC products.

In addition to SI, STS Microelectronics was established in 1994 as a joint venture between European company ST Microelectronics[35] and Shenzhen SEG Hi-Tech Industrial Co., Ltd (SHIC), a subsidiary of SEG. STS was set up to carry out the ULSI project in Shenzhen, mainly focused on the back-end assembly and testing of semiconductor components produced by ST. It took two years to construct and equip factories, located in the Futian Free Trade Zone, and from 1998 onwards STS assembled and tested a wide range of products, including power MOS (Metal Oxide Semiconductor) transistors, voltage regulators, and standard Linear devices, among other products, for domestic and foreign customers.

After establishing the back-end assembly and testing of ICs at ULSI level, STS started to expand its business to cover front-end design and fabrication. To attract its partner ST to locate front-end production lines in Shenzhen, SEG raised funds from bank loans and the capital markets to construct factories according to ST's standards. The Municipal Government also offered SEG subsidised loans to support its ULSI front-end project.

In 2005, STS became the largest chip assembler and testing company in Mainland China, with an annual output of 3.4 billion items. With continuous upgrading in product and manufacturing

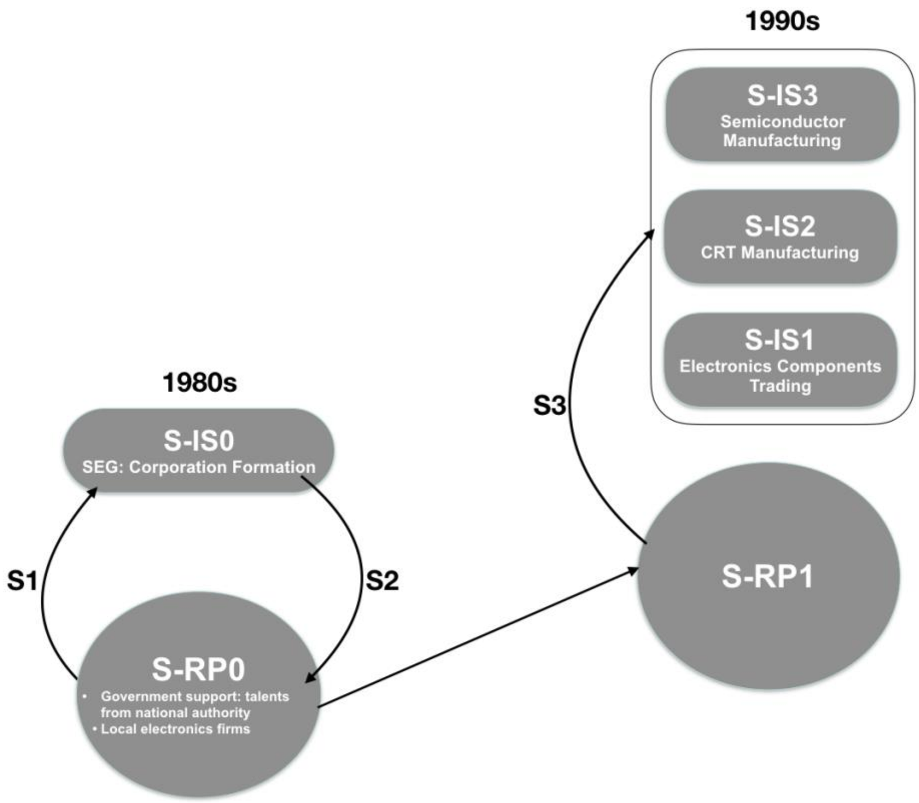
[35] ST Microelectronics is the company resulting from the merger of Italian semiconductor firm SGS and French semiconductor firm Thomson.

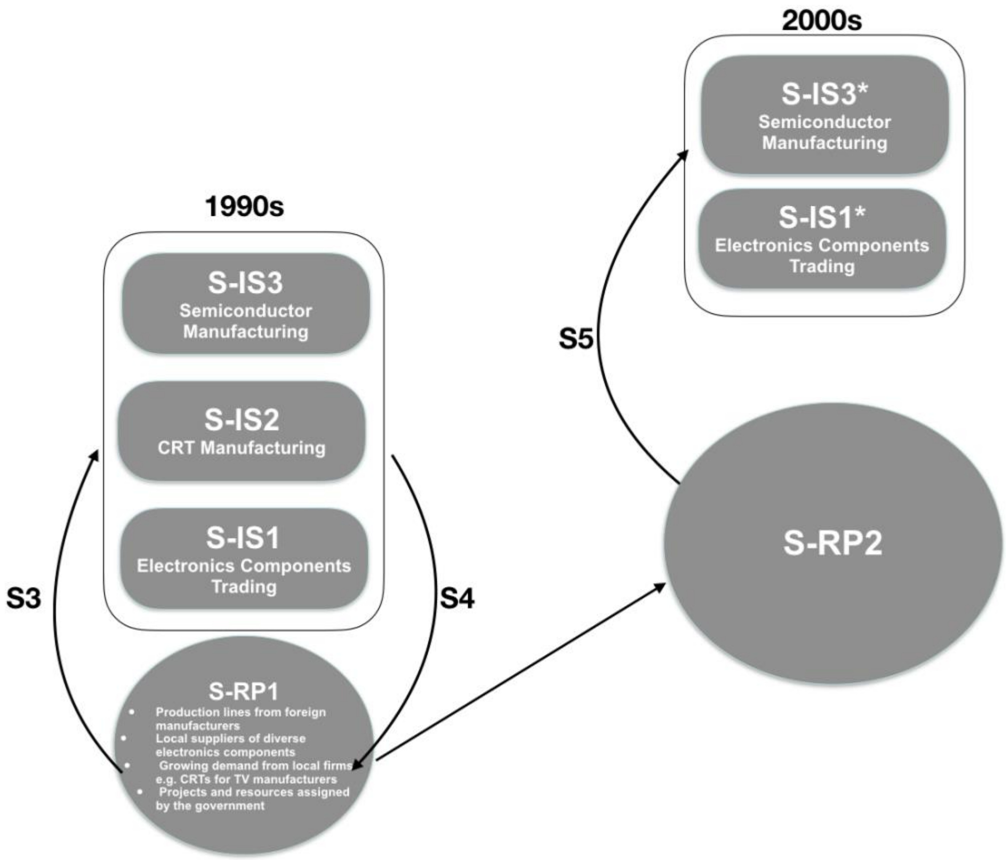
process, by 2009 it had become one of the largest factories in semiconductor assembly and testing.

Maker Space

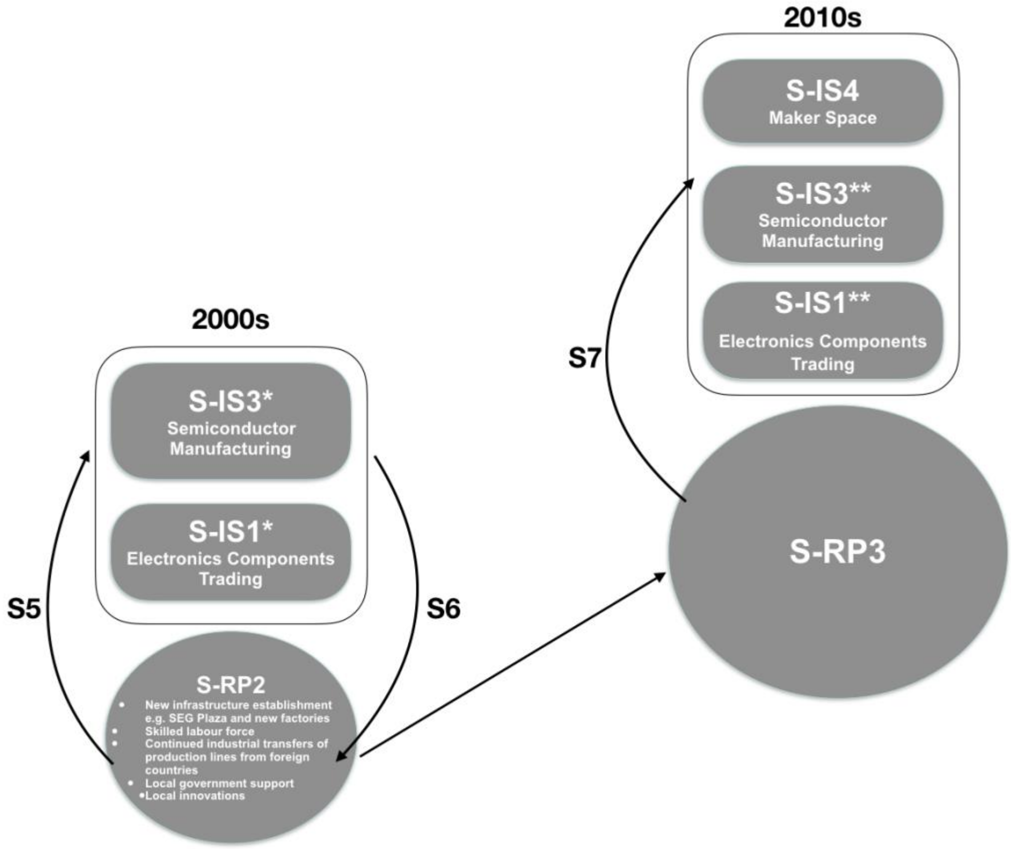
To respond to the call for mass entrepreneurship and innovation by the national government made in 2014, SEG established a makerspace called "SegMaker" a year later. Located on the floors of a building above the world's largest electronics trading market, SegMaker provided not only co-working space for start-up teams but also a Fablab (Fabrication Laboratory) equipped with all necessary facilities for makers to process electronics components they had purchased from the market down below. Moreover, every weekend SegMaker invited experts from various fields to give public lectures in software/hardware technologies, market trend analyses, and business model reviews/discussions, as well as organising salons for the sharing of professional knowledge and skills.

Analysis

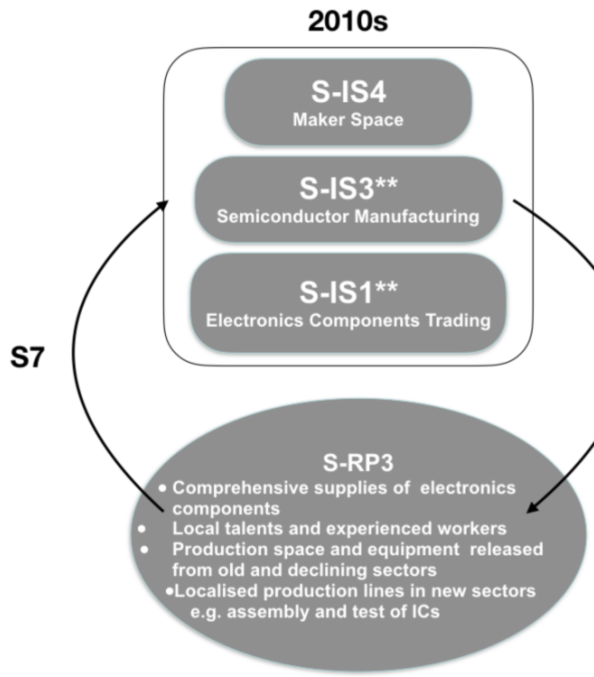




2000s
S-IS3*
Semiconductor Manufacturing
S-IS1*
Electronics Components Trading
1990s
S-IS3
Semiconductor Manufacturing
S-IS2
CRT Manufacturing
S-IS1
Electronics Components Trading
S5
S3
S4
S-RP2
S-RP1
Production lines from foreign manufacturers
Local suppliers of diverse electronics components
Growing demand from local firms e.g. CRTs for TV manufacturers
Projects and resources assigned by the government



2010s
S-IS4
Maker Space
S-IS3**
Semiconductor Manufacturing
S-IS1**
Electronics Components Trading
S7
2000s
S-IS3*
Semiconductor Manufacturing
S-IS1*
Electronics Components Trading
S5
S6
S-RP3
S-RP2
New infrastructure establishment e.g. SEG Plaza and new factories
Skilled labour force
Continued industrial transfers of production lines from foreign countries
Local government support
Local innovations



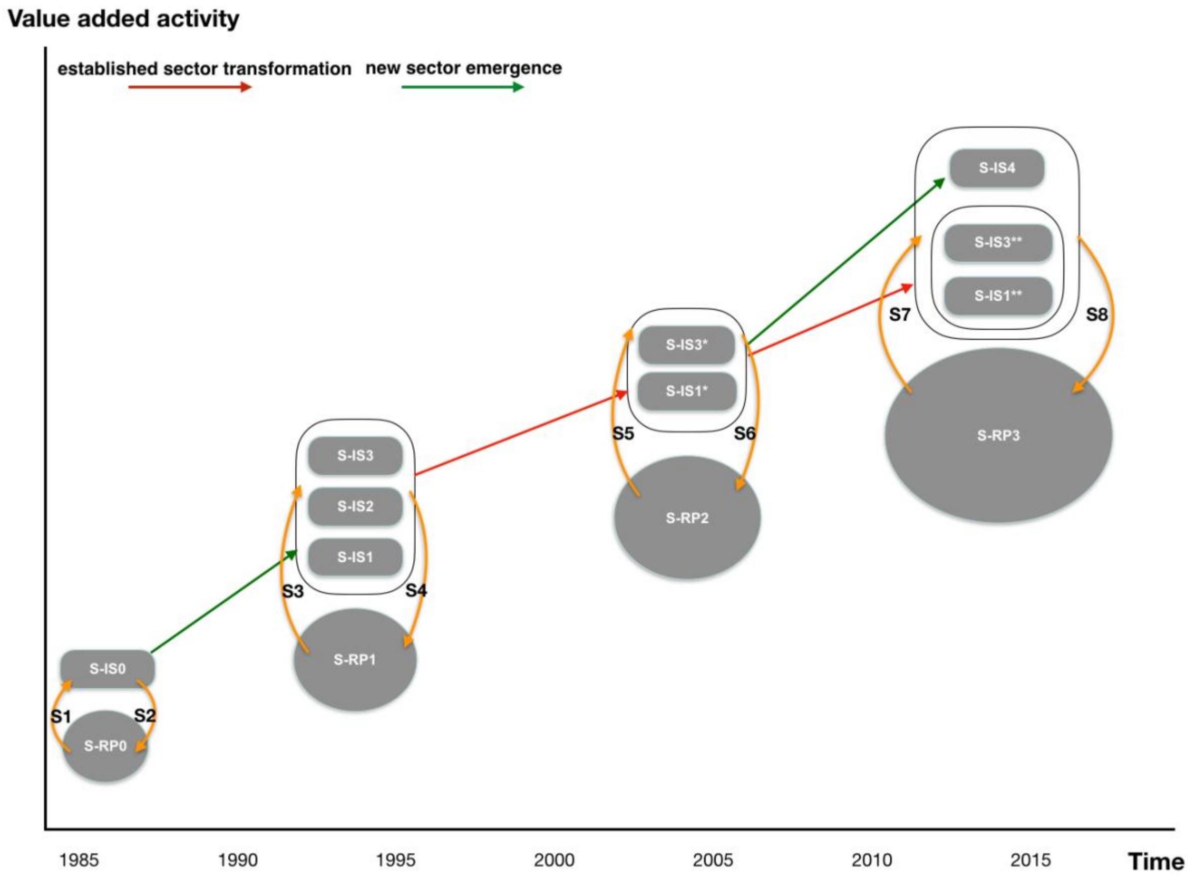


Figure 5-21 The Upgrading Path of SEG

Figure 5-21 shows the upgrading journey of SEG from a large corporation for electronics manufacturing to a company mainly focused on the operation of components trading market and maker spaces. A detailed analysis follows.

After Shenzhen was established as a Special Economic Zone in 1980, contract manufacturing in terms of “3+1” manufacturing was officially introduced to the mainland and the first generation of local electronics firms emerged. These firms were small in scale and undertook low value-added production tasks transferred from other regions (mainly from Hong Kong at that time). To improve the bargaining power of these firms and enhance the development of the local electronics industry, the government decided to gather them together to achieve the synergy effect, resulting in the formation of SEG as a large corporation (S-IS0) that mainly focused on the production of TVs, radio-cassette recorders and telephones. SEG then set up institutions such as the Shenzhen Electronics Industry Association and SEG Training Centre for vocational training in electronics manufacturing. SEG also provided scholarships for students at Shenzhen University, laying the foundation for cooperation between companies and academic institutions in Shenzhen.

SEG was thus in a number of ways a pioneering corporation. As one experienced manager put it, “Shenzhen is a ‘Special Economic Zone’ where people and firms are encouraged to experiment, even with the risk of breaking the rules.” He added that “SEG did not follow others to conduct processing manufacturing in its early stages but instead opened up self-run businesses.”

Being Shenzhen’s first large-scale corporation in electronics manufacturing and trading, SEG started its businesses in three main sectors in the early 1990s. Firstly, SEG was a pioneer in organising the electronics components trading market (S-IS1). The successful practice of this market for the free trading of production materials motivated other regions in China to set up similar markets. Secondly, to satisfy the demand for CRTs from local TV manufacturers, SEG engaged in CRT manufacturing (S-IS2) in collaboration with foreign enterprises. The wave of industrial transfers from these foreign countries to China also facilitated the emergence and development of the local CRT sector. Thirdly, SEG was assigned the task of initiating semiconductor production (S-IS3) in Shenzhen by the municipal government in order to lay the foundations for this emerging sector. Without core technologies, SEG could only get started from back-end assembly and testing by learning from production lines introduced from foreign countries.

Based on governmental support in terms of capital and skilled labour as well as the joint forces of local electronics firms, SEG was able to set up different production lines and the components trading market, providing job opportunities for local grassroots labour to work in the electronics industry. In this stage, the government played a critical role in planning and leveraging resources to carry out these projects. Although facing the usual rigidities associated with planned organisational structures for SOEs, SEG endeavoured to carry out projects according to rising demand for electronics and changing global trends in products and technologies.

In the late 1990s, Shenzhen attracted huge numbers of workers, managers and sales staff and formed a critical mass of skilled labour in electronics manufacturing. Some of these workers went on to start their own businesses in components manufacturing using their own savings and drawing on their industrial knowledge and social networks from their previous working experience. Then they rented stalls at SEG electronics market to sell their products, which drove SEG to expand the market space and reconstruct the building in 1999 (S-IS1*). During this period, SEG also established the first market for telecommunication devices and components, known as the SEG Communication Market, which laid the foundation for the mobile phone sector in Shenzhen.

Commenting on this aspect of critical mass effect of skilled workers starting their own ventures, the Operation Manager of SEG electronics market noted that, "Most vendors come from the same hometown, especially those from the Chaozhou-Shantou region, who have brought many relatives and friends to Shenzhen and run businesses together." He added that, "With mutual trust and social bonds, they gradually formed a comprehensive supply chain of electronics components." Such family businesses or business activities with relatives or friends to a great extent lowered transaction costs and improved efficiency.

As more foreign firms and their production lines were introduced to Shenzhen, together with a growing number of newly established firms and factories, local manufacturing capabilities and capacities were improved. In addition to contributing to existing sectors, some local innovations, such as the USB flash memory disk, were soon applied by manufacturers in the electronics market and developed into multi-functional devices, such as, for instance the MP3 player. Gradually, the Huaqiangbei area where electronics suppliers clustered around the SEG Electronics Market became the most popular spot for the latest electronics products and attracted many buyers and sellers to come and seek opportunities there. Local SMEs, especially those that had started investing in independent R&D, were the main customers for components supplied by an electronics market that was characterised as diversified and flexible. They could always get various components at small scale from the market and those vendors were sensitive to changes in global trends for products and components. When randomly interviewing several vendors at the market, they stated that:

"Many local companies buy components from us and we can customise our products according to their needs efficiently."

Others said:

"There are two types of vendors in the SEG Electronics Market, either with factories at their back or without factories and simply acting as sales agents for different upstream suppliers."

"In the market we can get help from each other. For instance, once I lacked stock of some components for urgent use, so I borrowed from others and paid back later."

"For a certain type of component there is more than one vendor selling it at the same time, and thus we cannot set the price much higher than our peers."

From these statements we can see that the trading market of SEG was functioning according to textbook dynamic free market mechanisms, replete with variety, collaboration and competition. At this stage, the government offered guidance and support in infrastructure construction and some regulations in market management but did not directly intervene in the manufacturing and trade of components. However, the government did play a more important role in the other two subsidiaries of SEG. By investing in glass bulb manufacturing (S-IS2*) and building factories for semiconductor manufacturing (S-IS3*), the manufacturing capabilities and production capacities in these two sectors were greatly improved. In the 2000s, the telecom sector grew rapidly on the one hand and mobile phones became the main focus of local electronics manufacturers. On the other hand, with technological advancement in the display sector, CRT manufacturing gradually lost its popularity when faced with the challenge from the rise of LCDs.

With two-decade development in specialised components markets led by SEG, the Huaqiangbei area had become the largest electronics cluster in Mainland China, and in 2008 it was formally titled “China’s No.1 Electronics Street” by the China Electronics Chamber of Commerce. Moreover, the Huaqiangbei Index has become a critical indicator for the prosperity of the trading market of electronic components and consumer electronics products. Since the first official release of the Huaqiangbei Index in 2007, it has now been widely used by different authorities and organisations in monitoring the electronics markets in Mainland China. The Shanzhai phenomenon in mobile phones also emerged from Huaqiangbei, where all kinds of electronics components could be easily brought from vendors within diversified markets and integrated into a functional or unbranded smart phone. All these enterprises in electronics components, as well as manufacturers supporting them, have become more and more flexible in supplying customised products facing growing uncertainties in the electronics industry.

Although SEG benefited from the flourishing electronics trading market, it also bore the losses of the declining CRT sector. Following the product lifecycle of CRT display, this sector gradually declined and was driven out of the market in the late 2000s. SEG then sold its CRT business to Zhiyuan Capital group, which was founded by the Municipal State-owned Assets Supervision and Administration Commission. During this period, the local government launched the policy of transferring factories from urban areas to peripheral areas of the city to facilitate local industrial upgrading, and thus factory space which was released was refurnished and transformed into buildings for other functions.

In addition, after experiencing turbulence in terms of organisational and ownership changes in the 1990s, semiconductor manufacturing, or more specifically the assembly and testing of ICs, was back on track and localised production began from the early 2000s, after which SI and STS both up-scaled their production in assembly and testing of ICs and expanded their businesses to cover more sectors. SI then became the number one company for semiconductor devices in Shenzhen with both front-end and back-end manufacturing capacity and was awarded the State Hi-Tech Enterprise in 2009 (S-IS3**).

Facing the decline in CRT manufacturing, SEG switched its main business to the components trading market and invested in emerging hi-tech sectors that were considered strategic for future industrial development, such as the front-end design of chips and photovoltaic modules. A senior manager from the strategic department of SEG emphasised that "the termination of SEG-Samsung in CRT manufacturing indicated that it is more important to allocate more resources to pursue innovation in emerging sectors rather than following existing pathways to develop an existing sector."

In the Huaqiangbei area, where the "Shanzhai" phenomenon had emerged in mid-2000s, a Shanzhai manufacturing system with high efficiency and flexibility was nurtured. There gradually accumulated many specialised component suppliers with vendors selling their products at the electronics markets (S-IS1**). In early 2010s, grassroot innovations and entrepreneurship were promoted by the government and many makers were attracted to Shenzhen and sourced electronics components from the Huaqiangbei markets. SEG sensed an opportunity and established its own makerspace, SegMaker, with government funds of 2 million RMB in 2015 (S-IS4). Then it located the makerspace space to just above its electronics markets and even installed a lift to facilitate makers settled in SegMaker to pick up components they needed more efficiently. Following this, more makers from all over the world chose to accommodate themselves in SegMaker to utilise Huaqiangbei's resources and regular public activities were organised by the makerspace for more grassroots workers to participate in.

Case Summary

There were three main transitions throughout SEG's development, involving eight groups of upgrading processes since its establishment in the mid-1980s. The main drivers, interactions and impacts of these processes are summarised in Table 5-8. The interactions between the resources in Shenzhen and SEG's industrial systems are highlighted for further analysis.

Table 5-8 Upgrading Processes of SEG

Process	Main Driver(s)	Main Interaction(s)	Impact(s)
S1	-Local electronics firms with poor technology and small scales	**-Local government lobbied the national authority to send talents to Shenzhen for the development of local electronics industry**	-Local electronics firms were gathered together to form SEG for joint development.
S2	-SEG aimed to vitalise the local electronics industry	**-SEG established the Shenzhen Electronics Industry Association** **-SEG set scholarships for students in Shenzhen University** **-SEG set up a training centre for technicians in electronics manufacturing**	-The capabilities of local electronics firms were enhanced.
S3	-The emergence of local component suppliers -The growing local demands for electronics goods and components -Government launched projects in electronics manufacturing	**- SEG refurnished and transformed its offices into the trading market for components** **-Foreign production lines were introduced e.g. CRT production lines from Japan** **-SEG was appointed to carry out the localised IC production by the government**	-The first electronics components trading market was established in Huaqiangbei. - The SEG-Hitachi factory was established for CRT manufacturing. - The SI Semiconductor Co., Ltd was established and production lines of 4" ICs were introduced.

Process	Main Driver(s)	Main Interaction(s)	Impact(s)
S4	-SEG continued to expand its businesses	**-SEG provided job opportunities for local grassroots** **-SEG attracted enterprises from other regions to locate their trading or manufacturing in Shenzhen**	-More skilled workers trained -More electronics enterprises settled down in Shenzhen.
S5	-Increasing demand for space in the electronics market -Local innovations in electronics components and products -Improved local manufacturing capabilities in electronics	**-SEG started new infrastructure construction that supported by the local government** **-Networks formed in the electronics market among vendors and suppliers** **-SEG continued its collaboration with foreign giants by introducing their production lines and technologies**	-The SEG Communication Market was established. -More component suppliers set up stalls at the electronics market. -Samsung collaborated with SEG and transferred its production lines of CRTs to Shenzhen. - STS was founded to assemble and test a wide range of IC products for domestic and foreign customers.

Process	Main Driver(s)	Main Interaction(s)	Impact(s)
S6	-The CRT display lost its popularity -The "Shanzhai" phenomenon initiated in Huaqiangbei	**-SEG gave up its CRT business and the local government backed it up** **- SEG switched its main business to the electronics market**	-Factory spaces released for new uses and redundant skilled workers sought for new jobs - Huaqiangbei became the largest electronics gadget market
S7	-Local innovations emerged boosted the demand for various electronics components -The Maker Phenomenon	**-The Huaqiangbei electronics markets linked local components suppliers with domestic and foreign makers** **-Local government encouraged indigenous innovation and establishment of maker spaces by providing funds and subsidies**	-SEG established its own maker space SegMaker.
S8	-Makers settled down in SegMaker	**-Makers based in SegMaker utilised the components market for their innovation and prototype development**	-Regular activities organised by SegMaker to promote maker culture and offer technological supports to local grassroots

These interactions are coded as the 1st order concepts and grouped according to their similarities, which then pointing towards the 2nd order themes. As shown in Figure 5-22, there are 5 types of interactions between regional resources and industrial systems for SEG's upgrading.

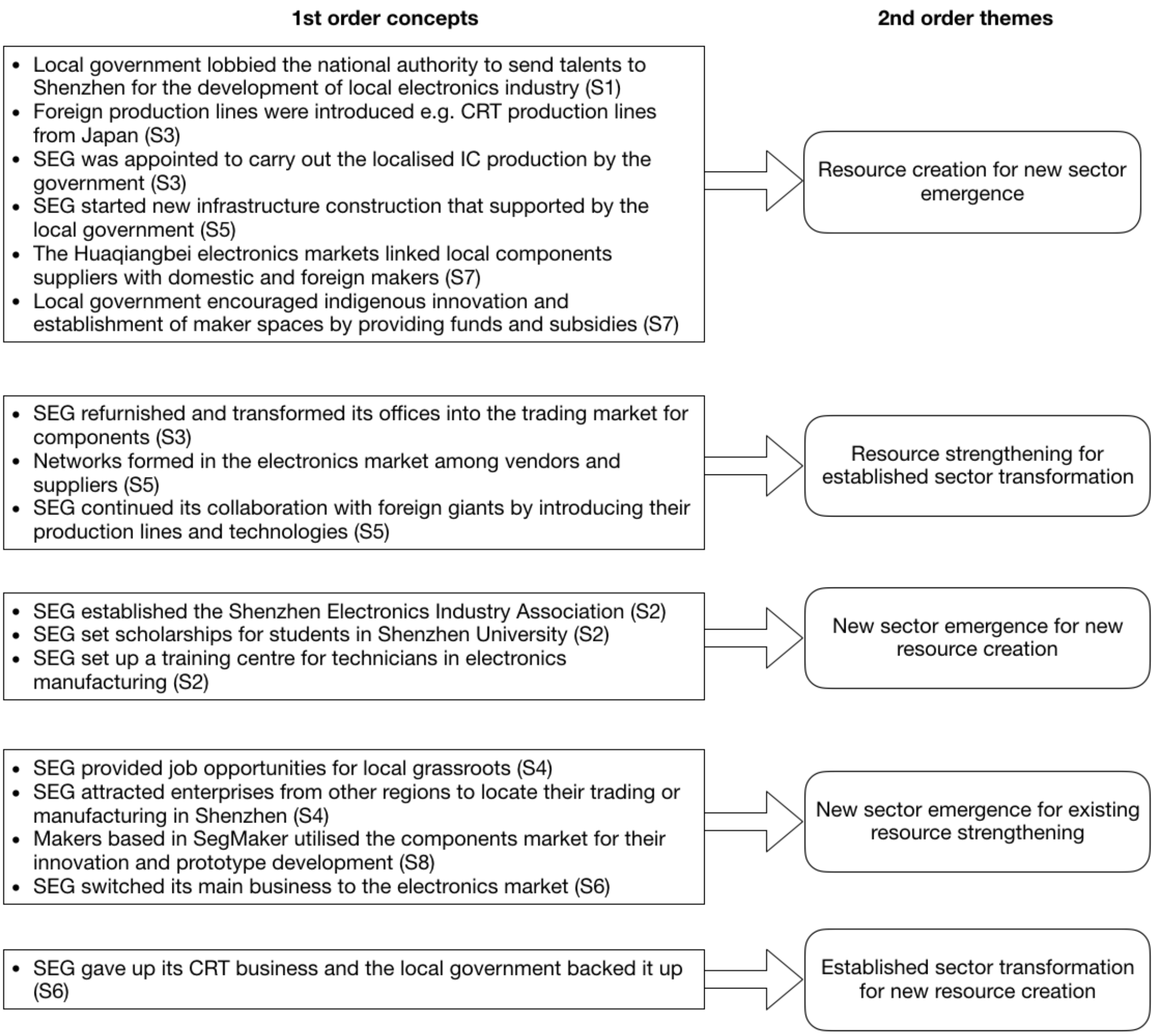


Figure 5-22 Interactions for the Upgrading of SEG

5.3.2 BYD

Overview

BYD, “Build Your Dreams”, is now a hi-tech company that manufactures products ranging from consumer electronics, electric vehicles, new energy devices and even rail transit. During the past 24 years, it has grown from a small battery factory to a cross-industry giant, employing more than 220 thousand staff all over the world. BYD is currently well known for its automobiles for the mass consumer market, including electric or hybrid buses and taxies widely used in public transportation. Switching to a greener industry to a great extent can be seen as the inter-sectoral upgrading of BYD, which has contributed to the development of industrial sustainability. However, its business within the electronics industry (BYD Electronic Company Limited) in fact plays the pivotal role in supporting BYD’s continuous growth.

Development Path and Transitions

Battery Production

In 1994, BYD was founded in Shenzhen as a battery manufacturer, initially producing Ni-Cd batteries. Its founder, Mr. Chuanfu Wang, is trained as a battery chemist and had been working in a research institute before arriving in Shenzhen. One year later, BYD attended the Telecom Fair held in Shenzhen and it was the first time for BYD to showcase its products to other firms and potential customers. From this event, BYD attracted talent to join its management team and Wang also identified the cordless telephone as a market niche for BYD to target.

In 1996, BYD started investing in manufacturing lithium batteries that had hitherto been monopolised by Japanese companies. Failing to procure a production line from Japan, Wang then led a team of local professionals to conduct R&D into the manufacturing equipment for lithium batteries. The team successfully innovated the first manual production line for lithium batteries and in August of 1997 BYD began the production of lithium batteries, which were at the time widely used in mobile devices such as functional mobile phones. In the same year, the

Asian Financial Crisis hit Japan, hitting hard those Japanese battery manufacturers who had applied automated production lines, resulting in high costs. BYD took advantage of the local cheap labour on its manual-automatic production line and became price competitive in the world market for lithium batteries. BYD also put efforts into tackling technical problems of battery manufacturing, as recorded in the company's internal documents. As Mr. Wang mentioned:

"In 1997 we invested a lot in purchasing equipment and seeking talents in developing Ni-Mh and lithium batteries…We recruited established chemists from outside to lead the team in addressing technical barriers…."

From 1995 to 1997, BYD achieved an annual growth rate of 100% and sales revenue of RMB 100 million by the end of 1997. During that period, traders in Hong Kong facilitated BYD to export its batteries to foreign customers.

In the mid-1990s, the municipal government of Shenzhen realised that continued reliance on traditional processing and trading would not be a sustainable way for regional economic development. As a result, the government planned to drive those factories for low value-added activities out of the city and move manufacturing bases from central districts to the eastern suburbs. Thereafter, an industrial zone of more than 190 km^2 was established in Longgang district, together with the requisite infrastructure such as roads and water and electricity supply. Firms like BYD were trying to scale up their production during that period and this new industrial zone offered them large space at low cost. The company rented two blocks in the industrial zone and space of 8000 m^2 enhanced its capacity for battery production. With the aim of enhancing the development of hi-tech industrial sectors, the local government also launched preferential policies such as subsidies and lower tax rates to motivate innovation through independent research and development (R&D) conducted by private firms. Such policies actually benefited firms that, like BYD, had focused on improving the quality of its products through continuous investments in R&D. By attending different fairs and exhibitions all over the world in the late 1990s, BYD gradually cultivated relationships with other companies, among which another Shenzhen firm - Huawei - has now become a national flagship and major global player.

Entering the 2000s, BYD continued to scale up its production and began to expand its main business from batteries to include other electronics components. It moved all its production lines from rented factories to the industrial park invested in and established by itself in Kuichong, with land of 260 thousand m^2 for production and 140 thousand m^2 for staff quarters to accommodate all employees. In these new factories, BYD innovated dust-free compartment production lines and drying rooms, which greatly improved efficiency. In September 2000, the lithium batteries produced by BYD passed strict Motorola quality checks and became the American company's first Chinese supplier of batteries. From BYD's internal records we found that Mr. Wang marked this as an important milestone for BYD, noting:

"With Motorola's approval of our batteries, we have got the permission to cooperate with other 'big brands'..."

More foreign brands then started approaching BYD for its batteries and other electronics components. During an interview I was told by a senior manager of BYD that another important reason was its proximity to Hong Kong:

"At that time those managers of foreign giants preferred to stay overnight in Hong Kong and BYD, being located in Shenzhen, was a convenient choice for them to commute in one day."

Mobile Phone Components (mainly casing) Manufacturing

2001 witnessed the fast growth of the mobile phone sector but there was a lack of component suppliers in China. BYD sensed this opportunity and after conducting detailed market research, it noticed that there was no mobile phone casing manufacturer in Mainland China at that time, so it made the decision to engage in manufacturing mobile phone casing and LCD screens. BYD invested RMB 100 million into the LCD segment between March 2001 and March 2002, when it began mass production. For mobile phone casings, BYD established its 3rd business unit to focus on precision structural components and a department of moulding at the end of 2002. In the same year it obtained an order of lithium batteries from Nokia, which further broadened its horizon to foreign markets in addition to local customers such as Bodao, TCL, Haier and Lenovo. In 2003, its cooperation with Nokia progressed from batteries to other mobile phone components, especially casings. BYD then invested in broadening its range of mobile phone structural components to include backlights and keyboards, among other features, as well as expanding its production base to the neighbouring city of Huizhou by establishing a branch for mobile phone components there. All these actions marked the first transition of BYD from battery manufacturing to more complex components production with more capital and new machinery.

ODM for Mobile Phones

From 2001 onwards, electronics firms mushroomed in Shenzhen, producing various products and components for consumer electronics. Huaqiangbei in central Shenzhen had become the world's largest electronics exchange, a place where retailers and manufacturers clustered. The emergence of design houses further enhanced the capabilities for new product development of local enterprises. As a senior engineer at BYD explained about how local design houses emerged:

"In the early 2000s, some former employees from Motorola set up their own businesses for designing CDMA mobile phones, which can be seen as the first batch of design houses in Mainland China… Then in Shenzhen such design houses proliferated…"

Around 2003 the "Shanzhai phenomenon" took place in Shenzhen, namely the emergence and flourishing of the white brand mobile phone market, which stimulated many local grassroots workers to start their own businesses in mobile phone components manufacturing and trading. Meanwhile, the government put effort into enhancing the development of chips by establishing the Shenzhen IC Industrial Base. This was one of eight national-level industrial bases for IC design and industrialisation, providing services for local companies such as BYD. Being a contractor of the IC industrial base, BYD was able to enjoy preferential policies and technological support in chip design and manufacturing. Then BYD founded its own micro-electronics branch in October 2004, locating the design and packaging department in Shenzhen. In 2005, BYD ranked as one of the top ten electronics companies in Shenzhen and among the top one hundred in China.

The second transition of BYD was initiated in 2007 after Apple launched its iPhone and unveiled a new era of smart phones. Metal parts instead of plastic parts were used in smart phones to support their heavier weight and strengthen their signal transmission capacity. Facing such changes in the mobile phone market and the progression of mobile communication technology from 2G to 3G, as well as the increasing demand for larger screens, BYD set up a department for metal parts and implemented vertical integration strategy on smart phone manufacturing. One senior manager said that to realise vertical integration:

"The most important step is building up the R&D team for whole product design instead of separate components… Previously there was no R&D for a whole product… BYD then started to participate in developing products with other companies…"

It would take longer for BYD to achieve vertical integration without the industrial know-how accumulated from manufacturing for foreign brands such as Motorola and Nokia and the abundant resources of electronics components in Shenzhen, especially those for smart phones such as ICs, cameras, PCBs and other key components. Shenzhen formed the most comprehensive electronics supply chain in China and facilitated local firms to innovate and upgrade. It was able to systematically design and manufacture mobile phones for its customers, known as an Original Design Manufacturer (ODM). In 2008, BYD delivered its first ODM mobile phone to Huawei and the relationship between these two Shenzhen companies was further consolidated.

ODM for Diversified Consumer Electronics

From 2007, it took BYD a further seven years to accumulate the manufacturing experience and improve capabilities in producing metal components. It continuously invested in R&D and achieved some technological breakthroughs such as Plastic-Metal Hybrid (PMH), Nano Moulding Technology and Super-energy Beam Induced Deposition (SBID). The PMH technology greatly impressed Taiwan's HTC and helped BYD gain orders of the product HTC One. BYD actively extended its mobile phone customers to include other global brands such as Samsung and HP so as to prevent itself from becoming overly reliant on Nokia and Motorola. Apart from the mobile phone sector, it got involved in the production of personal computers in 2008, paving the way for its ODM laptop manufacturing several years later.

In 2012, the launch of iPhone 5 by Apple led the trend of aluminium alloy casing on mobile phones to apply the 4G network. Facing increasing demand for metal casing, BYD purchased CNC (Computer Numerical Control) machinery from Japanese firm Fanuc to increase its capacity for production. The rise of local giants in the smart phone sector, such as Huawei and Vivo, offered more opportunities for BYD to provide ODM services. As their market shares increased, BYD further expanded its production capacity to accommodate increasing orders from them.

From 2013 onwards, with the booming smart phone, tablet and laptop markets, BYD was motivated to further diversify its product range in order to exploit these opportunities. Based on its existing capabilities and resources in consumer electronics (especially in batteries), BYD started engaging in sectors such as gaming PCs, portable medical devices and robotics, which indicated its third transition. For example, BYD provided the ODM service for Razer's gaming PCs.

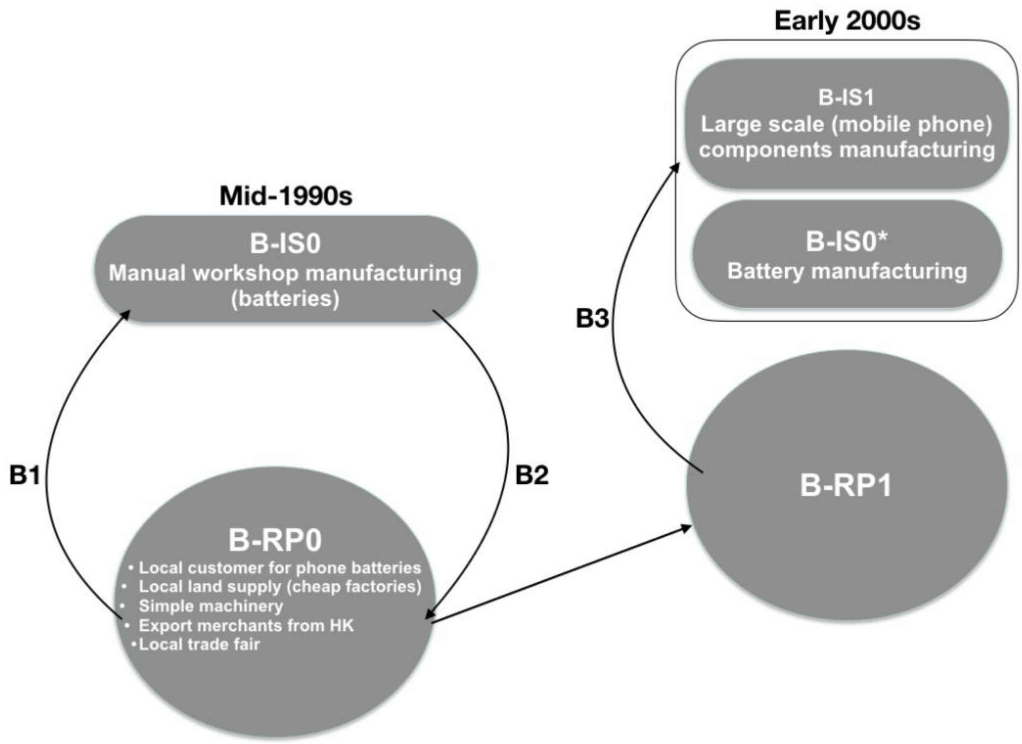
It would not be easy for BYD to achieve product diversification without the flexibility and adaptability of local component manufacturers and a mature supply chain ready at hand. All interviewees highlighted the comprehensiveness of the electronics supply chain in the region. With more than ten years' experience in the electronics industry, SMEs in Shenzhen and surrounding cities within the PRD area were highly specialised. For their own survival and growth, these SMEs chose to bundle with local leading firms such as BYD, who placed large and regular orders with local suppliers of components. To consolidate such bonds and obtain orders continuously, they had to keep up the pace with the industrial trend and make changes to their production of components to match requirements of new products launched by BYD. For instance, when the new generation of smart phones required lighter weight, those component manufacturers needed to react quickly and offer lighter components by using new materials or applying new techniques in manufacturing processes to reduce weight. All these nimble SMEs and their factories specialising in component manufacturing, together with thousands of design houses and product integrators, contributed to the complete electronics supply chain in Shenzhen. It is said that in Shenzhen one can get any electronics component within half an hour, and therefore it is more efficient to produce the prototype once an innovative idea arises. BYD has acted as both the supplier of components in terms of batteries and casings and the customer for other complementary parts such as PCBs, LEDs and so on. Human resources is another important aspect of BYD's strategy, with one senior manager from the President's Office noting that:

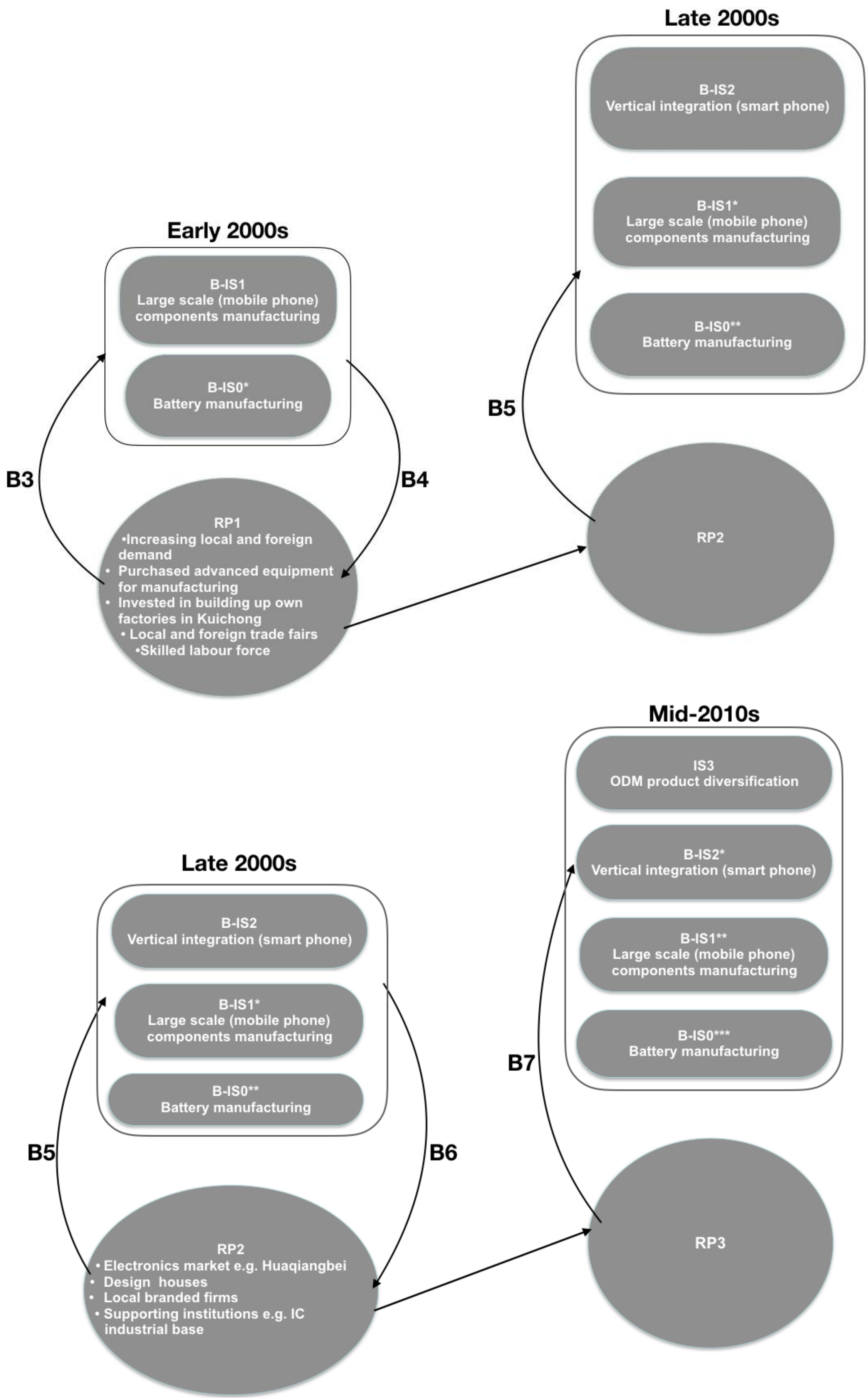
"In Shenzhen, it is easy to find and employ people with specific skills for electronics manufacturing (in materials, PCB, system, software, etc.) because local firms have cultivated many experts in related areas…"

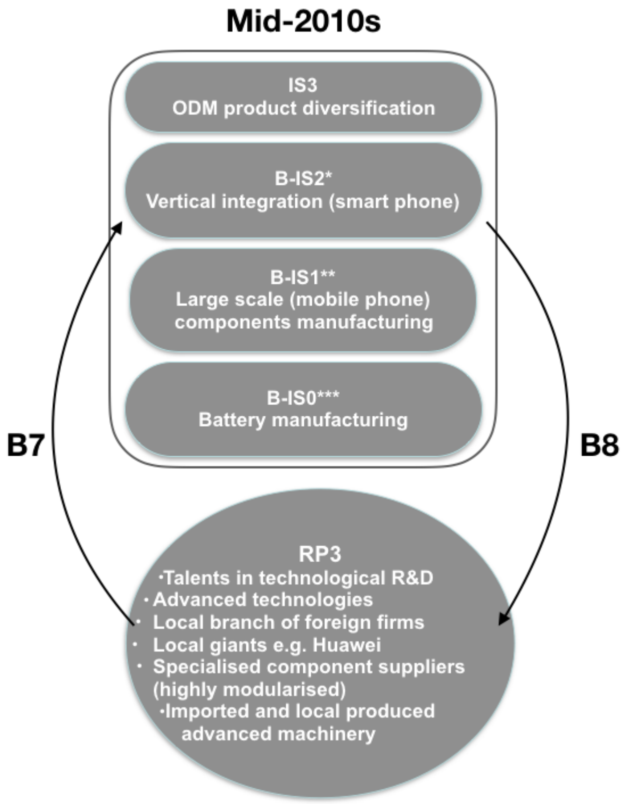
In addition, BYD started investing in manufacturing 3D glass that was used as a cover-plate for smart phones in 2015. As the cellular mobile communications sector was predicted to enter the 5G era in the late 2010s, 3D glass would be the preferred material for mobile devices in terms of sending and receiving signals. On the one hand, BYD set up its own research team working on technologies associated with 3D glass. Yet on the other hand, BYD also cooperated with Samsung, who had applied glass on mobile phones much earlier and accumulated manufacturing capabilities that BYD could learn from. With breakthroughs achieved in heat deformation, polishing, fitting, PET film decoration technologies, BYD began the mass production of 3D glass in early 2017.

Analysis

Figure 5-23 summaries the upgrading of BYD from a battery manufacturer to a local giant that is capable to produce a wide range of consumer electronics products.




Late 2000s
B-IS2
Vertical integration (smart phone)
B-IS1*
Large scale (mobile phone) components manufacturing
B-IS0**
Battery manufacturing
Early 2000s
B-IS1
Large scale (mobile phone) components manufacturing
B-IS0*
Battery manufacturing
B5
B3
B4
RP1
•Increasing local and foreign demand
• Purchased advanced equipment for manufacturing
• Invested in building up own factories in Kuichong
• Local and foreign trade fairs
•Skilled labour force
RP2
Mid-2010s
IS3
ODM product diversification
B-IS2*
Vertical integration (smart phone)
B-IS1**
Large scale (mobile phone) components manufacturing
B-IS0***
Battery manufacturing
Late 2000s
B-IS2
Vertical integration (smart phone)
B-IS1*
Large scale (mobile phone) components manufacturing
B-IS0**
Battery manufacturing
B7
B5
B6
RP2
• Electronics market e.g. Huaqiangbei
• Design houses
• Local branded firms
• Supporting institutions e.g. IC industrial base
RP3



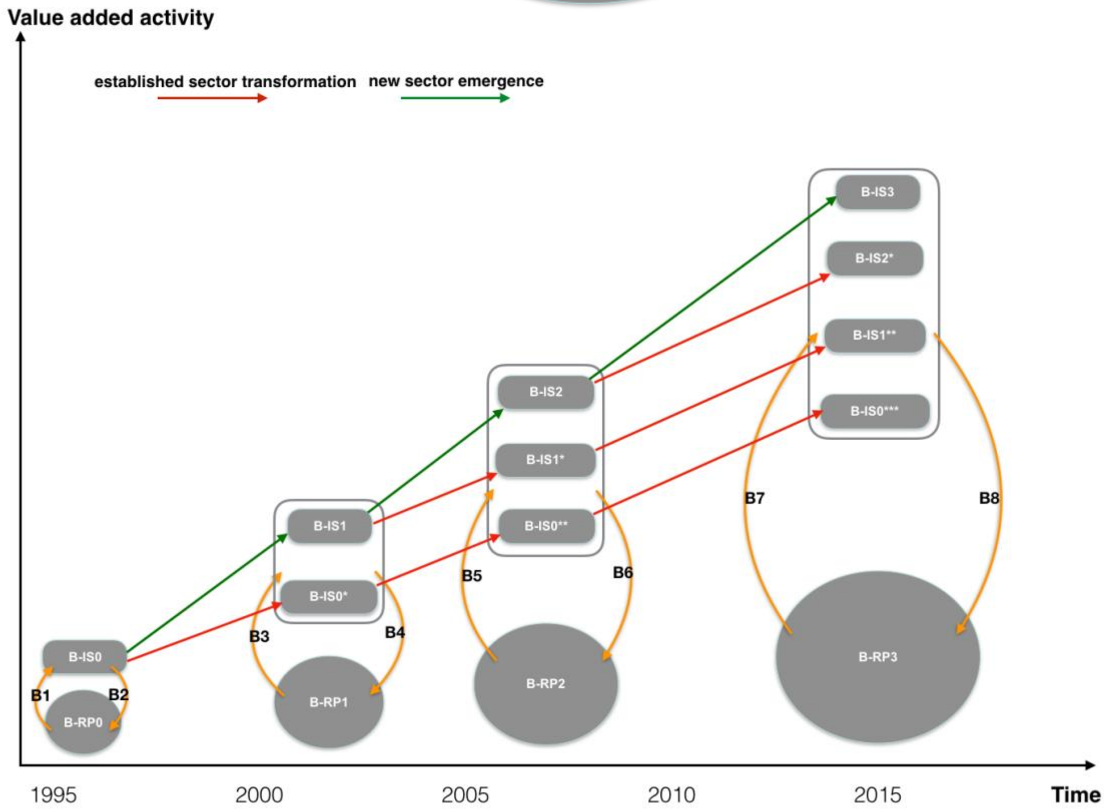


Figure 5-23 The Upgrading Path of BYD

In 1995, the municipal government of Shenzhen decided to switch the focus of local industrial development from low value-added contract manufacturing to higher value-added production with more advanced technologies. To pursue this transformation, the government launched preferential policies to attract talent to work or start their own businesses in Shenzhen. BYD was established at that time by battery specialist Mr. Chuanfu Wang from a research institute in Beijing. With old factories rented and loans from local banks, BYD started its mass production of batteries (B-IS0). As its sales of batteries grew due to the industrial transfer of Japanese manufacturers, BYD invested in expanding its production capacities and improving the quality of its products to compete with other firms. It also trained manual workers to use machinery efficiently and even created semi-automation production lines by combining labour and simple machines into solutions for specific tasks.

The growing demand for mobile phones in the early 2000s pushed BYD to step in the sector of mobile phone casing manufacturing (B-IS1), where no local competitors existed. Then it invested in establishing manufacturing facilities for casing production and extended its cooperation with mobile phone giant Nokia from batteries to structural components of mobile phones. During the same period local grassroot manufacturers started producing mobile phone components and formed the Shanzhai manufacturing system. Later, when BYD diversified its products and started its ODM business for mobile phones (B-IS2) and other consumer electronics goods (B-IS2), it was able to outsource production tasks to these local SMEs.

Facing growing uncertainties in the consumer electronics market in the later 2000s, BYD kept on investing in improving its manufacturing and innovation capabilities. By introducing advanced machinery, headhunting experienced engineers for R&D and collaborating with technology owners, BYD became a large ODM for a wide range of electronics components and products. Starting from battery manufacturing, it continued to strengthen its established sectors and explore new opportunities in the fast-changing consumer electronics market.

Case Summary

There were three main transitions throughout BYD's development, referring to eight groups of upgrading processes since its establishment in 1995. The main drivers, interactions and impacts of these processes are summarised in Table 5-9. The interactions between the resources in Shenzhen and BYD's industrial systems are highlighted for further analysis.

Table 5-9 Upgrading Processes of BYD

Process	Main Driver(s)	Main Interaction(s)	Impact(s)
B1	-Industrial transfer from Japan to China -Entrepreneurial talent came to Shenzhen to start their own businesses -Trade fairs in Shenzhen	**-BYD rented old factories for battery production** **-Shenzhen Hi-Tech Investment Group offered BYD guarantees to raise capital from local banks** **-BYD attracted talents to join its management team via the Telecom Fair**	-BYD established its industrial system for battery manufacturing and became a large supplier of electronics components (mainly batteries)
B2	-BYD up-scaled its production and continued invested in product development -BYD exported its products through traders in Hong Kong	**-BYD nurtured relationships with local customers, e.g. Huawei, TCL** **-BYD rented more new factories in Longgang district constructed by the local government** **-BYD combined human labour and simple machinery in its production lines**	-BYD trained workers for semi-automation production

Process	Main Driver(s)	Main Interaction(s)	Impact(s)
B3	-Increasing local and foreign demand for mobile phones -Proximity to Hong Kong	**-BYD invested in own factory construction and purchasing advanced equipment**	-BYD started the large-scale manufacturing of mobile phone components
B4	-BYD continued to strengthen its component manufacturing system	**-Local grassroots started their businesses in components manufacturing** **-Foreign customers pushed BYD to manufacture new components**	-BYD became not only the supplier of components but also the provider of moulding machinery for mobile phone casing manufacturing
B5	-The "Shanzhai phenomenon" -Local design houses emerged - Shenzhen IC Industrial Base was established by local government	**-BYD sourced local suppliers for components that were suitable for its mobile phone production** **-BYD benefited from preferential policies and technological support from the IC Industrial Base in chip design and manufacturing**	-BYD was able to deliver whole mobile phone products through its vertical integration strategy
B6	- BYD continued to invest in own R&D and acquired new technologies	**- More foreign brands placed orders on BYD for ODM whole mobile phone manufacturing**	-The rise of local mobile phone brands -More skilled labour

Process	Main Driver(s)	Main Interaction(s)	Impact(s)
B7	-Growing orders from local giants -Highly specialised supply chains of diverse components -Talents in technological R&D	**-BYD recruited more experienced engineers for R&D** **-BYD outsourced some component manufacturing tasks to local SMEs** **-BYD purchased most advanced machinery and offered related services**	-BYD was able to produce a wide range of consumer electronics goods
B8	-Large orders of diverse components from BYD - BYD invested in R&D for 3D glass	**-Local SMEs manufactured complementary components for BYD** **-BYD collaborated with Samsung to learn 3D glass manufacturing**	- Many local SMEs grew with BYD's expansion -BYD became a supplier of 3D glass components

These interactions are coded as the 1st order concepts and grouped according to their similarities, which then pointing towards the 2nd order themes. As shown in Figure 5-24, there are 6 types of interactions between regional resources and industrial systems for BYD's upgrading.

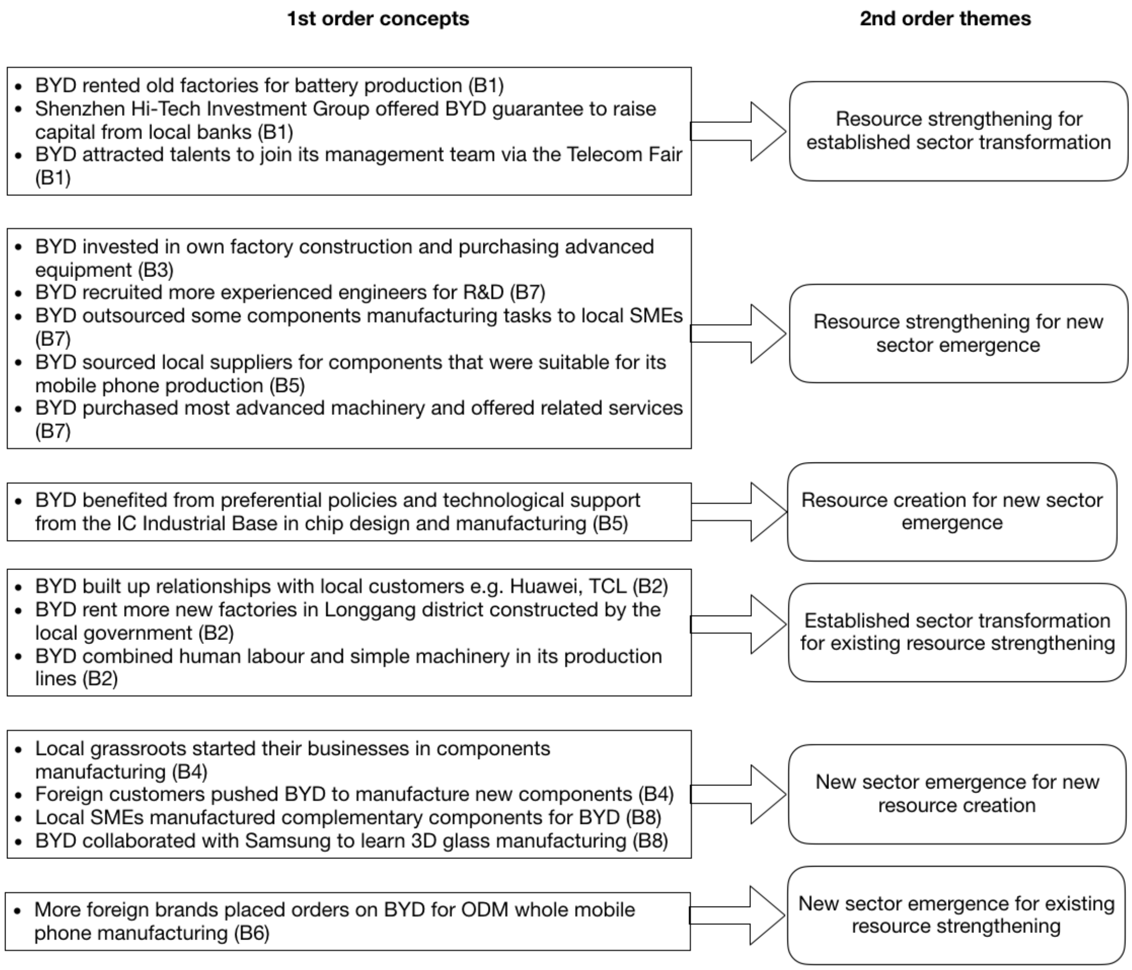


Figure 5-24 Interactions for the Upgrading of BYD

5.3.3 Lachesis

Overview

Lachesis is a hi-tech company located in Shekou, Shenzhen, focusing on innovating smart mobile medical devices for hospitals. Founded in 2010, it went through a five-year period in R&D before launching its first product – the Nurse Digital Assistant, which looks similar to a mobile phone. Interviews with its founder, Mr. Zhu, and one experienced project director, Mr. Li, revealed that it has strong connections with the local electronics industry.

Development Paths and Transitions

Before founding Lachesis, Mr. Zhu had ten years' experience in the commercial electronics sector. He was attracted to work as a salesman in a firm located within the Shenzhen Hi-tech Industrial Park in 2000. This industrial park was planned and set up by the municipal government in 1996, aiming to spur development of local pillar industries, especially the electronics industry. In 2001, with some personal networks established, he started his own business in manufacturing GPS for vehicles, which was a sought after product at that time. However, due to lack of experience in managing workers and supply chains, it failed to deliver products on time for customers and went bankrupt in 2002. This failure left Mr. Zhu in debt and forced him to rethink his approach to business planning carefully before starting a new business from the beginning. He investigated the electronics market in Huaqiangbei and discovered that opportunities associated with the USB flash drive had not been fully exploited. The USB flash drive was developed and commercialized by a local firm called Netac in early 2000s, and it was then popularized as the portable memory stick. In Huaqiangbei, Mr. Zhu noticed that there were USB sticks that could play music, which were actually the prototype of MP3 players. He cautiously tested the market by reselling these USB music players in other places, such as the Zhongguancun in Beijing, and received feedback from those electronics markets that there was considerable demand for this product. Consequently, he decided to invest in manufacturing MP3 players. After acquiring investment of RMB 4.8 million, he rented factories in Shajin, an industrial zone in Western Shenzhen, setting up a production line and employing workers for the mass production of MP3 players. He sold MP3 players to different regions in China and the company gradually grew as orders increased.

In addition to the domestic market, Mr. Zhu actively approached foreign customers and in 2003 his company successfully gained orders from French supermarket giant Carrefour. More foreign chain supermarkets such as Walmart and Tesco placed orders for MP3 players in the millions, and Zhu's company received significant revenues from exporting these pieces. In five years, Mr. Zhu not only paid back all his debts but also enabled the firm to become the largest exporter of MP3 players in Mainland China. During this period, the company used its profits and utilised local resources in terms of skilled labour, a mature components supply chain to diversify its products to include DVD players, eBook readers and tablets.

In 2008, when his company for consumer electronics was still performing well, Mr. Zhu decided to make a dramatic transition in his business: shut down the consumer electronics manufacturing and start exploring opportunities in a new sector. During these eight years in the consumer electronics sector, he had witnessed the evolution of the electronics industry in Shenzhen, observing that "huge changes took place more frequently", especially after the Global Financial Crisis. On the supply side, local labour and land costs had increased year by year, and this, together with the technological advances that accelerated the rate of iteration in consumer electronics, had squeezed a number of firms that had stayed in their original sectors out of the market. On the demand side, fast changing customer tastes gradually eliminated those traditional mass production manufacturers of homogeneous goods. All these factors drove Mr. Zhu to gamble that there are opportunities to be exploited by entering sectors in which there was more stable demand for the products. As Mr Zhu put it:

"There is actually no firm transition or industry transition but the only transition that exists is in the entrepreneur's mindset."

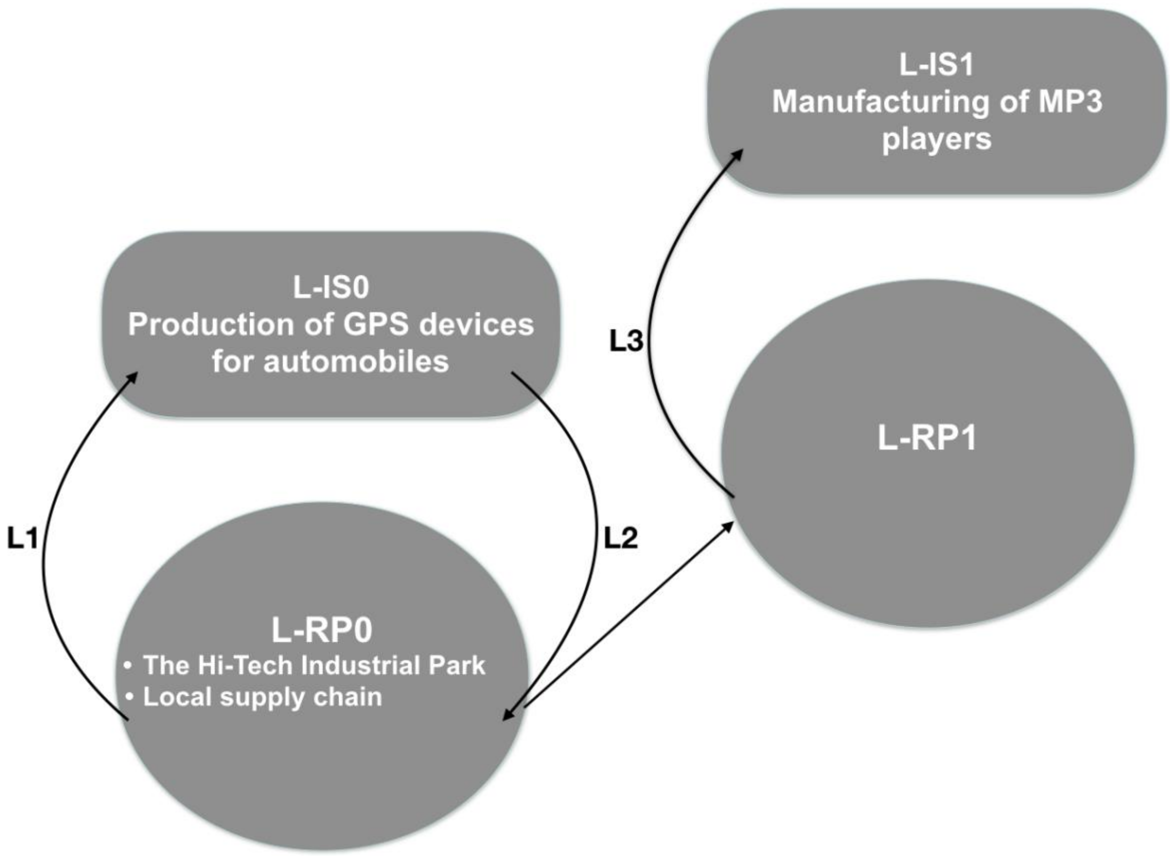
As Mr. Zhu noted, his mindset was totally changed by the external environment and the people he interacted with. During his visits to foreign customers he observed their lifestyles, and when cooperating with Hong Kong and Taiwan enterprises that located their businesses in Shenzhen he learned to plan for the future by keeping pace with global trends. He then determined that healthcare was compulsory for everyone and the demand for products in this sector was stable and long-lasting, so there existed great potential for medical electronics. However, although he had experience and resources in the consumer electronics sector, he had limited knowledge of medical devices and he tried to approach some professionals. During the same period, in the Shenzhen Institute of Advanced Technology (SIAT), a localized branch of the Chinese Academy of Sciences, a project team was working on the innovation of China's first MRI device. By chance, Mr. Zhu got to know the team leader, Prof. Min Xue, and was inspired by his vision that the only way to maintain growth or achieve higher value-added in products was to focus on independent R&D and become the leader of a new sector. So Mr. Zhu started collaborating with Prof. Xue and established Lachesis in 2010.

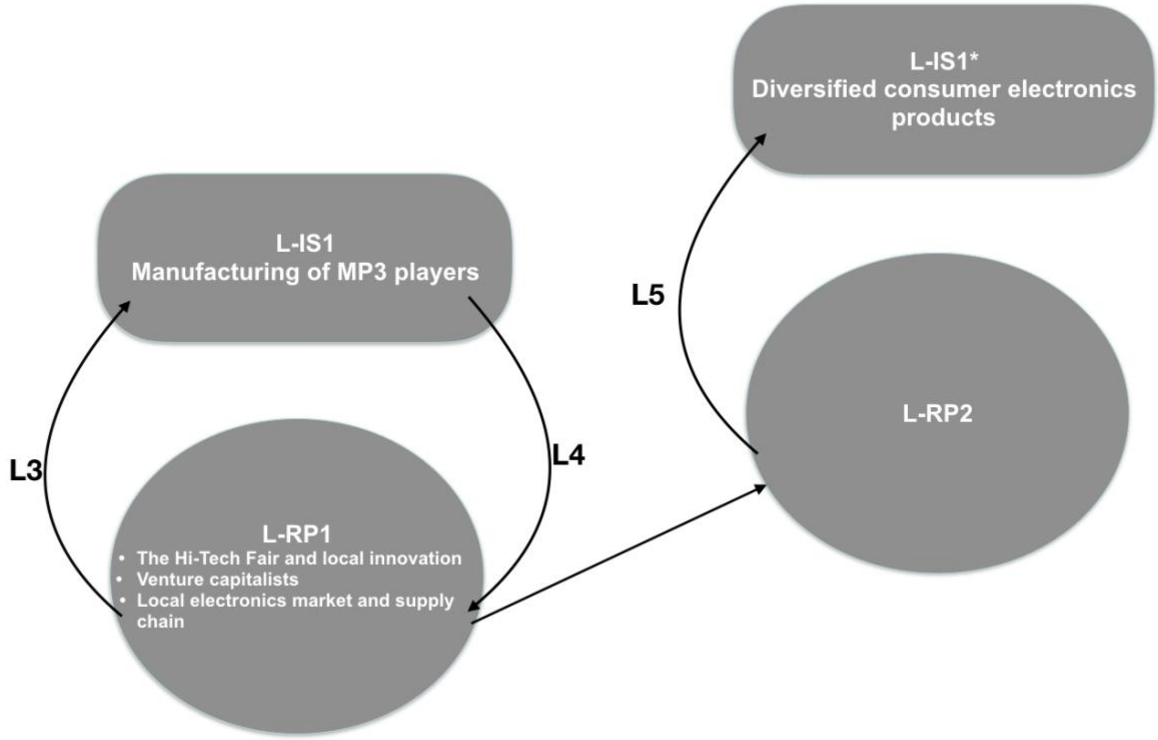
It took Lachesis five years in independent R&D before it was ready to launch its first product in late 2015. This product, named Nurse Digital Assistant (NDA), has a similar appearance to a mobile phone and it was designed specifically for nurses to monitor patients' conditions in hospitals. Lachesis then developed devices such as infusion sensors, nurse stations and doctor stations to complement the application of NDAs. All these products can be integrated to a solution package for an "intelligence ward". The novel products or solutions provided by Lachesis coincided with the needs of local hospitals during their digital transformation. Thus, Lachesis successfully grabbed the market share of mobile medical devices and became the pioneer in this new market niche. Up to now, Lachesis's products have been introduced into more than 600 hospitals in Mainland China.

Lachesis and its antecedents are among the players of the electronics industry in Shenzhen and experienced significant industrial transformation in the early 2000s. Before 2000, the local electronics firms benefited from the wave of industrial transfers from Taiwan and Hong Kong, who located their PC manufacturing in Shenzhen. From 2000 to 2010, the consumer electronics sector boomed, with products ranging from automobile devices like GPS, music players such as MP3s, to white brand mobile phones using the Symbian Operation System, and then to smart phones. During this period, Mr. Zhu engaged his business in consumer electronics and took advantage of local resources.

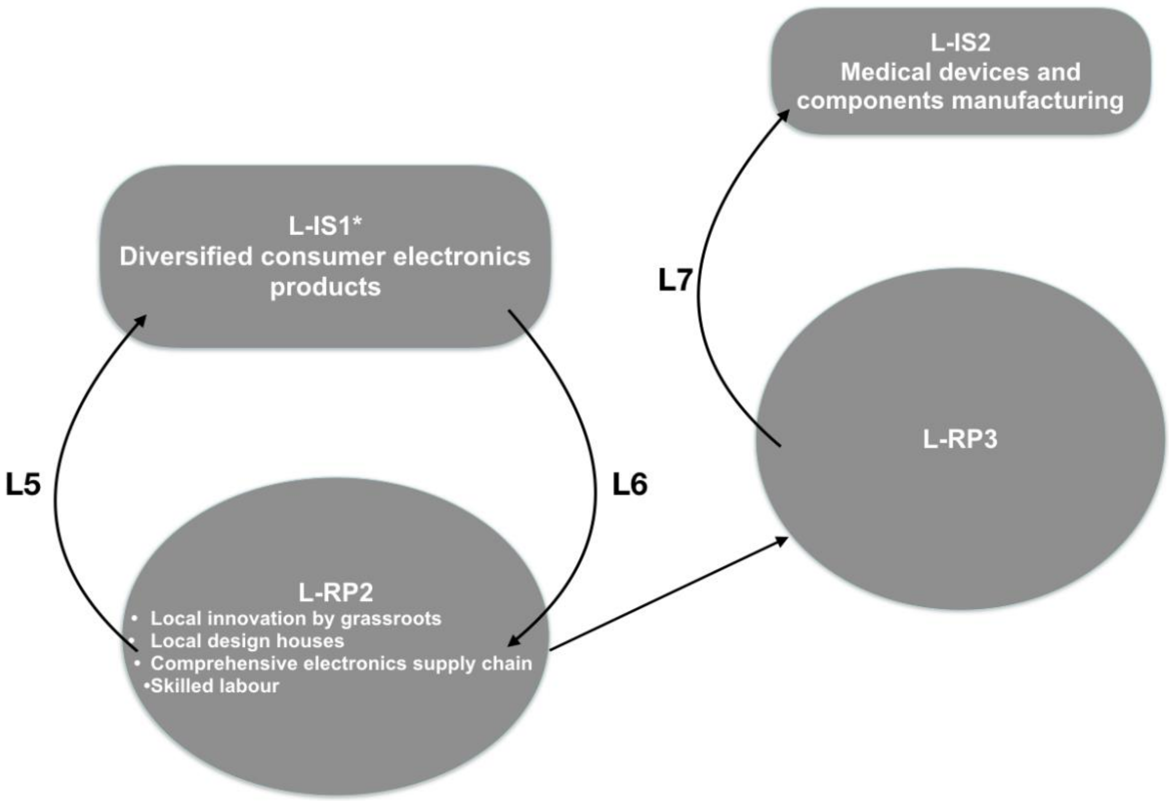
Analysis

Lachesis's upgrading path can be visualised as Figure 5-25, from which a consumer electronics manufacturer has transformed into a hi-tech company in portable medical devices.

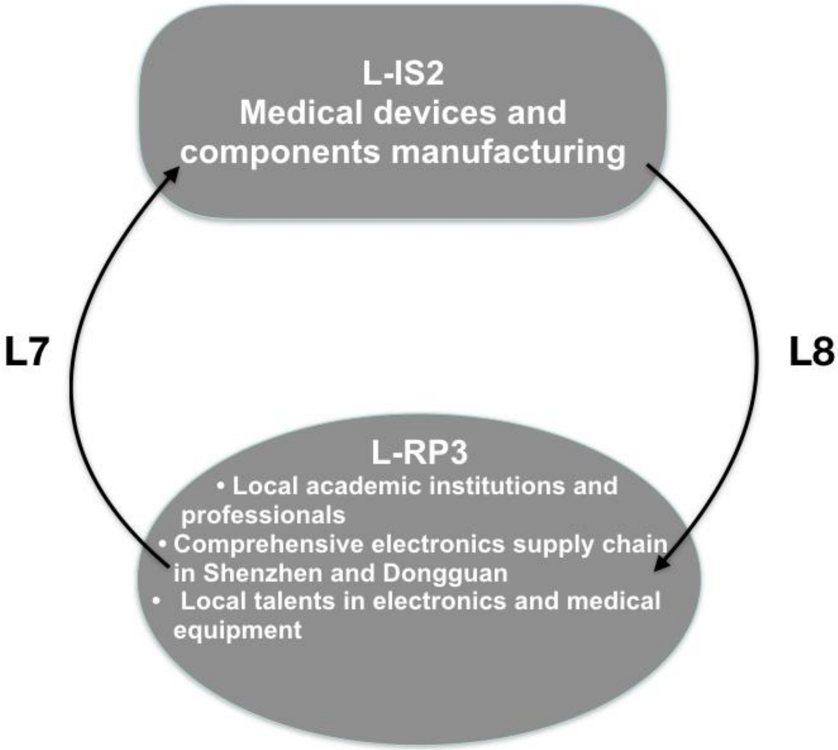




L-IS1*
Diversified consumer electronics products
L-IS1
Manufacturing of MP3 players
L5
L-RP2
L3
L4
L-RP1
• The Hi-Tech Fair and local innovation
• Venture capitalists
• Local electronics market and supply chain



L-IS2
Medical devices and components manufacturing
L-IS1*
Diversified consumer electronics products
L7
L-RP3
L5
L6
L-RP2
• Local innovation by grassroots
• Local design houses
• Comprehensive electronics supply chain
•Skilled labour



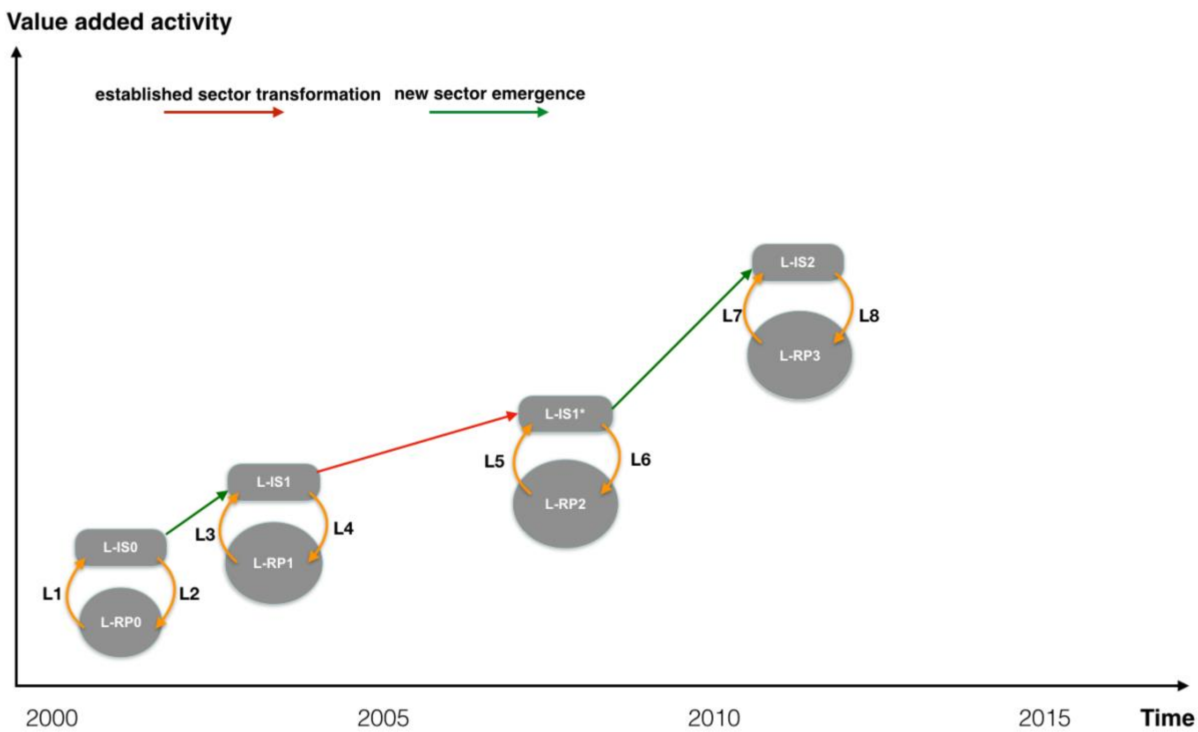


Figure 5-25 The Upgrading Path of Lachesis

For Mr. Zhu, the founder of Lachesis, the establishment of his first own business in Shenzhen was mainly a result of institutional support, especially the establishment of the Hi-tech Industrial Park, which can be traced back to policies launched by the local government in the mid-1990s. Known as the ‘Second Undertaking’ Initiative proposed by the incumbent Municipal Party leader Li Youwei, young people with different types of skills all over China were attracted to Shenzhen and set up SMEs, most of which were clustered in the Hi-Tech Industrial Park established in September 1996. Then in the ‘Outline of Development Plan of Shenzhen Hi-Tech Industrial Park’, launched in 1997, the electronics industry was established as the pillar industry within the zone. When Mr. Zhu arrived Shenzhen in early 2000, he was guided to seek job opportunities in the Industrial Park, which had been operating for three years. He secured the position of salesman in one Hi-Tech firm within the park and over his two years of employment there he accumulated experience in the electronics industry and built up his own social network with manufacturers along the electronics supply chain. Using own savings, he set up his first own company (hereafter Z1) in Shenzhen and started the production of GPS device for automobiles. However, after obtaining an order for 3800 devices, Z1 was not able to deliver them on time because of management issues such as the inadaptability of employees to install such devices on vehicles. This directly drove Z1 into bankruptcy and Mr. Zhu became heavily indebted. He was forced to seek other opportunities to survive and to pay back debts.

Z2 (L-IS1): Formation and Development (2002-2008)

When Netac launched the first generation of USB-based flash memory technology, opportunities were brought to the consumer electronics market. When investigating products in the Huaqiangbei electronics market, Mr. Zhu discovered one type of USB flash disc that could play music, which he perceived as a product with great – and unexploited - market potential. Then he tried to test the market potential by purchasing some devices from Huaqiangbei and selling them in Zhongguancun in Beijing, which was the largest electronics market in China at that time. After receiving positive feedback from Beijing, he decided to conduct mass production of the product, which later became known as an MP3 player. After the first Hi-Tech Fair in 1999, many venture capitalists were attracted to Shenzhen and some of them were interested in Zhu’s idea and were willing to invest in the production of MP3 players. The second company he set up (Z2) then became an EMS provider, mainly for MP3 manufacturing. Z2 received an order from Carrefour in 2003, described by Mr. Zhu as a "life-saving panacea" because the successful delivery of this order helped him to pay back all debts and even make a profit. From 2003 to 2008, Z2 grew steadily based on the manufacturing of various consumer electronics products, ranging from MP3s and DVDs to tablets and e-book readers, for both domestic and foreign customers (L-IS1*). This can also be attributed to the Shanzhai phenomenon that was occurring during the same period. The participation of local grassroots and component suppliers in the process of new prototypes and product development enabled Z2 to efficiently respond to changing consumer demands. Figure 5-26 illustrates Z2's MP3 catalogue at its peak around the year 2008, which also marked the watershed of Mr. Zhu's business.

Figure 5-26 Different Types of MP3 Players produced by Z2[36]

Z2: Shutdown and new investment (2008-2015)

When Z2 continuously brought Mr. Zhu profits on the back of large sales volumes, he was not complacent but started worrying about the future of such EMS businesses. With foreseeable

36 Source: https://www.globalsources.com/si/AS/Itone-Digital/6008811792889/Homepage.htm

increasing land and labour costs, as well as stricter regulations in environmental protection, he predicted that the low-value-added manufacturing of Z2 as unsustainable and that its competitiveness would decline. Through his years in the consumer electronics sector, Mr. Zhu witnessed the shortening of product lifecycles of consumer electronics and the increasingly volatile shifts in consumer demands, realising that it would be risky to continue mass production in this sector. In his own words:

"A certain type of consumer electronics goods can easily be 'killed' by new technologies and new products, so it is crucial (for us) to switch to a sector in which products have a long lifecycle and steady consumer demand."

With such motivation to pursue changes, Mr. Zhu started searching for new opportunities. By communicating with enterprises in his social network, especially those from Hong Kong and Taiwan, he noticed that the aging of the population in these regions had generated increased demand for portable medical devices, for example blood pressure monitoring devices for the elderly with a Bluetooth function. Then he travelled to Germany and after investigating the medical electronics market there, he realised that although China might lag behind in technologies, there existed huge market potential and possibilities to catch up with the strong consumer electronics base.

Upon returning to Shenzhen, Mr. Zhu actively consulted professionals in medical equipment for advice, among whom Prof. Min Xue was a leading expert in carrying out projects for self-developed medical imaging devices in the Shenzhen Institute of Advanced Technology (SIAT), which had been established in 2006. Mr Zhu said:

"I was inspired by Xue's vision of being the leader of a new industry and two strategies in terms of talents and industry knowledge."

Mr. Zhu then determined to engage in the medical device sector, which he saw as having steady demand since everyone will need healthcare services at some point in their life. However, in contrast to Prof. Xue's business in large-scale equipment such as MRIs, Mr. Zhu decided to invest in the R&D for portable medical devices by utilising his knowledge and resources in consumer electronics. It took him two years to shut Z2 down and deal with the issues associated with factories, employees and equipment. So it was only in 2010 that he was able to establish Lachesis in Shenzhen. At the same time, he maintained businesses in consumer electronics by investing in a company called Sixiang, in Dongguan, for components manufacturing.

From 2010 to 2015, Mr. Zhu headhunted young talents from the local consumer electronics industry into his team for the new product development. In Shenzhen, there had already accumulated many skilled workers and experienced engineers for hardware and software development, and most of them were equipped with fast learning capability and adaptability. Lachesis was fully dedicated to R&D during the first five years before launching any products. Mr. Zhu spent his own savings, together with earnings from the Dongguan company he had invested in, on the R&D process and was under significant pressure to deliver marketable products. All the hard work paid off when Lachesis delivered its first product, the Nurse Digital Assistant (NDA) device, and soon received positive feedback from hospitals that has tested the product. With NDA, Lachesis successfully opened up a niche market for portal medical devices and soon became the market leader. The manufacturing of NDAs was similar to that of mobile phones and since Mr. Zhu had rich experience in and knowledge of consumer electronics supply chains, Lachesis was able to efficiently respond to orders with customised designs. Lachesis established its own production lines on a much smaller scale than previous consumer electronics lines, while it also utilised local production capacities and supplies of different components by outsourcing tasks.

Lachesis (L-IS2): 2015-now

In addition to the NDA, Lachesis developed products covering almost every aspect of hospital wards for nurses to deliver medical care services, such as working stations, nurse information systems and a variety of patient monitoring sensors. After diversifying its products, Lachesis integrated them into a package of Intelligent Hospital Ward Solutions, including the information system of diagnosis and treatment, and an infusion management system. In addition to continuous investments in internal R&D, Lachesis also actively sought collaborators with advanced technologies. In 2017, Lachesis started its partnership with Israeli company EarlySense by integrating its contactless monitoring technology into the new Intelligent Hospital Ward Solutions. For Mr. Zhu: [37]

"The need to continuously monitor post-acute care patients is growing, and we are pleased to collaborate with leading smart sensor developer EarlySense on a solution that will prove essential to both patients and healthcare staff across the region."

By combining the advanced wireless sensing technology with knowledge about Chinese hospitals, Lachesis was able provide solutions to streamline local healthcare services, as well as minimising costs by transferring information end-to-end from patients directly to working stations and handheld devices used by doctors and nurses. One year later, Lachesis raised $29 million in a B Round led by venture capitalist GTLA to further develop its smart healthcare and mobile health technologies. As Mr Zhu said:

"We are not afraid of being copied by other firms in terms of products, instead we will keep on investing into R&D of intelligent healthcare devices."

Faced with growing competition in this emerging mobile healthcare market, Mr. Zhu showed his confidence in Lachesis:

[37] Source: https://www.prnewswire.com/news-releases/earlysense-teams-up-with-lachesis-on-new-intelligent-ward-patient-monitoring-solution-for-chinese-market-622280203.html

"Put such challenges in another way, more local participants can make the pie bigger and we will continue playing our role as the market leader."

Case Summary

Lachesis was founded by an entrepreneur that has had experience in the manufacturing of consumer electronics products. The development of companies Z1, Z2 and Lachesis actually reveal the trend of the electronic industry from early 2000s to mid-2010s. The main drivers, interactions and impacts of the upgrading processes from Z1, Z2 to Lachesis are summarised in Table 5-10. The interactions between the resources in Shenzhen and industrial systems of Z1, Z2 and Lachesis are highlighted for further analysis.

Table 5-10 Upgrading Processes of Lachesis

Process	Main Driver(s)	Main Interaction(s)	Impact(s)
L1	-The 'Second Undertaking' of Shenzhen	**-Shenzhen Municipal Government established the Hi-tech Industrial Park to attract talents and enterprises**	-SMEs emerged from the Hi-tech Industiral Park (Mr. Zhu started his own business in GPS manufacturing)
L2	- The failure of the GPS business	**-Enterprise sought new opportunities from the local electronics market**	-New ideas emerged based on components or products from the electronic market

Process	Main Driver(s)	Main Interaction(s)	Impact(s)
L3	-The commercialisation of the USB flash memory technology -The emergence of venture capitalists	**-MP3 players developed based on the USB flash memory drive**	-The industrial system of MP3 players was established
L4	-The up-scale of MP3 prodcution	**-More workers employed and machinery introduced**	-The development of local complementors and competitors
L5	-Fast changing demand for consumer electronics -The "Shanzhai" phenomenon -Local design houses emerged for electronics goods	**-Enterprise reconfigured design houses, component suppliers and its own production lines for the manufacturing of new consumer electronics**	-The industrial system of diversified consumer electronics products was established
L6	-Flexiblity in consumer electronics production	**-Enterprise enhanced manufacturing capabilities of its upstream firms**	-Highly specialised component manufacturers

Process	Main Driver(s)	Main Interaction(s)	Impact(s)
L7	-Local research institute SIAT -Rising labour costs -Talent pool for software and hardware development in Shenzhen	**-Enterprise shut down factories and dismissed manual workers for consumer electronics** **-Collaboration between enterprise and professional from research institute** **-Enterprise invested in R&D and headhunted young talents for the new product development** **-Enterprise invested in a component manufacturing firm**	-The industrial system of portable medical devices was established
L8	-Portable medical devices developed and integrated into a solution for local hospitals to use	**-Lachesis continued to invest in internal R&D and sought collaborators with advanced technologies and manufacturing facilities**	-Local complementors and competitors emerged

These interactions are coded as the 1st order concepts and grouped according to their similarities, which then pointing towards the 2nd order themes. As shown in Figure 5-27, there are 6 types of interactions between regional resources and industrial systems for the upgrading from Z1, Z2 to Lachesis.

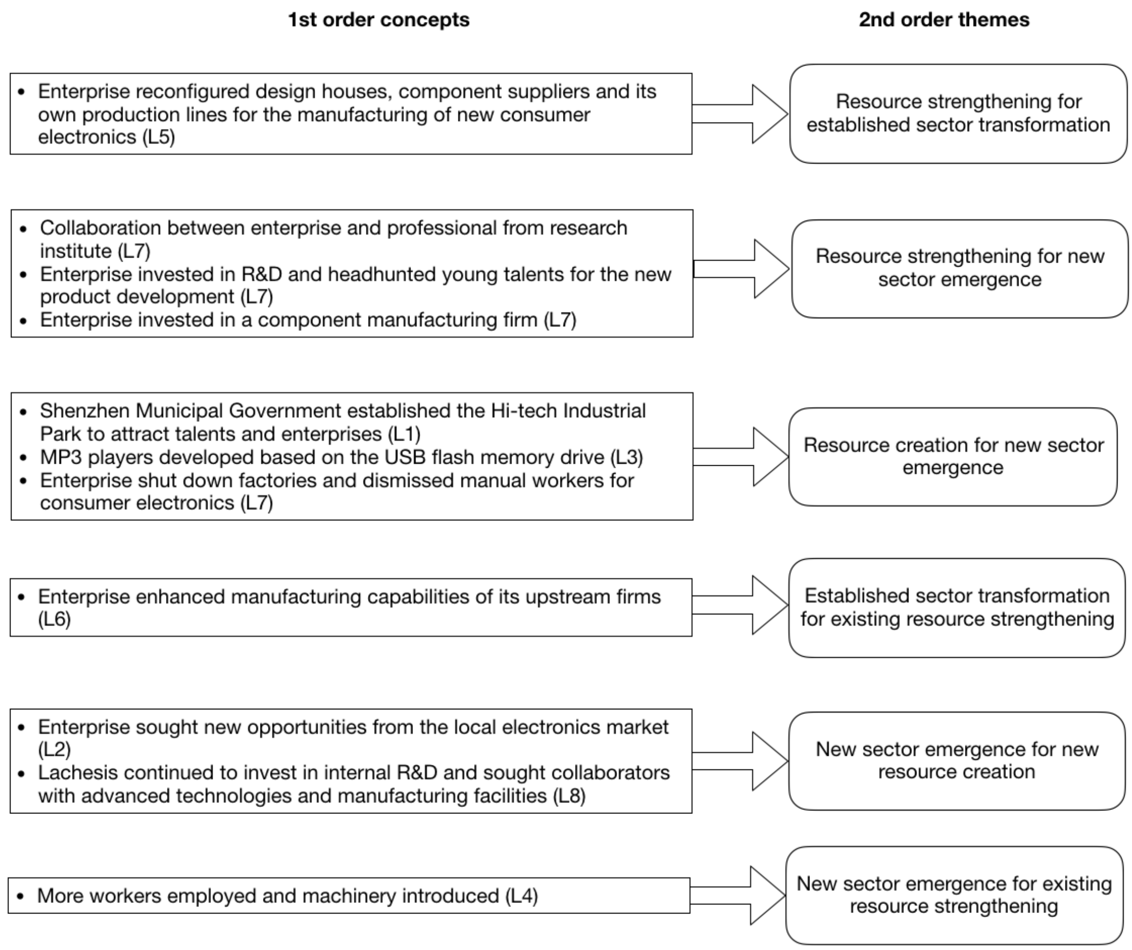


Figure 5-27 Interactions for the Upgrading of Lachesis

5.3.4 Netac

Overview

Netac Technology is a Shenzhen-based hi-tech company specialising in flash memory device manufacturing. Established in 1999, Netac has grown rapidly and was successfully listed in the Growth Enterprise Market (GEM) of the Shenzhen Stock Exchange in 2010, becoming the first public listed portable storage producer in mainland China. Netac is well known for its patent "electronic flash storage method and device for data processing system", which legitimises it as the inventor of flash memory and the owner of the first generation of USB-based flash memory technology in the world. During its development in Shenzhen during the past two decades, it has experienced some dramatic changes.

Development Paths and Transitions

Late 1990s to late 2000s

The two co-founders of Netac, Mr. Deng Guoshun and Mr. Cheng Xiaohua, were colleagues working in the same multinational company in Singapore. Cheng had accumulated experience from developing applications for the USB while Deng focused on the driver programme of the Windows system. In the late 1990s, Deng sensed the opportunity of a portable storage device to transfer or backup data between desktop computers and laptops. After discussing this with Cheng, they decided to set up their own business making a new portable device that had much larger storage than 3.5-inch floppy disks but was also much lighter than mobile hard disks. Then they went to Silicon Valley to present their ideas to more than 70 venture capitalists for potential investments.

In addition to the initial investment obtained from the US, they participated in the first China Hi-Tech Fair (CHTF), held in 1999, and successfully attracted the attention of foreign and local investors during this 6-day exhibition in Shenzhen. As a senior manager at Netac put it:

"We were offered the display booth at the 1st CHTF for free to show our prototypes of a USB disk and our demonstration attracted many people during the fair… Later, the government helped us to set up our business in Shenzhen by subsidising us and offered us a loan of 1.5 million RMB without a payback period."

Co-founder Deng said in a media interview:

"We were very lucky to attend the 1st CHTF and test the market by presenting our product… More importantly, through the platform provided by the fair we were able to get in touch with many investors and get our first venture capital fund soon after the fair."

According to the strong support from local government and investment obtained from venture capitalists after the 1st CHTF, Deng and Cheng decided to locate the headquarters and manufacturing base of Netac in Shenzhen. Then, in November 1999, Netac proposed the application for the patent of electronic flash memory external device and method for a data processing system to the National Intellectual Property (IP) Administration. Its first product was launched in June 2000, based on the prototype shown in the fair, and the patent was approved on 24th July in 2002 and would last for twenty years from the application date. Netac was also granted the US patent "Electronic Flash Memory External Storage Method and Device" in 2004. Netac then up-scaled its production of USB flash memory devices and continued to apply for domestic and foreign patents.

In 2006, Netac sued the US company PNY Technologies for its infringement of the "Electronic Flash Memory External Storage Method and Device" patent and they reached an out-of-court settlement in 2008. It was not the first time Netac had taken other companies to court, but it was the first lawsuit of a Chinese firm pursuing patent charges overseas. This also alerted IT companies in mainland China to protect their innovations or inventions by applying patent strategies.

Late 2000s to late 2010s

Netac distinguished itself from other electronics or IT companies in Shenzhen by the number of patents it held. By the year 2009, it had filed more than 300 patents globally. The government then tried to set Netac as a role model for other local companies to follow in terms of technological innovation and IP strategy by providing it with not only beneficiary policies but also a brand-new office building. After moving into the new Netac Mansion building, the company gradually switched its main businesses from manufacturing USB flash memory products to lawsuits for patent charges and office rentals.

As a vice general manager of Netac put it:

"The USB flash memory stick was easy to copy, and thereby many competitors producing similar products mushroomed and set much lower prices than us… However, being a public listed company, we paid a tariff for every chip imported and were not able to lower costs in manufacturing."

Netac then targeted organisations rather than individual consumers in the market by providing them with customised storage devices as promotional gifts or souvenirs for their customers. However, facing with increasing costs, its profits from this kind of low value-added manufacturing continued to decline. Then Netac gradually switched its focus to licencing its patents. Moreover, after going public in early 2010, all decision-making processes in Netac became more time-consuming and there were also critical personnel changes, in particular with the co-founder, Mr. Deng, leaving the company. As a result of these issues, Netac found itself stuck at a crossroads for its future development.

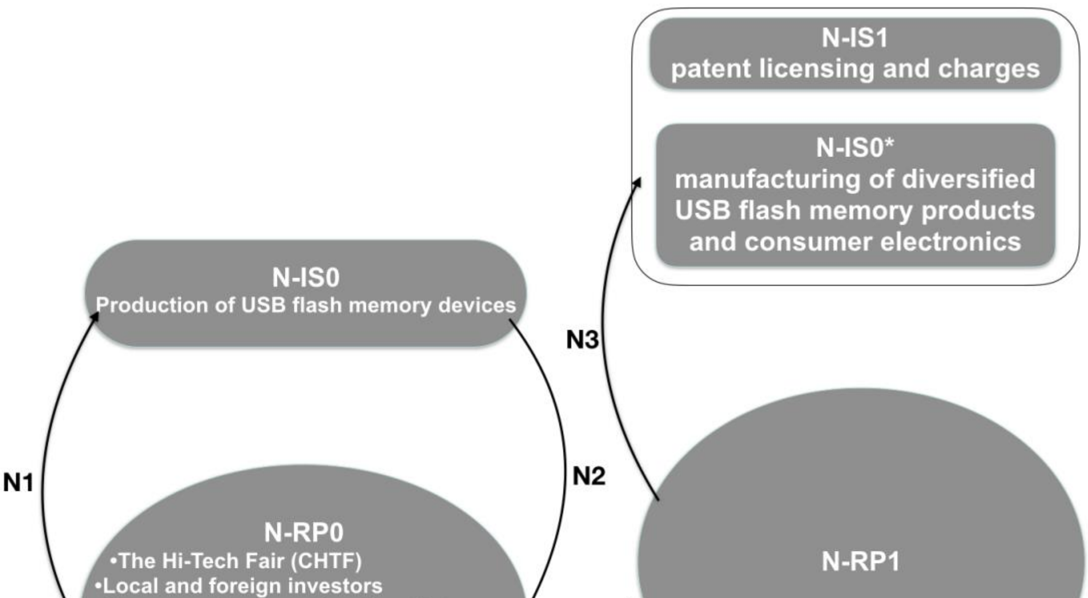
When asked about the upgrading of Netac, a vice general manager answered:

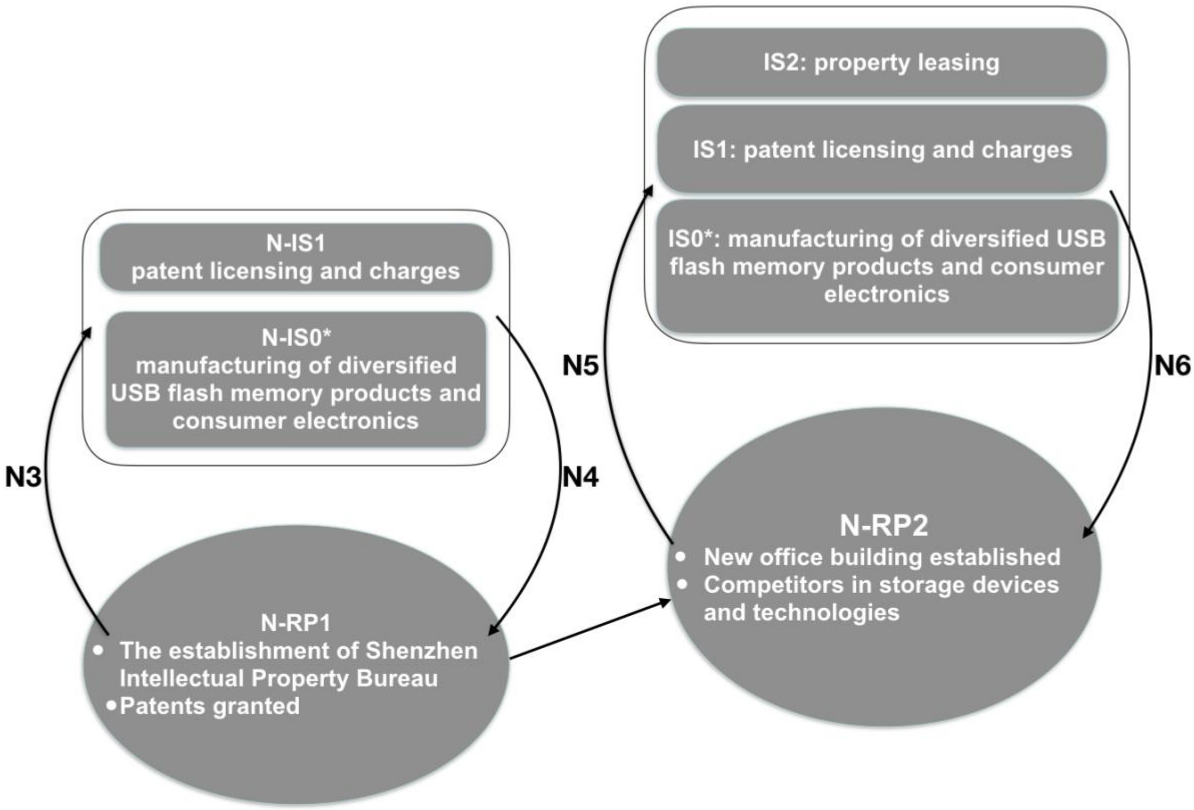
"The manufacturing process for our products (mainly assembly) is relatively simple and there have not been any significant changes in our production lines in our local factory… Yet we are not sure which way to go, although we are actively seeking opportunities for upgrading."

In its own R&D, Netac extended the applications of existing products by adding new functions such as fingerprint verification to them according to new technologies. Nevertheless, it seemed difficult for Netac to step out of its comfort zone with the monopoly of its patents. This became particularly evident from 2011 onwards, as Netac conducted an increasing number of lawsuits for patent charges and gradually treated them as its main source of income. Netac also leased out stories of its office building to local companies such as Tencent and these rentals accounted for a large proportion of its income.

Analysis

Netac was well supported by the local government since it was born in 1999. Although it has made efforts in upgrading its products, it gradually switched to utilise and became more dependent on its licenses and properties owned. Figure 5-28 shows all these changes.




IS2: property leasing
IS1: patent licensing and charges
IS0*: manufacturing of diversified USB flash memory products and consumer electronics
N-IS1
patent licensing and charges
N-IS0*
manufacturing of diversified USB flash memory products and consumer electronics
N3
N4
N5
N6
N-RP1
The establishment of Shenzhen Intellectual Property Bureau
Patents granted
N-RP2
New office building established
Competitors in storage devices and technologies

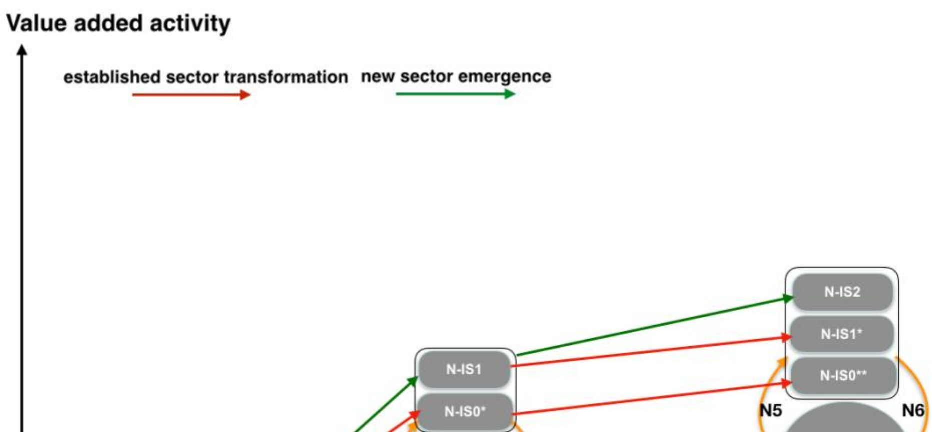

Value added activity
established sector transformation
new sector emergence
N-IS2
N-IS1*
N-IS0**
N-IS1
N-IS0*
N5
N6

Figure 5-28 Upgrading Path of Netac

Netac chose to settle in Shenzhen mainly due to the 1st CHTF in 1999 and the local resources available for its own development (N-IS0). In addition to government support and venture capital gained after the fair, Netac also took advantage of the electronics supply chain in Shenzhen. According to the co-founder of Netac, Mr. Cheng:

"Shenzhen has several characteristics that were really attractive to us. First, there existed the most comprehensive auxiliary supply chains with many components that large manufacturers no longer produced but could be found here; second, local government encouraged grassroots and people with foreign experience to start their own businesses by offering subsidies and preferential policies; third, being a migrant city, Shenzhen provided everyone opportunities under fair competition; fourth, there were many young people in Shenzhen who were full of innovative ideas and drive to pursue better lives; fifth, in early years, the proximity to Hong Kong facilitated manufacturing firms in Shenzhen to export products to foreign customers via agencies in Hong Kong; lastly, Shenzhen has got a much better natural environment compared to other mainland cities."

Since the local electronics industry had been well developed during the previous two decades, it was convenient for Netac to recruit professionals in chip design and factory management. Facilities for exporting in Shenzhen and neighbouring Hong Kong also enabled Netac to gain orders from foreign customers after it launched its first product.

The OnlyDisk USB flash drive was one representative product of Netac that was incorporated by IBM into its solution package of wireless applications in 2000. In following years, Netac continuously improved its products and released the first USB flash drive with a security function (named SecurePro OnlyDisk) and the driverless OnlyDisk in 2001, the dual-bootable USB flash drive in 2002, and the USB flash drive controller chip (named U-chip) in 2003. With the rapid development in terms of its USB flash drive products, it was recognised as one of China's best exporters of USB flash drives by Global Sources and awarded one of the Top Ten Excellent Hi-tech companies by the Shenzhen Municipal Government.

Netac then started to apply for patents and the local government also realised the importance of IP protection, thereby establishing the Municipal IP Bureau in 2004 to help local innovative firms to deal with their IP issues. Such institutional reforms implied that the government was putting more effort into encouraging and protecting indigenous innovations from local firms and gave these enterprises the confidence to invest more into R&D. With a growing number of patents granted, Netac was able to earn from licencing their patents or compensation charges from those firms violating its patents (N-IS1). In addition to product development based on its USB flash memory technology, Netac also diversified its products to include not only storage devices but also consumer electronics goods such as digital photo frames and GPS (N-IS0*).

With more than 200 patents in hand, the income earned from licencing and lawsuits increased continuously. At the same time, facing challenges from domestic and foreign manufacturers in the field of mobile storage devices, Netac gradually lost market share in this sector. Moreover, the technological advancement in cloud storage exerted extra pressure on companies producing physical storage devices. Netac did not proactively conduct R&D and explore new opportunities for development in product and technology but instead relied more heavily on licensing and authorisation of its patents. After the new Netac office building was completed in 2012, it started in the property leasing business (N-IS2), which brought it considerable financial returns.

From 2011 to 2018, Netac conducted more than 100 lawsuits related to patent infringement, and since 2015 the company has earned annual rents of more than 30 million RMB from property leasing[38]. However, such a business model was not sustainable because the key patent of Netac, the "electronic flash storage method and device for data processing system" patent, would expire in November 2019. Without the licencing fees earned from this key patent, Netac would suffer huge losses and in a public announcement it admitted that "currently there is no effective measure to cope with the risk caused by the expiry of this patent"[39].

Case Summary

Netac was founded based on its original technology in combining flash memory and a USB interface, which induced a new sector of portable storage device in China and even the whole world. Although it endeavoured to diversify its products in the first decade after its establishment, there was a lack of continuous R&D activities within the company and it gradually switched to developing its "IP strategy" by suing other companies for infringement of its flash memory patent and licencing its patents to other firms. Because of its success in patent litigation against foreign companies, Netac was highly praised by local government and offered many beneficial conditions, for instance a new office building. In the second half of its development journey, the profits gained from patent charges and property leasing overtook those from its sales of manufactured products and Netac became "locked-in" a risk-free comfort zone. The overreliance on this unsustainable business model or strategy brought Netac

38 Source: http://www.sohu.com/a/308373992_104421

39 Source: https://tech.ifeng.com/c/7l1r7BoXjQ8; http://finance.ifeng.com/a/20170326/15260946_0.shtml

inflexibility and, faced with a potential crisis in the future, especially after the expiry of its key patent, Netac will be very vulnerable.

Table 5-11 Upgrading Processes of Netac

Process	Main Driver(s)	Main Interaction(s)	Impact(s)
N1	-The 1st Hi-Tech Fair in Shenzhen	**-Innovators received investments from venture capitalists and subsidised by the government**	-Netac started the production of USB flash memory disk
N2	-Netac continued improving its products	**-Local electronics manufacturers applied the flash memory technology to develop new products e.g. MP3 players**	-Emergence of local manufacturers for USB flash memory related products and components
N3	-The government started protecting indigenous innovations -Netac was granted more patents	**-Besides selling its USB flash memory products in domestic and foreign markets, Netac also earned from licensing their patents or suing firms that violated its patents** **-Netac diversified its products according to the trend of consumer electronics goods e.g. digital photo frame and GPS**	-Netac established its licensing business and expanded its USB manufacturing business
N4	-Netac was set as a role model in patent licensing by the local government	**-Local hi-tech firms learned to apply for patents for their innovative products and production processes**	-More patents granted to local firms

Process	Main Driver(s)	Main Interaction(s)	Impact(s)
N5	-Supports from the local government e.g. subsidies and office building construction -Netac went public -The challenge from new technology in mobile storage e.g. the cloud	**-Netac moved to the new office building in the Nanshan Hi-Tech Park** **-Netac invested in developing products with fingerprint recognition technology** **-Time-consuming decision-making process for Netac after going public**	-Netac gradually switched its main business to IP licensing and property leasing
N6	-The decline of the storage device sector -The rising costs of rents for factory	**-Netac leased out stories of its office building to local hi-tech firms e.g. Tencent**	-Potential risks for Netac

Table 5-11 summarises the upgrading processes for Netac. All related interactions are coded as the 1st order concepts and grouped according to their similarities, which then pointing towards the 2nd order themes. As shown in Figure 5-29, there are 5 types of interactions between regional resources and industrial systems for the development of Netac.

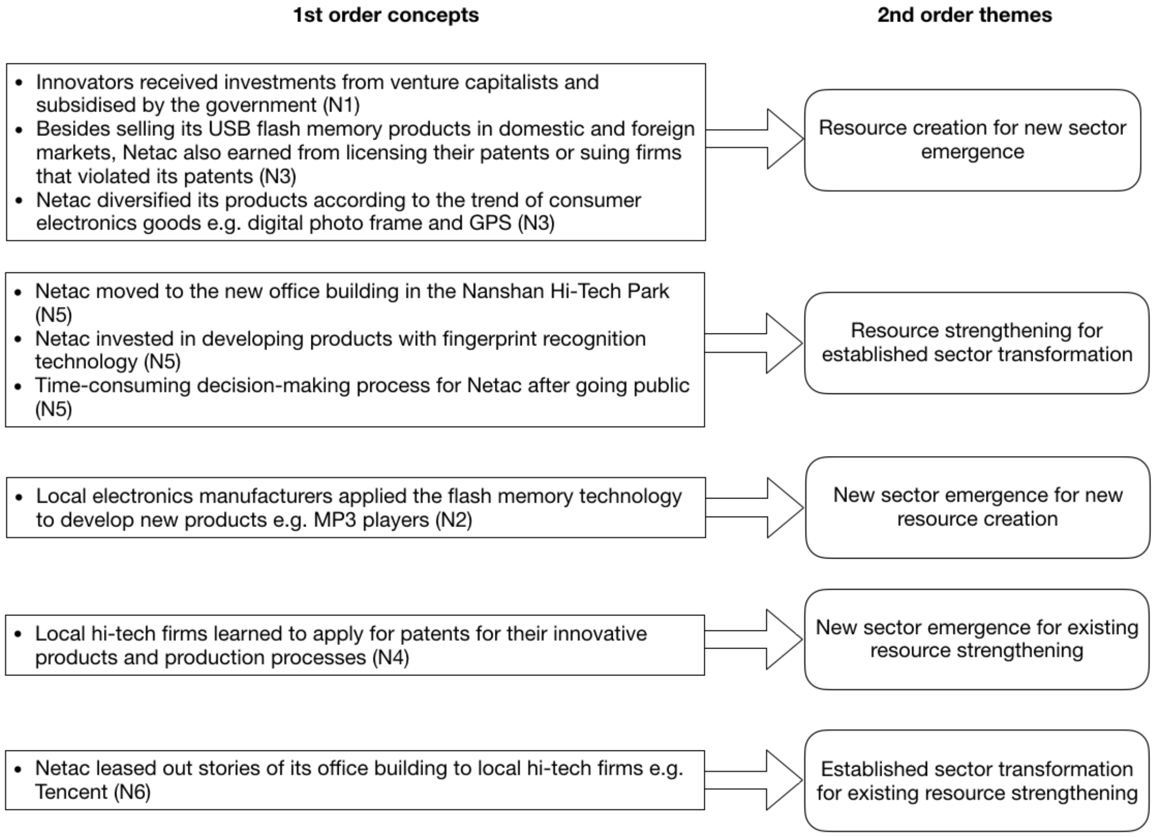


Figure 5-29 Interactions for the Upgrading of Netac

5.3.5 Rapoo

Overview

Rapoo Technology Co., Ltd., is now recognised as the largest keyboard and mouse manufacturer in China. Starting out as an ODM (with the company name "Hot Key") for foreign customers, it then moved into OBM (Original Brand Manufacturer) with quality products and gradually transformed to conduct smart manufacturing with the application of robotics technologies. In recent years, it has also engaged in the manufacturing of industrial robots and robot system integration for electronics firms.

Development Paths and Transitions

<u>ODM</u>

The founder of Rapoo, Mr. Hao Zeng, graduated from Shenzhen University in the mid-1990s with a bachelor's degree in automation control. After graduation, he started working as an engineer in designing products such as electronic anti-theft locks and during this period, he kept on developing a wireless mouse. After successfully launching the first optical mouse with wireless peripheral technology in 2001, he established his own company named Hot Key in 2002 and began manufacturing keyboards and mice for foreign brands. The 'wireless' feature differentiated Hot Key from other ODMs for computer peripherals in Shenzhen and its revenue tripled (from 100 to 300 million RMB) in five years. Yet, Zeng himself acknowledges:

"However, there was no significant technological breakthrough in our products during this period."

Mr. Zeng was worried about the potential risk inherent in relying on contract manufacturing until he encountered an emerging technology in 2006. In this year, Norwegian chip producer Nordic launched a new 2.4 GHz (gigahertz) chip that was far more superior to the dominant 27 MHz (megahertz) technology in terms of signal strength and coverage. From a prototype with 2.4 GHz chip developed by a Taiwanese partner firm of Hot Key, Mr. Zeng noticed its advantages in terms of lower power consumption and being more user friendly. He also sensed the great market potential for the application of such new technology in wireless peripherals, especially witnessing the growing laptop market. Then he endeavoured to obtain chips from Nordic and, after tough negotiations, they finally reached an agreement. Hot Key could obtain those chips at half market price from Nordic with the condition of selling at least 500 thousand sets of 2.4 GHz products every three months. Two other solution providers were also persuaded by Mr. Zeng to form collaborations with Hot Key. In four months, 18 new mice and 10 new keyboards with 2.4 GHz technology were launched by Hot Key and impressed its foreign customers.

ODM to OBM

In 2007, facing under pressure from foreign customers supressing prices, it was no longer profitable for Hot Key to continue manufacturing for these brands. Mr. Zeng then decided to establish his own brand, “Rapoo”, and transformed the role of his company from ODM to OBM. After Rapoo was founded, it launched diversified mice and keyboards with similar quality to foreign brands but at much lower prices. For wireless peripheral products, the average price of foreign brands was more than 300 RMB whilst Rapoo only charged a third or at most two thirds of this. The product soon grabbed the domestic market share of wireless peripherals from its foreign competitor Logitech and by the end of 2008 Rapoo had obtained about half of the market share in mainland China. In 2009, the sales revenue of Rapoo from its own branded products reached 300 million RMB. In addition to products for office use, Rapoo also expanded its product portfolio to include high-end devices, such as the V8 gaming mouse, which was launched in March 2009 and marked China’s first indigenous innovation in wireless gaming mice.

Application of robotics

However, rising labour cost in the mainland increased the cost burden on manufacturing firms. For Mr Zeng:

"…in China there has been a very big salary increase beginning from 2008. So we feel a little pressure from the labour side. So we decided to change a lot our manufacturing system to robots…We started to explore the automation of our factory in 2008…(now) even in the logistics we use robots…it will make my company more competitive in the field."

Facing competition from not only domestic competitors but also global giants such as Logitech, Razer, SteelSeries, and Microsoft, Rapoo introduced industrial robots into its production lines. In 2010, it purchased 75 robots from ABB[40] and became the world's largest customer for ABB robots. As one senior line manager said:

"The application of robots has reduced the number of manual workers from more than 3000 to about 1000… We believe that we can run an unmanned factory in the coming future."

Robots have now been applied in a wide range of production tasks within Rapoo's plants, including distributing materials, processing electronic components and assembling, testing, packing, and palletising finished products. The efficiency of Rapoo was greatly enhanced with automation. For instance, in mouse manufacturing alone productivity was improved by 2 to 2.5 times.

Production of robotics

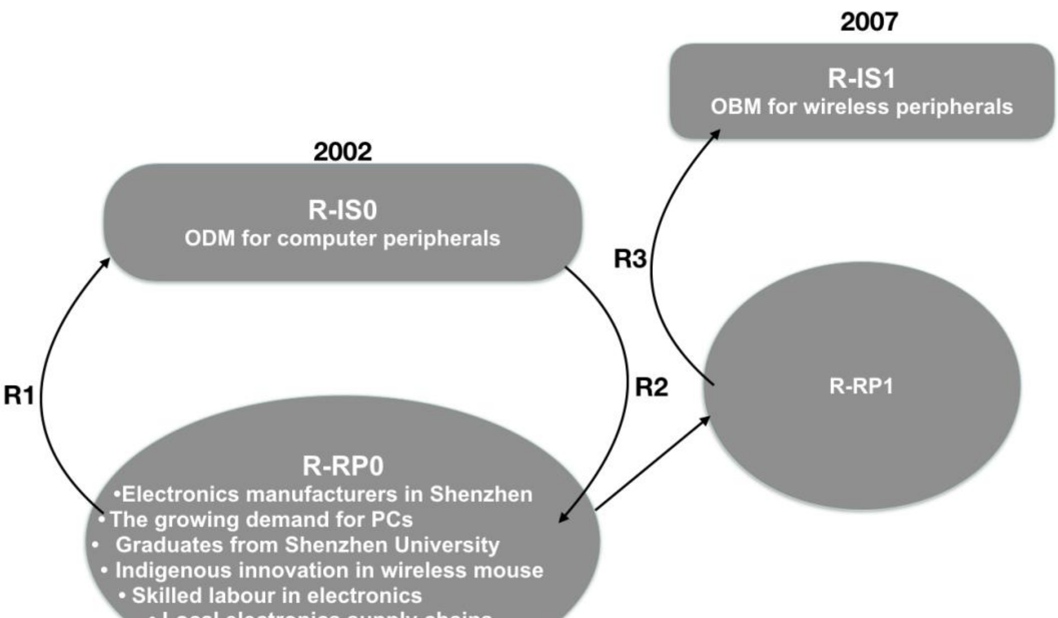
Rapoo was listed on the Shenzhen SME board in 2011. It subsequently further diversified its products and upgraded its manufacturing systems. It developed the Blade series keyboard that won the iF product design awards and the 5.8 GHz technology for its wireless mice. In April

[40] ABB is a world leading manufacturer of industrial robots and robot systems - operating in 53 countries, in over 100 locations around the world. Source: https://new.abb.com/products/robotics/home/about-us

2012, Rapoo moved its production line to a newly established factory site in Pingshan District, recognised as the world's largest production base for peripherals. In addition to robotic arms from ABB, Rapoo also introduced robots from Kuka[41] and domestic robotics manufacturers such as QKM (Quotient Kinematics Machine)[42] at the new production site. With experience accumulated from using industrial robots for factory automation, it then started developing its own robotics and designing robotic production lines. In 2013, Rapoo set up a business unit for robotics and invested in R&D for automation devices. For example, it launched the AGV (Automated Guided Vehicle) that could be controlled using an app on a mobile phone and was then applied in its own production lines. With the application and innovation of robotics in peripheral production, Rapoo was then chosen to participate in the manufacturing project for the National Hi-Tech R&D Programme (known as the 863 Programme). In 2015, it was recognised as one of the first batch of smart manufacturing pilot demonstration enterprises (known as replacing the human labour force with robots) by the National Ministry of Industry and Information Technology. To date, Rapoo has provided more than 50 large electronics manufacturers with customised solutions for robot system integration.

Analysis

Rapoo has been a "hidden champion" of computer peripheral manufacturing in Shenzhen for more than a decade before it stepped into the field of robotics manufacturing. The upgrading path of Rapoo is depicted as Figure 5-30.



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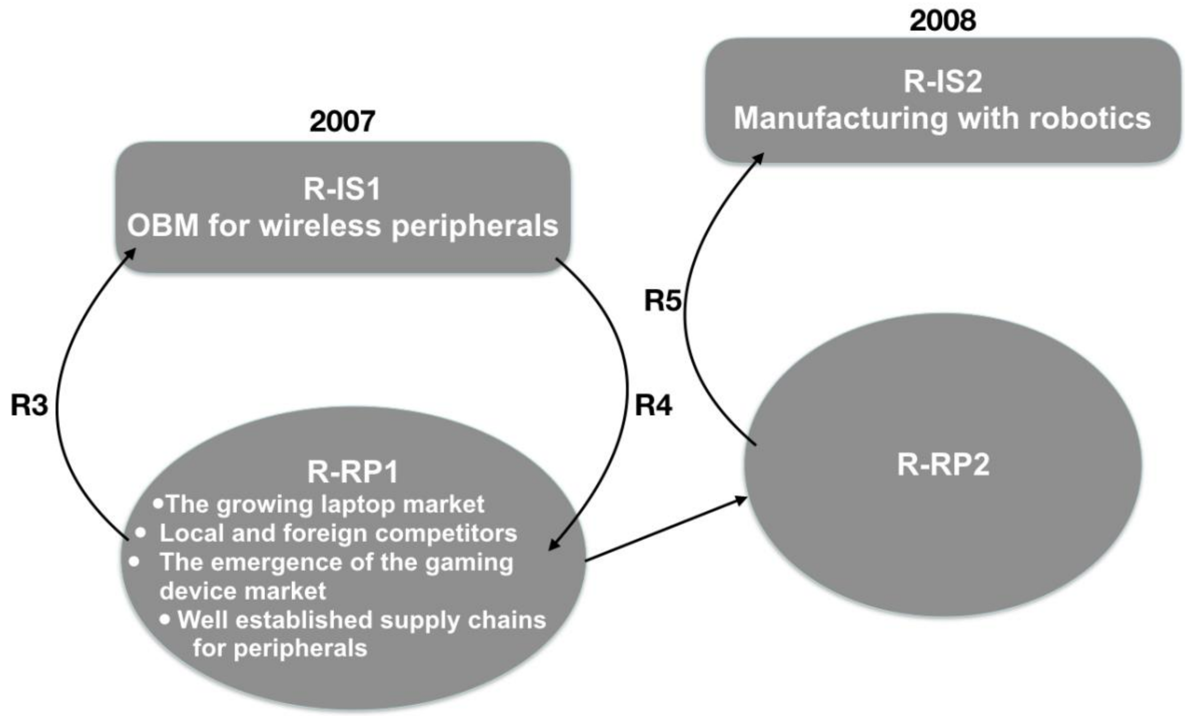
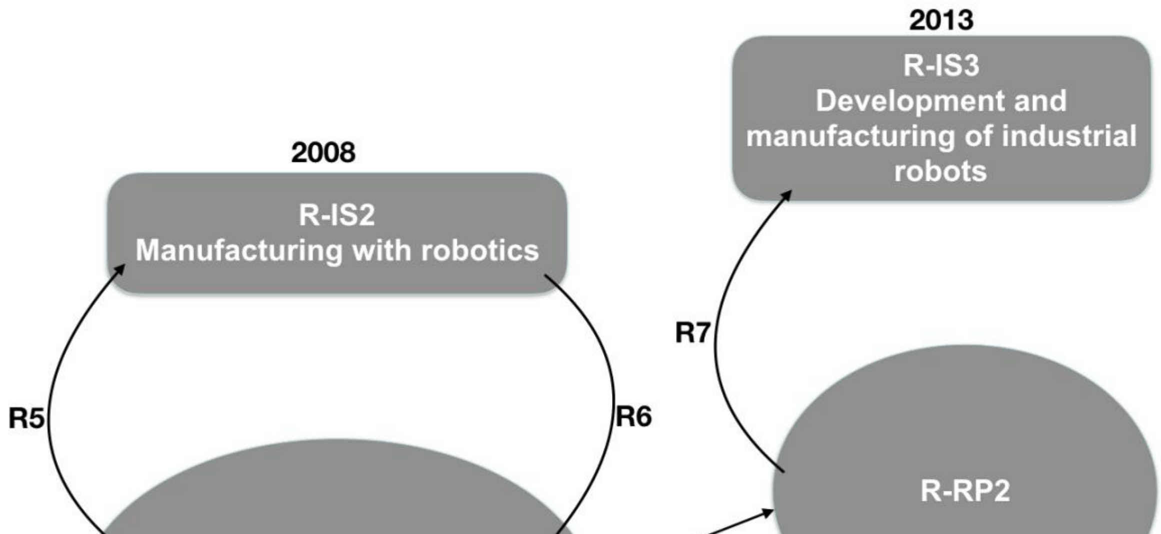
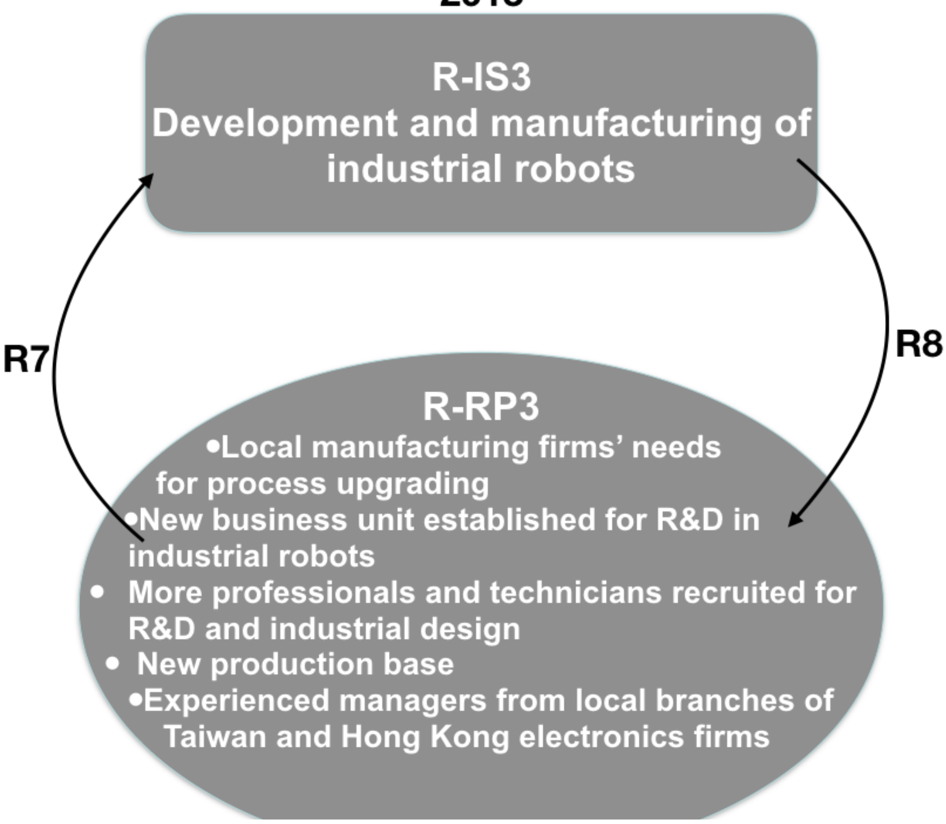
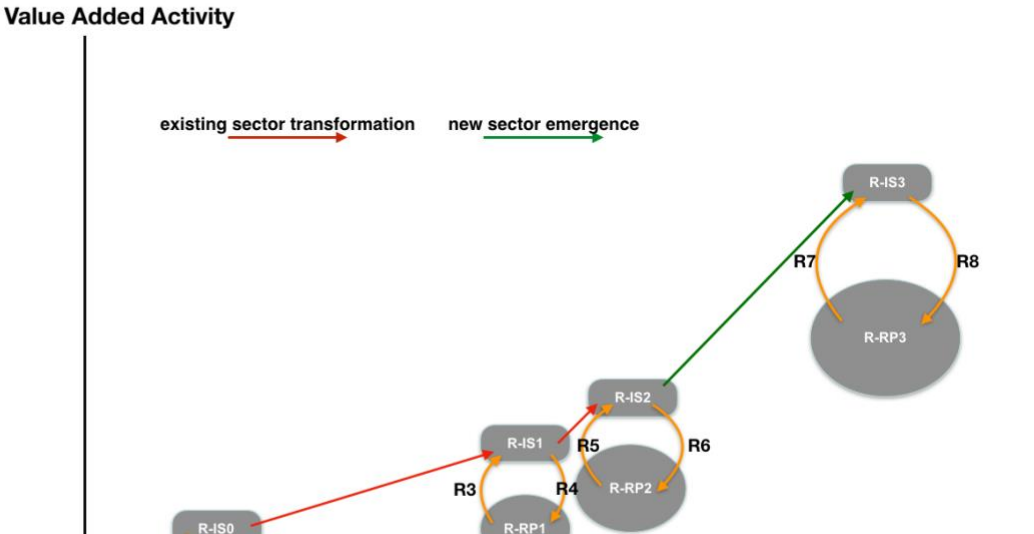

2007
R-IS1
OBM for wireless peripherals
2008
R-IS2
Manufacturing with robotics
R3
R4
R5
R-RP1
•The growing laptop market
• Local and foreign competitors
• The emergence of the gaming device market
• Well established supply chains for peripherals
R-RP2


2013
R-IS3
Development and manufacturing of industrial robots
2008
R-IS2
Manufacturing with robotics
R7
R5
R6
R-RP2

2013



R-IS3
Development and manufacturing of industrial robots
R7
R8
R-RP3
•Local manufacturing firms' needs for process upgrading
•New business unit established for R&D in industrial robots
• More professionals and technicians recruited for R&D and industrial design
• New production base
•Experienced managers from local branches of Taiwan and Hong Kong electronics firms



Value Added Activity
existing sector transformation
new sector emergence
R-IS3
R7
R8
R-RP3
R-IS2
R5
R6
R-RP2
R-IS1
R3
R4
R-RP1
R-IS0

Figure 5-30 Upgrading Path of Rapoo

The antecedent of Rapoo, Hot Key, was established under the context of a burgeoning market for PCs in the early 2000s. Its founder, Mr. Zeng, who innovated the first RF (Radio Frequency) wireless mouse in 1996 and the first human body induction power-saving optical mouse in 2001, decided to devote his own company to the manufacturing of computer peripherals. He rented a factory in Bao'an district and started production. As he put it:

"When we set up Hot Key in Bao'an district, there already located more than 500 firms producing mice and keyboards, so we tried to differentiate our products by promoting the 'wireless' concept, which was fashionable but in fact there was not much difference in technologies (to existing products)."

Mr. Zeng admitted that, in the beginning, there was nothing new about the manufacturing of Hot Key based as it was on existing technologies, skilled workers and comprehensive supply chains of components, Hot Key grew steadily from 2002 to 2007 by providing ODM services for foreign customers. As shown in Figure 5-30, Hot Key set up its ODM system (R-IS0) to produce computer peripherals by organising existing suppliers, workers and technologies in the regional resource pool.

In addition to continuously launching different types of wireless peripherals, Hot Key also took the lead in applying 2.4 GHz technology to its products in 2006. Many other peripheral manufacturers followed Hot Key and applied the new technology to their wireless products. The development of Hot Key has also driven the growth of its local suppliers. In order to maintain orders, these suppliers inevitably upgraded their production systems to adapt new standards requested by Hot Key. For example, one local PCB supplier has grown from a small workshop to a modern factory with well-established production lines following the development of Hot Key. Facing more intense competition from other ODMs, Rapoo was established to operate the OBM system for wireless peripherals (R-IS1) and replace the ODM businesses of Hot Key. Meanwhile, the growing laptop market and declining desktop computer market further increased the demand for wireless mice and keyboards.

Mice and keyboards with the "Rapoo" brand soon attracted domestic customers to its quality products with relatively low prices. In order to maintain its market leader position in wireless peripherals, Rapoo invested more in its own R&D and industrial design in order to launch new products continuously. This stimulated the emergence of local firms that copied its products (known as "Shanzhai"). Some of these copycat manufacturers were even set up by technicians who had been employees of Rapoo. As a senior manager at Rapoo put it:

"In the HQB electronics market, when you ask vendors for Rapoo's products, they will first check with you whether you want the 'real' or 'fake' ones…. As far as I know, more than 10 firms manufacturing similar peripheral products as Rapoo were established by people who had worked for our R&D department."

Facing more intense competition and rising labour costs, especially following the launch of a new labour law in 2008, Rapoo chose to move its manufacturing system towards higher degree of automation to pursue higher efficiency. It purchased industrial robots from both foreign and domestic manufacturers and spent more than one year adapting all robots to its production lines

(R-IS2). The local government encouraged technological upgrading of manufacturing firms from 2008 and Rapoo was subsidised for its use of industrial robots.

With the application of industrial robots in production lines, workers were trained to not only use these robots but also deal with maintenance tasks. Such "learning by doing" processes enabled Rapoo to equip itself with skilled technicians in operating different types of robots. In 2009, Rapoo planned to construct its own factory and purchased land in Pingshan district at a preferential price offered by the municipal government. Before moving to the new site, Rapoo also actively headhunted experienced management personnel from local electronics firms, especially those managers that had been trained by Taiwan and Hong Kong companies. One senior manager at Rapoo said:

"Before coming to Rapoo, I had been working for a Taiwanese firm for a decade… Since 2012, experienced managers helped Rapoo to lay off redundant workers and improve efficiency."

After moving to the new production base in 2012, Rapoo also recruited more talents in industrial design and R&D for peripheral products. With experience in manufacturing with industrial robots for more than five years, Rapoo was able to design and manufacture robots, as well as flexibly organise robots for different production tasks. Such capability in designing manufacturing systems with robots triggered Rapoo to establish a new business unit for industrial robot development and solution design (R-IS3). Following this, Rapoo offered advice and services in designing production lines with robots for local firms to pursue process upgrading.

Case Summary

Rapoo's development reflects the upgrading journey of an electronics manufacturer from an ODM to an OBM, then to a robot user and a robot system integrator. It took Rapoo more than

10 years to consolidate its leading position in the PC peripheral market through product and process upgrading on its industrial system for peripheral production. Then it stepped into the field of robot manufacturing and solution design, which induced the formation of a new industrial system through cross-sectoral upgrading. The detailed processes are shown in the table below.

Table 5-12 Upgrading Processes of Rapoo

Process	Main Driver(s)	Main Interaction(s)	Impact(s)
R1	-Indigenous innovation in wireless mice	**-Grassroots started their own businesses based on own innovation and the local supply chain**	-The ODM system for wireless mice was established
R2	-Wireless technology applied in more peripheral devices	**-Local peripheral manufacturers were induced to move towards wireless products** **-Local component suppliers upgraded their production systems to adapt new standards**	-The local peripheral supply chain was strengthened
R3	-The growing demand for laptops -More intense competition	**-Rapoo terminated its contract manufacturing for foreign customers and switched to the production of own branded peripherals**	-The ODM system was upgraded to the OBM system

Process	Main Driver(s)	Main Interaction(s)	Impact(s)
R4	- Rapoo invested more in R&D and industrial design for new product development	**-Some employees of Rapoo quit and started their own businesses**	-Local followers emerged
R5	-Rising labour costs -Local competitors -The development of local robotics firms -The government encouraged industrial automation via measures such as subsidies and tax incentives	**-Rapoo introduced industrial robots into its production lines and was subsidised by the local government**	-Industrial robots were applied in the OBM production lines
R6	-Industrial robots were used in different production tasks	**-Employees were trained to use robots and deal with maintenance issues**	-Rapoo reduced the number of manual workers

Process	Main Driver(s)	Main Interaction(s)	Impact(s)
R7	-Rapoo accumulated know-how for robot operation and robot system integration -Growing demand for applying robotics in factories -Construction of new production base	**-Rapoo set up a new business unit for R&D in industrial robots** **-Rapoo recruited professionals and technicians in R&D and industrial design of products** **-Rapoo recruited experienced factory managers from local branches of Taiwan and Hong Kong electronics firms**	-The industrial system for robot manufacturing was established -The efficiency of OBM production was enhanced
R8	-Indigenous innovations in robotics, e.g. the AGV and successful practices	**-Rapoo was able to deliver services of robot system design and integration for local manufacturers in sectors such as mobile phone, TVs, air-conditioners, PC peripherals, etc.**	-More local manufacturing firms upgraded their production lines with assistance from Rapoo

The interactions for Rapoo's upgrading are coded as the 1st order concepts and grouped according to similar types of industrial systems and resources involved. As shown in Figure 5-31, there are 8 types of interactions for the development of Rapoo.

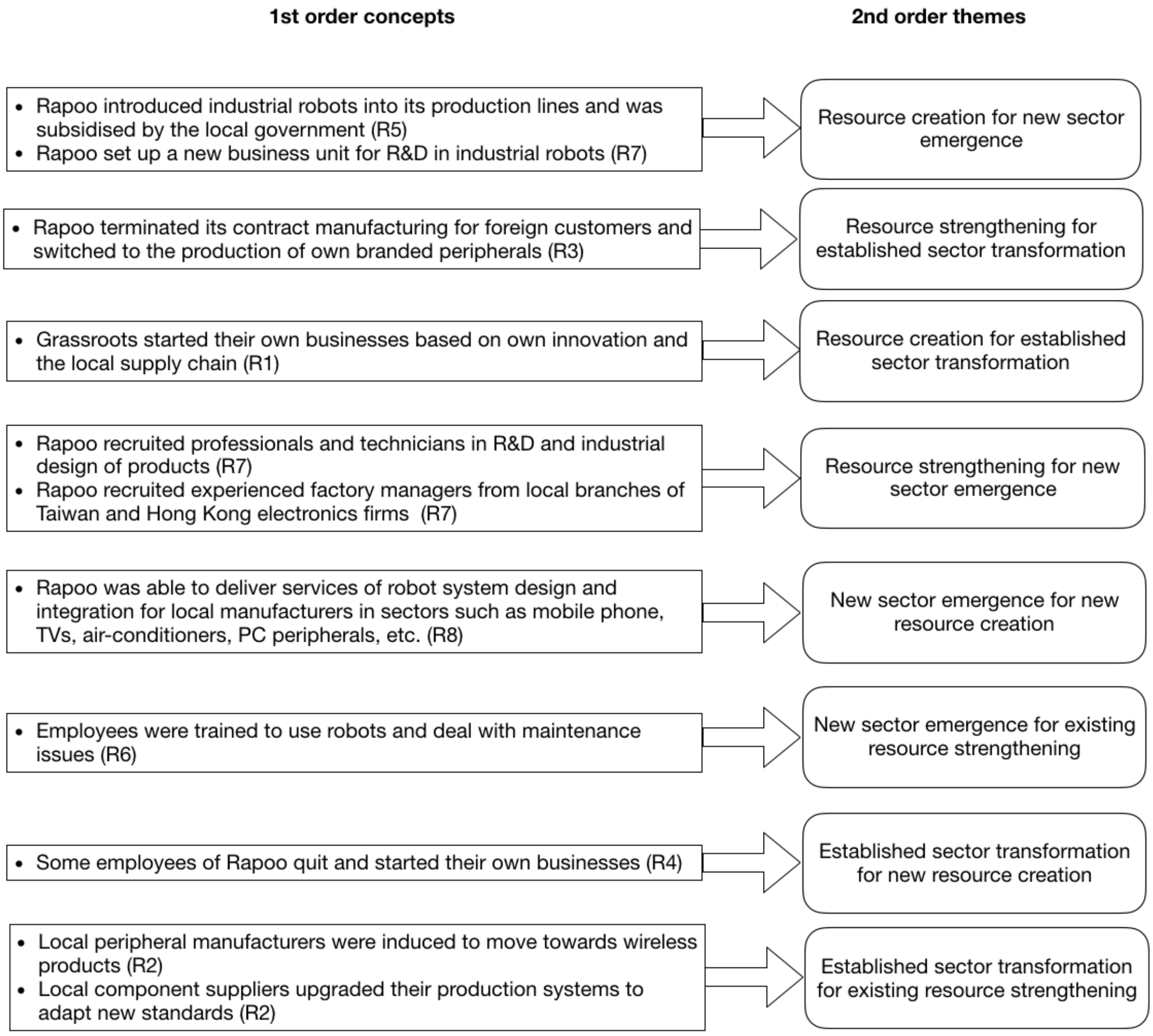


Figure 5-31 Interactions for the Upgrading of Rapoo

5.3.6 Comtech

Overview

Comtech is the largest distributor of chips and other electronics components in Mainland China and provides local firms with technical support, as well as other value-added services. Established in 1995 and headquartered in Shenzhen, Comtech has grown rapidly and its subsidiary Cogobuy has become the largest online platform for ICs (integrated circuits) components trading. Its development path and transitions reflect both the changing technologies and consumption habits associated with the local electronics industry.

Development path and transitions

Components Trading

The founder of Comtech, Mr. Jeffrey Kang, went to Shenzhen as a job seeker in the early 1990s after graduating with a bachelor's degree in electronics engineering. He first worked as a technician in an audio and radio components factory and in 1992, he took the sales engineer position in the local branch of global giant Panasonic. This three-year experience in sales of foreign brand products enabled him to build relationships with upstream foreign suppliers such as Intel and downstream local firms such as Huawei, the first customer he approached after taking this job. Then he decided to start his own business retailing imported electronics components. From 1995 to 2002, Comtech provided components to most domestic telecom companies including Huawei and ZTE. With the rise of these Chinese firms in the global market, Comtech also expanded its product range and became the largest distributor in Mainland China for some key components that could not be produced domestically. In 2000, with the Internet boom, Mr. Kang endeavoured to start a new business in online video streaming by providing related software and hardware. However, the attempt was not successful due to the limitations of bandwidth at that time and the burst of the Internet bubble in late 2000, after which Comtech retreated to focus on its original business in component distribution, especially IC-related products.

In 2002, the flourishing mobile phone market brought new opportunities to Comtech. Being a large distributor of imported ICs in Mainland China, Comtech built relationships with foreign upstream suppliers, including those providing chips with the latest technologies for mobile phones. Then Comtech was able to become the exclusive agency of these foreign brands in mainland China and distributed chips to local mobile phone companies. This has greatly facilitated the localised manufacturing of mobile phones, which then nurtured some local brands. With the stable and gradual increase of income from components trading, Comtech's holding company, Cogo Group, Inc., was listed on the NASDAQ in 2005. In addition to mobile phones, Comtech provided OEMs, ODMs and EMS providers in China with various electronic components that could be applied in different sectors such as, for instance, wireless communications, telecommunication equipment, enterprise networks, digital media, household appliances, automotive electronics and industrial control. Comtech connected more than 100 local companies, including Huawei, ZTE and BYD, with established semiconductor suppliers such as Intel, Microsoft and Broadcom, extracting profit from the price differences and value-added services.

"Cogobuy.com": The Online B2B Platform for Components Trading

In 2008, Mr. Kang learned about the concept of "social marketing" from a business consultant who had provided advice to IBM's restructuring, while another Chinese firm, Xiaomi, had already successfully applied such a strategy by selling products through its network of "fans" ("Mi Fen" in Chinese). Then, in two years, Comtech launched "Cogobuy.com", which acted as an online platform for components trading. Comtech's e-commerce differentiated itself from other B2C platforms such as Taobao and JD that target individual consumers, instead aiming at providing components to electronics SMEs. It also chose not to compete with the domestic

Alibaba but engaged in the market niche that the giant B2B company had not entered[43]. Bridging suppliers of IC components from all over the world with firm-level customers via this website, Comtech successfully transformed its main business from traditional offline trading to O2O (Online to Offline) e-commerce. As Mr. Kang stated during a media interview[44]

"We learned from the transformation of foreign business, especially retailing in the US from small stores to large retail corporations such as Walmart, then to Amazon (an e-commerce marketplace) ... Nowadays, all IC component markets in China are offline and we don't even have a 'Walmart' for IC products, so what we need to do is directly transform from small offline stores to 'Amazon'."

In Shenzhen, many SMEs in electronics are clustered, resulting in a long tail market for different IC components. Previously, distributors aimed to provide components to only large companies like Huawei and ZTE, who purchased in bulk, whilst leaving those SMEs unserved. Local SMEs could only buy from leftovers and local electronics markets such as HQB and, moreover, the quality of these components was not guaranteed. When Cogobuy emerged, Comtech gathered orders from SMEs via this online platform and placed orders to foreign suppliers, which enabled local SMEs to get specified IC components they needed with the same quality as those supplied to large firms.

Cogobuy did not achieve considerable profits, as expected, until 2011, when WeChat was released. WeChat is a popular social network app developed by indigenous flagship Tencent, with functions including messaging, social media and mobile payments, now covering more than 1 billion monthly active users. Collaborating with WeChat, Comtech developed a CRM (Customer Relationship Management) system on the app to deliver trading and promotion

43 Alibaba mainly earns from advertisements on the platform but does not engage in the transaction process of trading.
44 Source: https://www.csdn.net/article/a/2013-09-26/15816722

information to decision makers in SMEs for component procurement. With the proliferation of WeChat, Comtech was able to link many SME buyers scattered in different places across Mainland China, incorporating them as members of Cogobuy and providing them with components they needed. In just a few years, the sales revenue of Cogobuy rocketed to approximately 10 billion RMB. Commenting on the importance of WeChat, Mr Kang acknowledged:

"Without WeChat, we would not have been able to grow so fast… Generally, there were three to five key decision makers in a firm and we grouped all these people together into an online community using WeChat."

Comtech was able to target these key decision makers and sell components according to their demands.

IngDan: The Online Supply Chain Platform for Start-ups and Innovations

In 2014, Cogobuy Group was listed in the HKEX (Hong Kong Exchanges and Clearing Limited). Comtech was not complacent with the success from this e-commerce platform and it launched another online platform called IngDan, which aimed to serve hi-tech start-ups. Based on the supply chain resources accumulated through the Cogobuy platform, IngDan was able to provide start-ups with the hardware manufacturers they needed for prototype development. Ms Song, a senior PR manager of Comtech, noted that:

"We (IngDan) attracted our 'fans' by organising an annual start-up competition in Shenzhen, many public lectures (3 to 5 per week) inviting professionals in advanced technological areas and assisting the government in event organisation, for instance the exhibition of robotics VR applications… We also helped SME 'fans' when they faced challenges in terms of capital,

manufacturing, etc. by offering them hardware and software support, as well as connecting them with local factories we were familiar with."

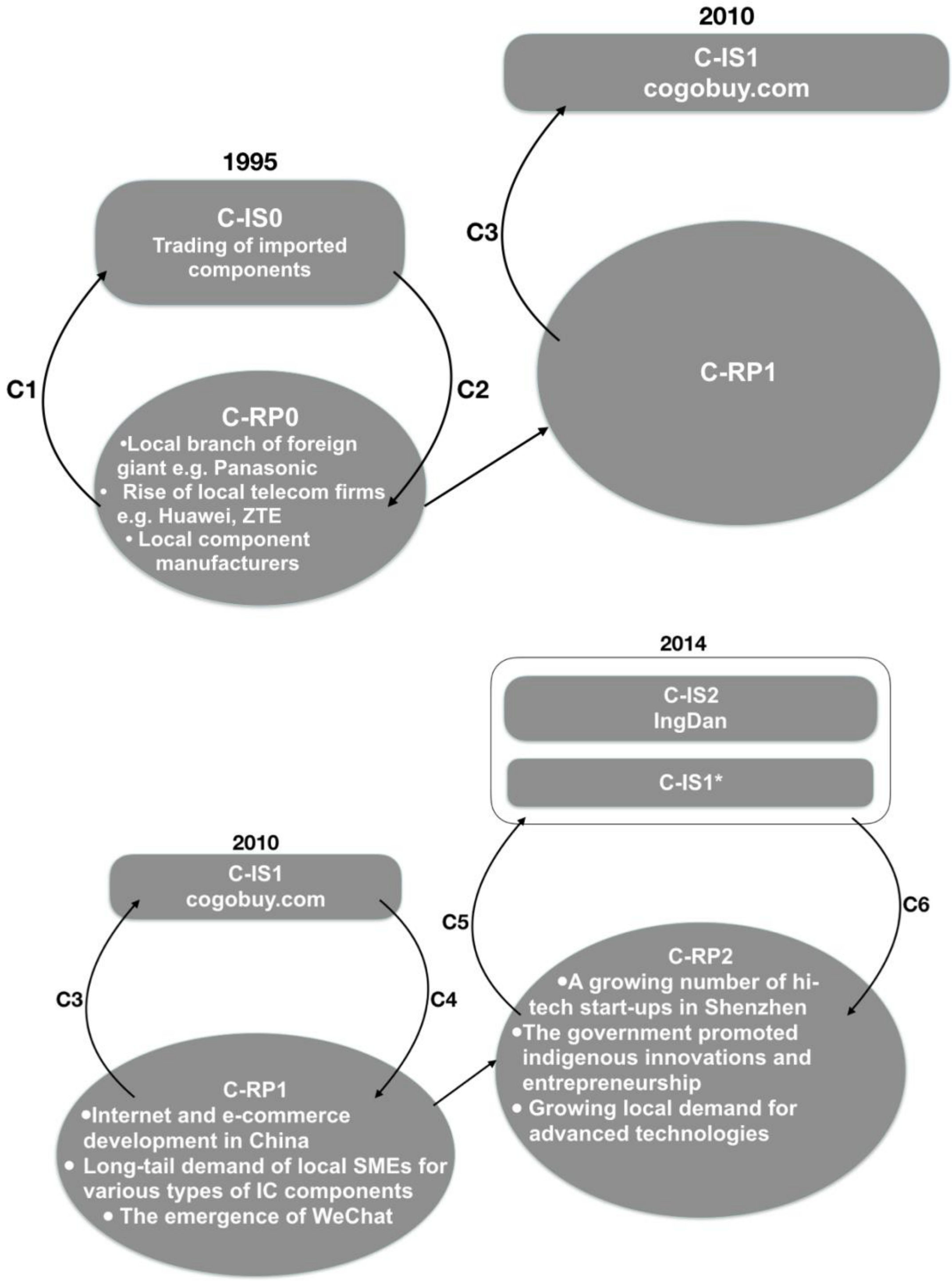
In three years, IngDan attracted more than 16 million 'fans' and launched 16000 projects in hardware innovation, 80% of which were originated from domestic start-ups. By linking these SMEs with more than 14000 local manufacturers specialised in moulding, IC design and other areas, innovative electronics products were continuously developed and some of them were successfully commercialised. For example, the dancing robot Alpha 1 Pro, produced by local hi-tech start-up UBTECH, was facilitated by the IngDan platform in its early stage of product development. In addition to supporting hi-tech firms, IngDan also enhanced the growth of Comtech by inducing emerging firms to purchase IC components from Cogobuy. Mr. Kang, in a public speech in 2016, said:

"IngDan is now the largest online supply chain platform for start-ups and innovations in smart hardware… We focus on consolidating our hardware supply chain services and linking grassroot innovators in mainland China with manufacturers in the PRD region, especially in Shenzhen and its surrounding areas."

In 2017, Comtech started a new round of transformation, mainly on its IngDan platform. With a growing number of registered members (or 'fans'), IngDan provided services to more and more SMEs and became overloaded. It then decided to focus primarily on three aspects: introducing foreign technologies into the Mainland China market, providing screened local firms with supply chain services and building up an ecosystem around the IngDan platform.

Analysis

Although Comtech is not directly involved in manufacturing, it has continuously played an irreplaceable role in the electronics industry by supplying IC components to local firms. Based on its trading and distributing businesses, Comtech has gradually developed its online platforms to provide more products and services (as shown in Figure 5-32).



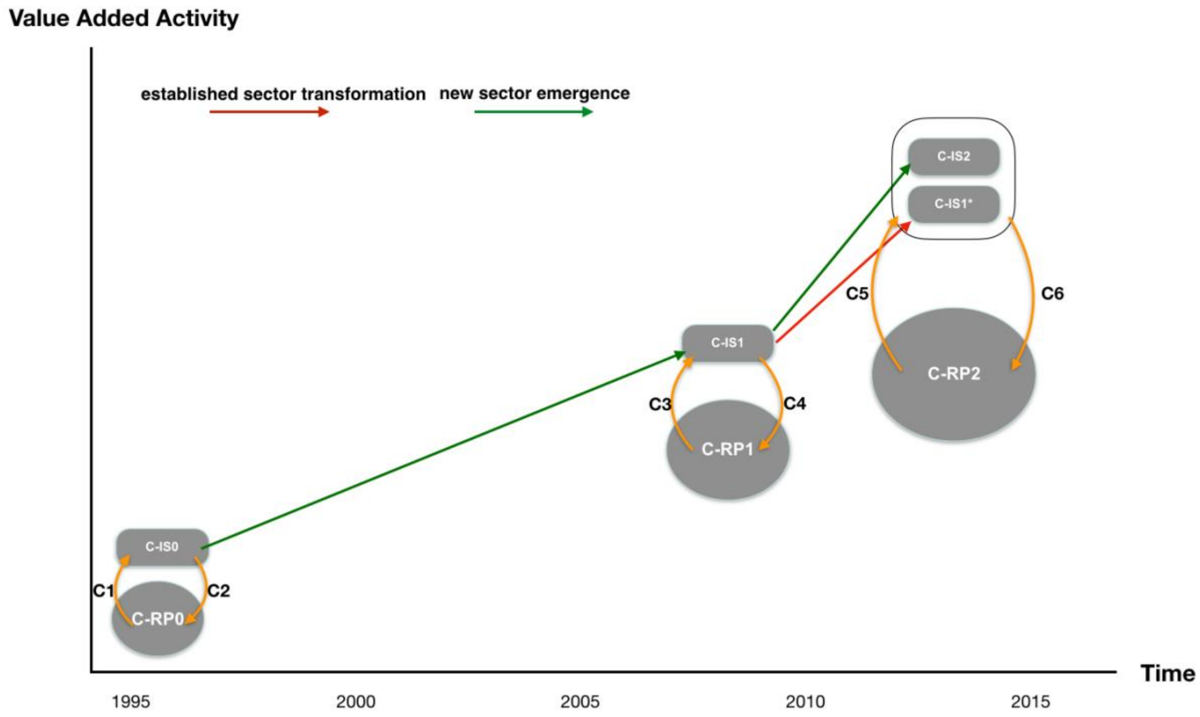


Figure 5-32 Upgrading Path of Comtech

From traditional offline component trading (C-IS0) to online sales platform (C-IS1)

The establishment of Comtech was mainly driven by the growing demand for IC components from local telecom firms. Based on his working experience in the electronics industry, Mr. Kang sensed the opportunity of bridging local customers with foreign suppliers he had already built up relationships with. When asked about the reasons behind the success of Comtech in its early stages, Mr. Kang mentioned the importance of bonds formed with both suppliers and customers:

"I have accumulated resources that seem very valuable and rare in this industry and (that is why) there is never a lack of resources for Comtech since its establishment." [45]

[45] Source: http://www.lundaowang.com/a/2015-10/2299.html

From 1995 to 2010, Comtech steadily grew to become the largest distributor of high-end chips from foreign suppliers for electronics firms in Shenzhen. During this period, local electronics firms gradually shifted from mainly contract manufacturing to the production of branded goods with indigenous innovation. In addition to those local giants that regularly placed large-scale orders of ICs on Comtech, Mr. Kang noticed that the fragmented demands from local SMEs could altogether be pooled as a large and unexploited market. However, it was not easy to follow the traditional pathway in building up relationships with SMEs scattered around the region and even within the whole country. Instead, the online platform was seen as a plausible way to gather SMEs together and get instant feedback from them. In Shenzhen, the rise of Internet companies from the late 1990s had resulted in a talent pool with veteran software engineers from which Comtech was able to screen and recruit people needed for the online system development. In 2010 Comtech launched "Cogobuy.com" and soon transferred its existing suppliers and customers from offline to online. Cogobuy did not follow the traditional way of B2B or B2C to run this e-commerce platform because its sales volumes of high-value IC and other electronic components always resulted in a transaction value that was much higher than traditional B2C e-commerce companies. Instead, it could be seen as a B2B platform applying B2C marketing strategies. Mr. Zhu, the incumbent vice president of Cogobuy at the time, said during an interview in 2012 [46]:

"It is not meaningful to define our business model as B2C or B2B as long as it creates value for our customers."

He also stated that the comparative advantage of Cogobuy was Comtech's offline experience in the IC sector for more than ten years, which enabled it to provide professional services for SMEs in choosing the most suitable types of IC components from branded suppliers and channels for their products. This implies that the successful transformation from offline to online was largely attributable to the foundation laid by Comtech in terms of the in-depth

[46] Source: https://www.sootoo.com/content/354484.shtml

understanding of resources it can leverage, although technological advancement played an important role in the new online system development.

From online trading platform (C-IS1) to supply chain-based service provider for innovation (C-IS2)

The emergence of WeChat in 2011 brought Cogobuy the opportunity to go social and expand its coverage. By partnering with WeChat, they developed a mobile application called "Cogobuy Cloud" for enterprises and built up an online community for suppliers and customers to exchange information and ideas via the front-end user interface. Cogobuy then collected and processed data through the back-end cloud computing system so as to provide customised enablement services for various electronics companies, including those blue-chips and SMEs (C-IS1*). From 2011 to 2013, with the support of WeChat, the GMV (Gross Merchandise Volume) of the Cogobuy.com e-commerce platform grew exponentially from approximately 200 million RMB to approximately 4 billion RMB.

In addition to the sales platform Cogobuy, Comtech launched another platform, "IngDan", aiming to promote idea and knowledge exchanges among electronics designers and engineers in China. As Mr. Wen, the operation manager of IngDan, said of this project:

"Our goal is to develop a dedicated ecosystem for the electronics value chain… based on industry know-how we have accumulated and the in-depth understanding of technological and market trends, we are able to offer local SMEs critical resources for their upgrading processes."

IngDan was launched before the national government officially promoted indigenous innovation and entrepreneurship in September 2014, and it acted as the pioneer in linking local start-ups and hardware innovators with its rich supply chain resources, including global top brands such as Intel and Microsoft. Mr Wen noted:

"Initially we simply wanted to facilitate SMEs to upgrade their technologies through our platform, and then as they grow and expand, we can sell more (components) to them. But as the sales volume increased, we were pushed to upgrade our own system to serve more customers and enhance the formation of supply chain-based ecosystem."

IngDan teamed up with WeChat in organising events such as smart hardware innovation competition and again developed an interactive and engaging online community called "IngDan WeChat community". In contrast to "Cogobuy Cloud", IngDan community targeted start-ups in smart hardware and aimed to commercialise those with market potential. Following the government's advocation of grassroot innovations, IngDan also organised public events regularly, such as technology discussion forums and new product launches for more citizens to participate.

Case Summary

There were two main transitions throughout Comtech's development, referring to six groups of upgrading processes since its establishment in 1995. The main drivers, interactions and impacts of these processes are summarised in Table 5-13.

Table 5-13 Upgrading Processes of Comtech

Process	Main Driver(s)	Main Interaction(s)	Impact(s)
C1	-Growing demand for IC components	**-Foreign IC suppliers sold their products through local sales agents**	-Comtech was established as the channel between foreign suppliers of IC components and local customers.
C2	-The continuous growth of Comtech	**-Comtech provided IC components from top foreign brands for large local firms**	-Local firms grew rapidly with imported IC components.
C3	-Long-tail demand of local SMEs for various types of IC components -The development of local Internet companies such as Tencent	**-Comtech recruited local IT talents to develop the online system** **-Comtech collaborated with WeChat**	-E-commerce system Cogobuy established for online IC components trading.
C4	-The fast growth of Cogobuy facilitated by WeChat	**-Cogobuy provided local SMEs with top brand ICs according to their needs**	-More local SMEs were able to conduct independent innovations and produce prototypes with branded ICs from Cogobuy.

Process	Main Driver(s)	Main Interaction(s)	Impact(s)
C5	-A growing number of hi-tech start-ups in Shenzhen -The government promoted indigenous innovations and entrepreneurship	**-Innovators searched for suppliers to manufacture their prototypes and a channel to distribute their products**	-IngDan was established as a platform to connect innovators with manufacturers
C6	-The growing number of smart hardware start-ups on the IngDan platform -The demand for traditional manufacturing firms to upgrade in product and process	**- IngDan helped technology start-ups and innovators to source appropriate manufacturers and find a distributor for small quantities** **-IngDan facilitated the traditional manufacturing firms to go "smart" by bridging them with hardware innovations** **-IngDan collaborated with local hi-tech giants and organised public events for local grassroots innovators**	-Upgrading of traditional manufacturing firms and emergence of new hi-tech firms in the region

The interactions for Comtech's upgrading are coded as the 1st order concepts and grouped according to similar types of industrial systems and resources involved. As shown in Figure 5-33, there are 5 types of interactions for the development of Rapoo.

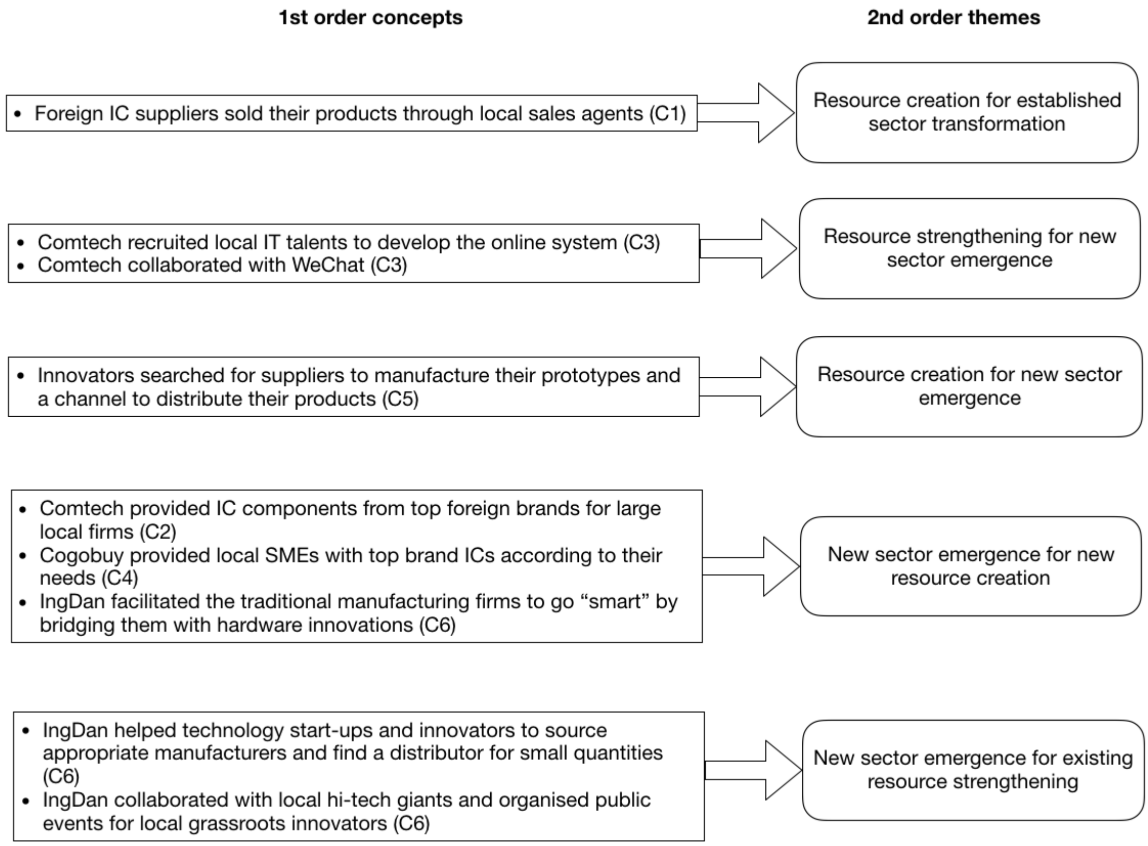


Figure 5-33 Interactions for the Upgrading of Comtech

5.4 Cross-case Analysis of Company Cases

From the within-case analyses of six companies, the types of interactions between industrial systems of the electronics industry in Shenzhen and the regional resource pool are presented. Although each company has exhibited certain processes for upgrading, there are eight types of interactions between the regional resource pool and industrial systems according to the types of resources and industrial systems, which implies eight types of generic mechanisms. Such generic mechanisms for upgrading processes in a region-based business ecosystem can be extracted by cross-case analyses according to their interaction types, as shown in Table 5-14 to 5-21.

Table 5-14 Configuring process from ER (Existing Resources) to NIS (New Industrial System)

ER-NIS	BYD	Lachesis	Rapoo	Comtech
Interactions	-BYD invested in own factory construction and purchasing advanced equipment (B3) -BYD sourced local suppliers for components that were suitable for its mobile phone production (B5) -BYD recruited more experienced engineers for R&D (B7) -BYD outsourced some components manufacturing tasks to local SMEs (B7) -BYD purchased most advanced machinery and offered related services (B7)	-Collaboration between Mr. Zhu and professional from research institute (L7) -Enterprise invested in R&D and headhunted young talents for the new product development (L7) -Enterprise invested in a component manufacturing firm (L7)	-Rapoo recruited professionals and technicians in R&D and industrial design of products (R7) -Rapoo recruited experienced factory managers from local branches of Taiwan and Hong Kong electronics firms (R7)	-Comtech recruited local IT talents to develop the online system (C3) -Comtech collaborated with WeChat (C3)
Generic Mechanism	• Enterprises invest in improving own resources and/or actively approach established technology owners for collaboration (B3, B5, B7, L7, R7, C3)			

Table 5-15 Configuring process from ER (Existing Resources) to EIS (Established Industrial System)

ER-EIS	BYD	Lachesis	Rapoo	SEG	Netac
Interactions	-BYD rented old factories for battery production (B1) -Shenzhen Hi-Tech Investment Group offered BYD guarantee to raise capital from local banks (B1) -BYD attracted talents to join its management team via the Telecom Fair (B1)	-Enterprise reconfigured design houses, component suppliers and its own production lines for the manufacturing of new consumer electronics (L5)	-Rapoo terminated its contract manufacturing for foreign customers and switched to the production of own branded peripherals (R3)	--SEG refurnished and transformed its offices into the trading market for components (S3) -Networks formed in the electronics market among vendors and suppliers (S5) -SEG continued its collaboration with foreign giants by introducing their production lines and technologies (S5)	-Netac moved to the new office building in the Nanshan Hi-Tech Park (N5) -Netac invested in developing products with fingerprint recognition technology (N5) -Time-consuming decision-making process for Netac after going public (N5)
Generic Mechanism	• Enterprises incorporate already established but idle or underexplored resources in the region into their production (B1, L5, R3, S3, S5, N5)				

Table 5-16 Configuring process from NR (New Resources) to NIS (New Industrial System)

NR-NIS	BYD	Lachesis	Rapoo	SEG	Comtech	Netac
Interactions	**-BYD benefited from preferential policies and technological support from the IC Industrial Base in chip design and manufacturing (B5)**	**-Shenzhen Municipal Government established the Hi-tech Industrial Park to attract talents and enterprises (L1)** **-MP3 players developed based on the USB flash memory drive (L3)** **-Enterprise shut down factories and dismissed manual workers for consumer electronics (L7)**	**-Rapoo introduced industrial robots into its production lines and was subsidised by the local government (R5)** **-Rapoo set up a new business unit for R&D in industrial robots (R7)**	**-Local government lobbied the national authority to send talents to Shenzhen for the development of local electronics industry (S1)** **-Foreign production lines were introduced e.g. CRT production lines from Japan (S3)** **-SEG was appointed to carry out the localised IC production by the government (S3)** **-SEG started new infrastructure construction that supported by the local government (S5)** **-The Huaqiangbei electronics markets linked local components suppliers with domestic and foreign makers (S7)** **-Local government encouraged indigenous innovation and establishment of maker spaces by providing funds and subsidies (S7)**	**-Innovators searched for suppliers to manufacture their prototypes and a channel to distribute their products (C5)**	**-Netac received investments from venture capitalists and subsidised by the government (N1)** **-Besides selling its USB flash memory products in domestic and foreign markets, Netac also earned from licencing their patents or suing firms that violated its patents (N3)** **-Netac diversified its products according to the trend of consumer electronics goods e.g. digital photo frame and GPS (N3)**
Generic Mechanisms	• **The government provides (institutional/financial/technological) support for implementation or commercialisation of innovations (B5, L1, S1, S5, S7, N1)** • **Enterprises incorporate nascent resources in the region into their production (L3, L7, R5, R7, S3, S7, C5, N3)**					

Table 5-17 Configuring process from NR (New Resources) to EIS (Established Industrial System)

NR-EIS	Rapoo	Comtech
Interactions	-Grassroots started their own business based on own innovation the local supply chain (R1)	-Foreign IC suppliers sold their products through local sales agent (C1)
Generic Mechanism	• Enterprises start own businesses in an established sector by applying nascent resources in the region (R1, C1)	

Table 5-18 Embedding process from EIS (Established Industrial System) to ER (Existing Resources)

EIS-ER	BYD	Lachesis	Rapoo	Netac
Interactions	-BYD built up relationships with local customers e.g. Huawei, TCL (B2) -BYD rent more new factories in Longgang district constructed by the local government (B2) -BYD combined human labour and simple machinery in its production lines (B2)	-Enterprise enhanced manufacturing capabilities of its upstream firms (L6)	-Local peripheral manufacturers were induced to move towards wireless products (R2) -Local component suppliers improved their production systems to adapt new standards (R2)	-Netac leased out of stories its office building to local hi-tech firms e.g. Tencent (N6)
Generic Mechanism	• Enterprises expand its influence over local established resources (B2, L6, R2, N6)			

Table 5-19 Embedding process from EIS (Established Industrial System) to NR (New Resources)

EIS-NR	Rapoo	SEG
Interactions	-Some employees of Rapoo quitted and started their own businesses (R4)	- SEG gave up its CRT business (S6)
Generic Mechanism	• Enterprises and the government follow the market mechanism: competition and risk mechanisms (R4, S6)	

Table 5-20 Embedding process from NIS (New Industrial System) to ER (Existing Resources)

NIS-ER	BYD	Lachesis	Rapoo	SEG	Comtech	Netac
Interactions	-More foreign brands placed orders on BYD for ODM whole mobile phone manufacturing (B6)	-Employed more workers and introduced more machines for production (L4)	-Employees were trained to use robots and deal with maintenance issues (R6)	-SEG provided job opportunities for local grassroots (S4) -SEG attracted enterprises from other regions to locate their trading or manufacturing in Shenzhen (S4) - SEG switched its main business to the operation of its electronics market (S6) -Makers based in SegMaker utilised the components market for their innovation and prototype development (S8)	- IngDan helped technology start-ups and innovators to source appropriate manufacturers and find a distributor for small quantities (C6) -IngDan collaborated with local hi-tech giants and organised public events for local grassroots (C6)	-Local hi-tech firms learned to apply for patents for their products and production processes (N4)
Generic Mechanism	• Enterprises cultivate the flexibility for their application of local established resources (B6, L4, R6, S4, S6, S8, C6, N4)					

Table 5-21 Embedding Process from NIS (New Industrial System) to NR (New Resources)

NIS-NR	BYD	Lachesis	Rapoo	SEG	Comtech	Netac
Interactions	**-Local grassroots started their businesses in components manufacturing (B4)** **-Foreign customers pushed BYD to manufacture new components (B4)** **-Local SMEs manufactured complementary components for BYD (B8)** **-BYD collaborated with Samsung to learn 3D glass manufacturing (B8)**	**-Enterprise sought new opportunities from the local electronics market (L2)** **-Lachesis continued to invest in internal R&D and sought collaborators with advanced technologies and manufacturing facilities (L8)**	**-Rapoo was able to deliver services of robot system design and integration for local manufacturers in sectors such as mobile phone, TV, air-conditioner, PC peripheral and etc. (R8)**	**-SEG established the Shenzhen Electronics Industry Association (S2)** **-SEG set scholarships for students in Shenzhen University (S2)** **-SEG set up a training centre for technicians in electronics manufacturing (S2)**	**-Cogobuy provided local SMEs with top brand ICs according to their needs (C2)** **-Comtech provided IC components from top foreign brands for local large firms (C4)** **-IngDan facilitated the traditional manufacturing firms to go "smart" by bridging them with hardware innovations (C6)**	**-Local electronics manufacturers applied the flash memory technology to develop new products e.g. MP3 players (N2)**
Generic Mechanism	• **Enterprises expanded their businesses according to market trends (B4, B8, L2, L8, R8, S2, C2, C4, C6, N2)**					

From the cross-case analyses of company cases, the data structure for the industrial upgrading mechanisms in a region-based business ecosystem is illustrated in Figure 5-34.

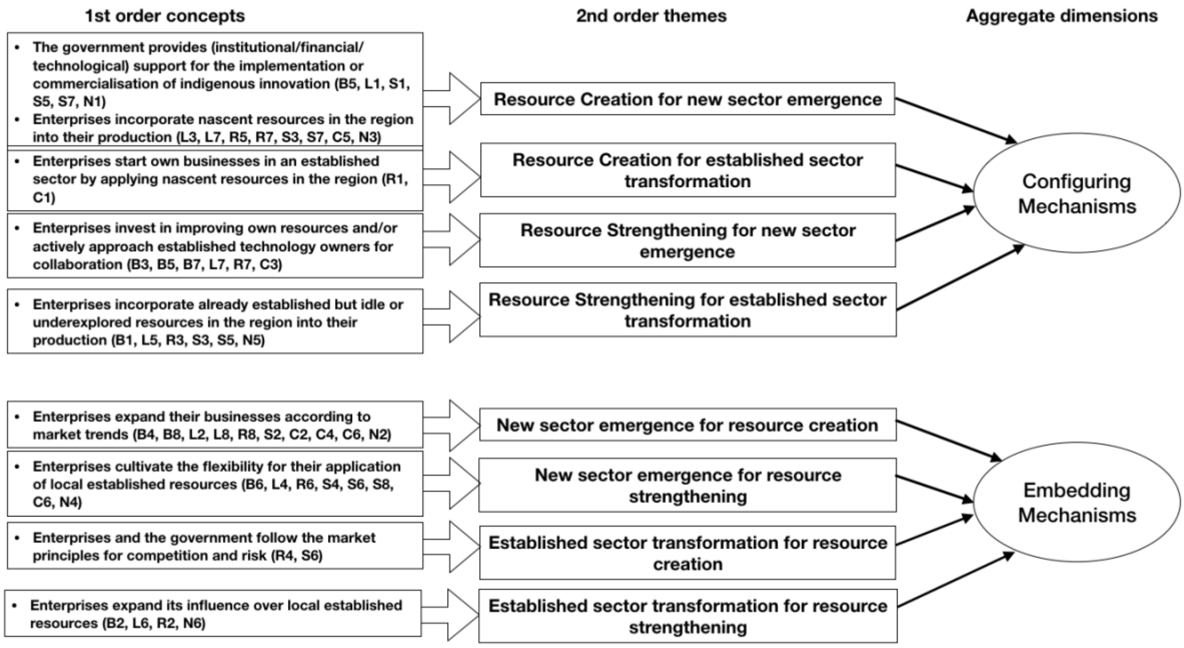


Figure 5-34 Data Structure

Chapter 6 Research Findings

6.1 Towards an Understanding of Regional Resource Pool Evolution

Regional development is a broad concept and can be assessed from different perspectives. In this research, the development of Shenzhen is expressed as an evolutionary process of regional resources. From the evolutionary mapping of Shenzhen's electronics industry, temporal bracketing strategy (Langley, 1999) is applied to identify six milestone events that laid the foundation for the urban and industrial development in a chronical order. In section 5.1 detailed analyses of these events reveal various types of resources and their interactions for events to take place. Then from the event synthesis in section 5.2, resources are classified into six general types that constitute a regional resource pool, namely the governmental resources that mainly refer to policies; financial resources which are capital that determines the survival and growth of firms; industrial resources that are essential for production; research resources for technological development; educational resources for the training of skilled labour and professionals; and intermediary resources that enhance the collaborations between other types of resources. These general types of regional resources are triangulated with secondary data in practical and literature reviews to ensure construct validity (Miles & Huberman, 1994; Yin, 2009).

The establishment of the Shekou Industrial Zone (CMSK) and the introduction of the '3+1" trading mix strategy paved the way for the rise of the local electronics industry through contract manufacturing. From the late 1970s to the mid-1990s, capital, production and policy resources played the key role in scaling up the local electronics industry (see Figure 6-1) and in turn they facilitated the evolution of each other.

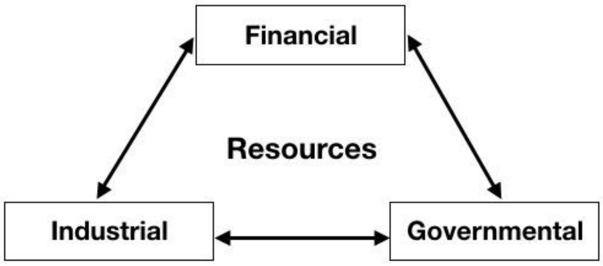


Figure 6-1 1st stage resources for industrial system formation

In 1995, although contracting manufacturing of electronics products still fuelled the local economy, the municipal government was conscious of its unsustainability and took the lead in transforming the industrial structure towards more hi-tech sectors by encouraging enterprises to conduct independent R&D activities. Then, research institutions and intermediary organisations were introduced from other regions or jointly formed by local firms and the government. The launch of the first Hi-tech Fair (CHTF) in 1999 marked a successful practice in organising capital, production, policy and research resources in the region to form a new type of intermediary resource in a platform manner. From then on, the interactions between these five types of resources (see Figure 6-2) greatly enhanced the development of the local electronics industry from low value-added contracting manufacturing to production with advanced technologies and indigenous innovations. The “Shanzhai” phenomenon in the 2000s was another example which showed how local electronics manufacturers utilised and further strengthened these resources.

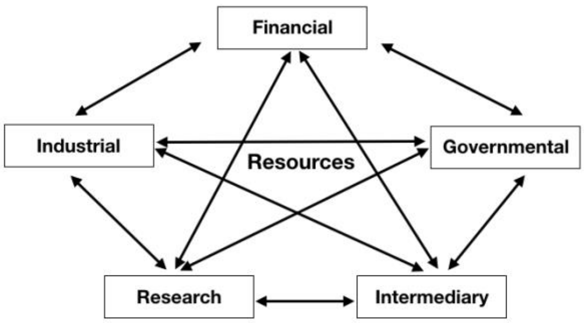


Figure 6-2 2nd stage resources for industrial system transformation

In the late 2000s, Shenzhen became the hub of hardware innovators and start-ups in China, with a strong base in electronics manufacturing. However, the lack of higher education resources resulted in a shortage of talents, which hindered the development of local hi-tech firms. Realising the growing importance of technological innovations from fundamental research on industrial development, the municipal government then actively persuaded reputable universities to set up branches such as postgraduate schools in Shenzhen and invested in jointly established institutions. The Shenzhen Institutes of Advanced Technology (SIAT) was among the earliest batch of these localised higher education institutions in Shenzhen and provided local firms with talents and technologies.

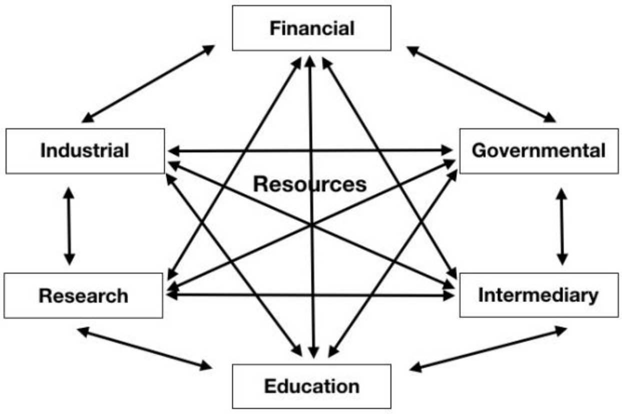


Figure 6-3 3rd stage resources for industrial system improvement

Being a developing region that transformed itself from a fishing village to a modern metropolis in only four decades with a well-established and continuously growing electronics industry, Shenzhen went through the evolution of its regional resource pool (RRP) in mainly three stages (see Figure 6-4). The evidence from the story of Shenzhen implies that to pursue continuous regional growth from industrial upgrading, the corresponding regional resource pool should be progressively consolidated to consist of governmental, financial, industrial, research, educational and intermediary resources that are able to organically interact with each other.

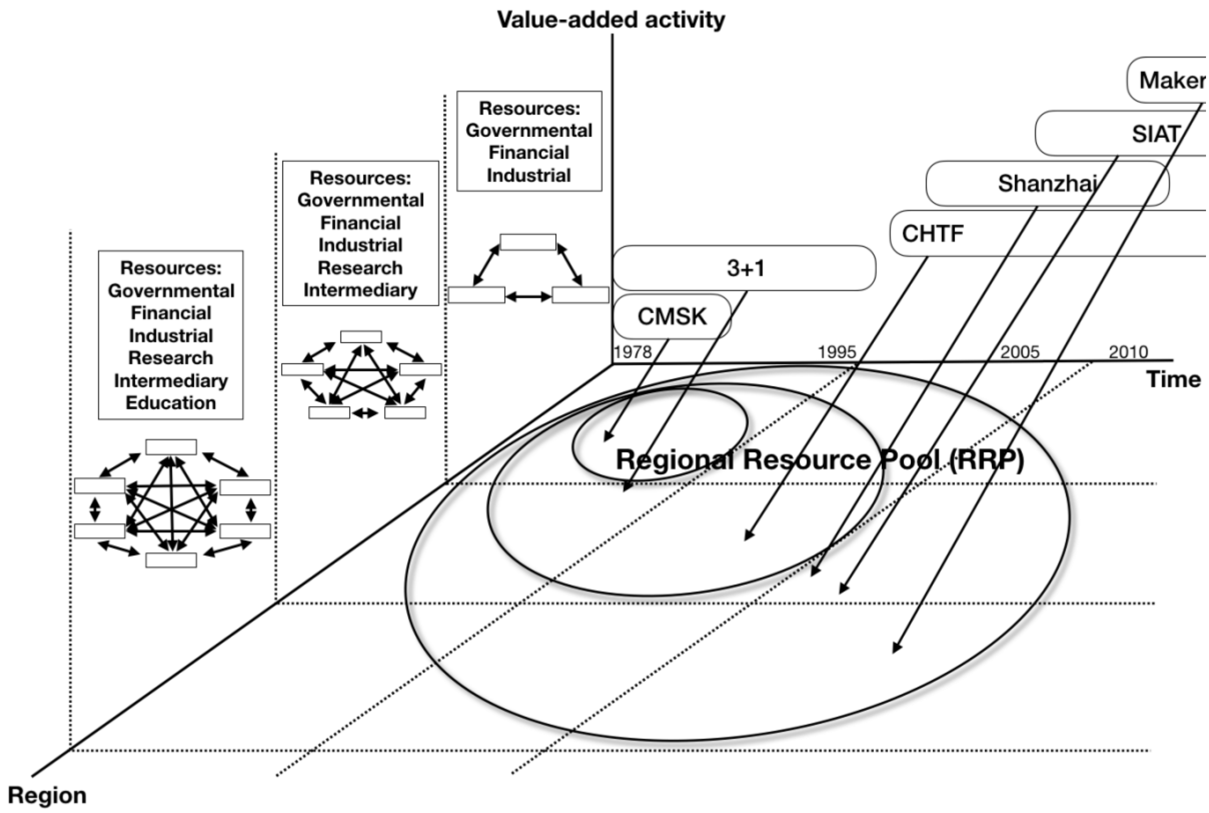
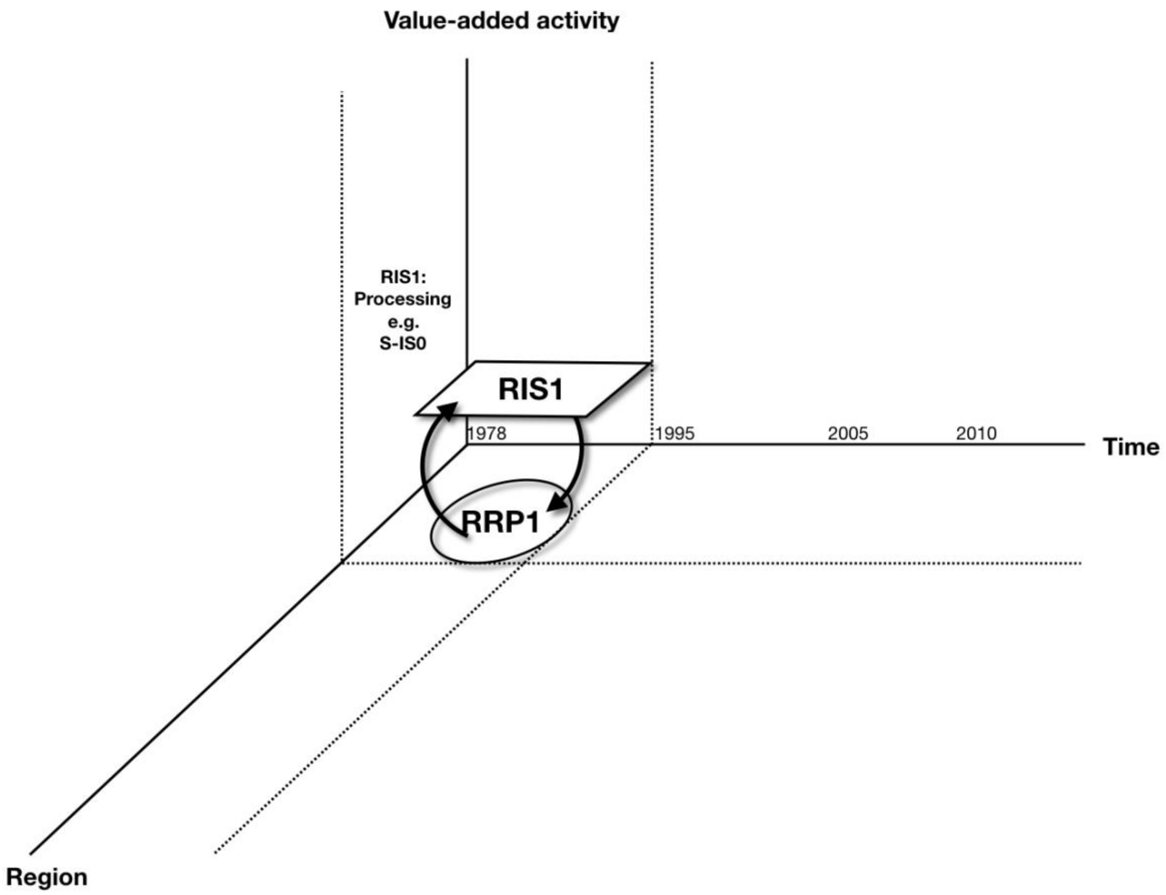


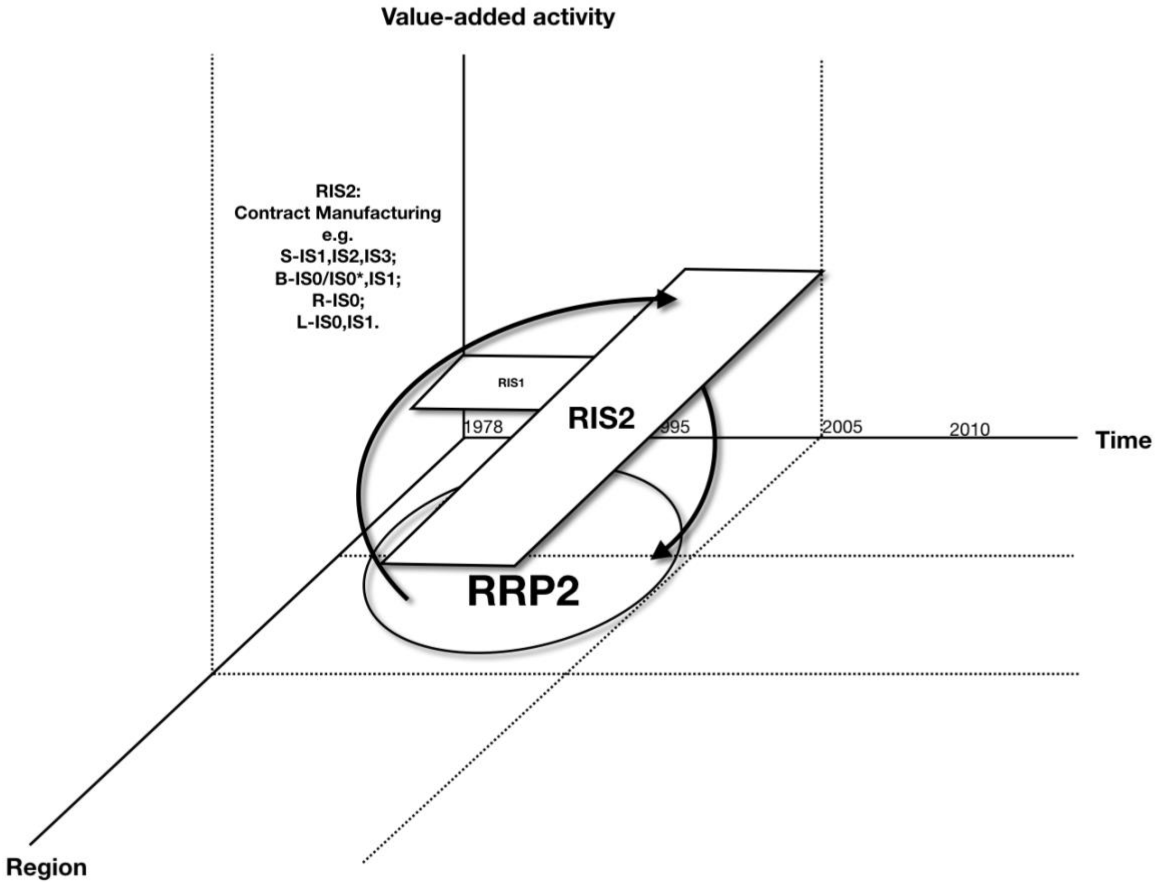
Figure 6-4 The evolution of a regional resource pool in three stages

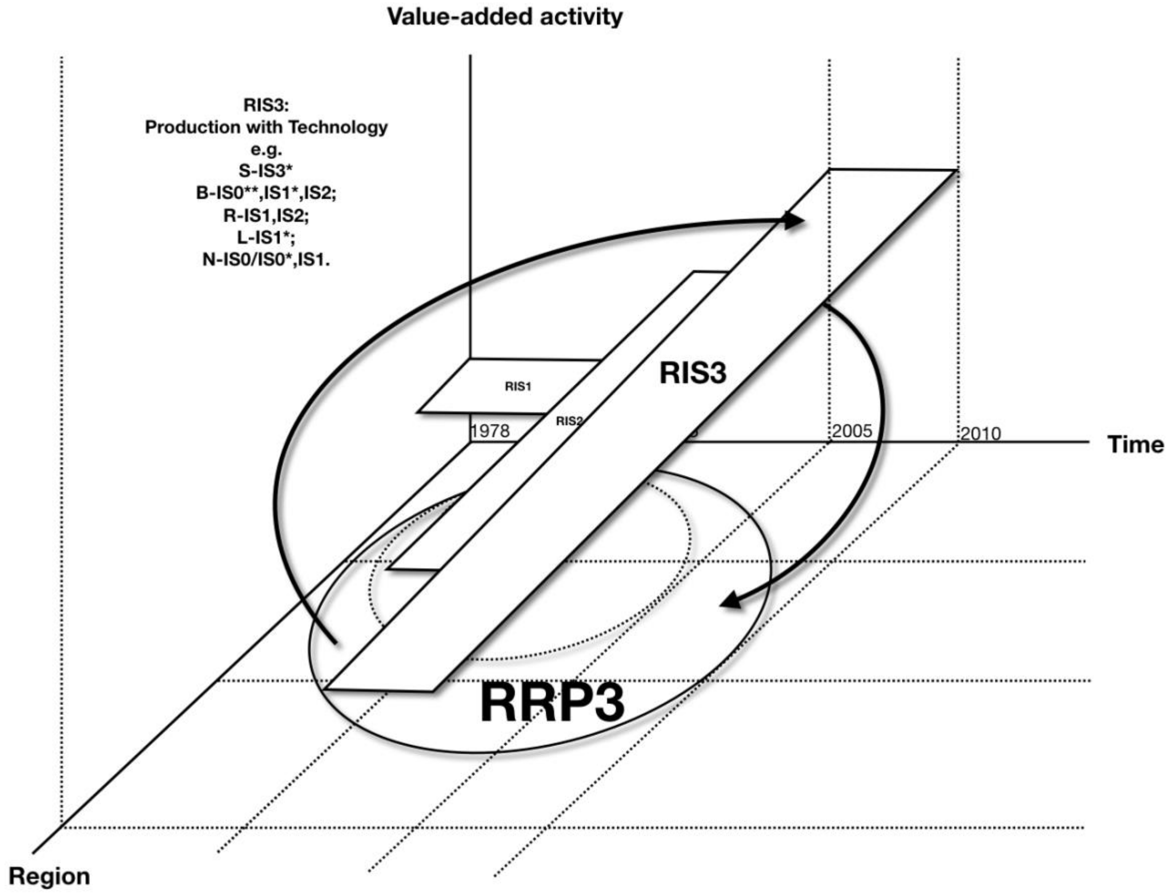
6.2 Towards an Understanding of Regional Industrial Upgrading

Traditionally, industrial upgrading carried out by firms is analysed by applying the GVC framework with seven types of pathways or strategies (Gereffi & Fernandez-Stark, 2016). However, the upgrading of a region-specific industry is a continuous process that involves efforts from generations of firms, and such processes cannot be simplified as combinations of different upgrading strategies. They should be analysed in a longitudinal way with dynamic iterations identified from practices of firms within the industry. Moreover, the region from which enterprises and the government extract and exploit resources for the industrial upgrading process should be viewed as an evolving pool of resources (see Section 6.1) rather than a static context.

From detailed studies of six Shenzhen-based electronics companies, upgrading processes undertaken by them across certain time periods in Shenzhen were mapped out. Since these six companies cover different segments of the electronics value chain, ranging from R&D to manufacturing, distribution and other services (detailed in Section 5.3), they are selected to resemble the electronics industry of Shenzhen (see selection criteria in Chapter 4). For each case, upgrading is not only the continuous improvement of an established sub-sector of the company from low to high value-added activities but also involves the emergence of a new sub-sector at some points. Furthermore, industrial upgrading has not been fully interpreted at regional level by any extant theoretical framework. By adding the regional dimension in terms of regional resource pool evolution, this research visualises the upgrading processes obtained from each case companies in a three-dimensional process model for the upgrading of the electronics industry in Shenzhen (see Figure 6-5).




Value-added activity
RIS2:
Contract Manufacturing
e.g.
S-IS1,IS2,IS3;
B-IS0/IS0*,IS1;
R-IS0;
L-IS0,IS1.
RIS1
1978
RIS2
995
2005
2010
Time
RRP2
Region


Value-added activity
RIS3:
Production with Technology
e.g.
S-IS3*
B-IS0**,IS1*,IS2;
R-IS1,IS2;
L-IS1*;
N-IS0/IS0*,IS1.
RIS1
RIS2
RIS3
1978
2005
2010
Time
RRP3
Region

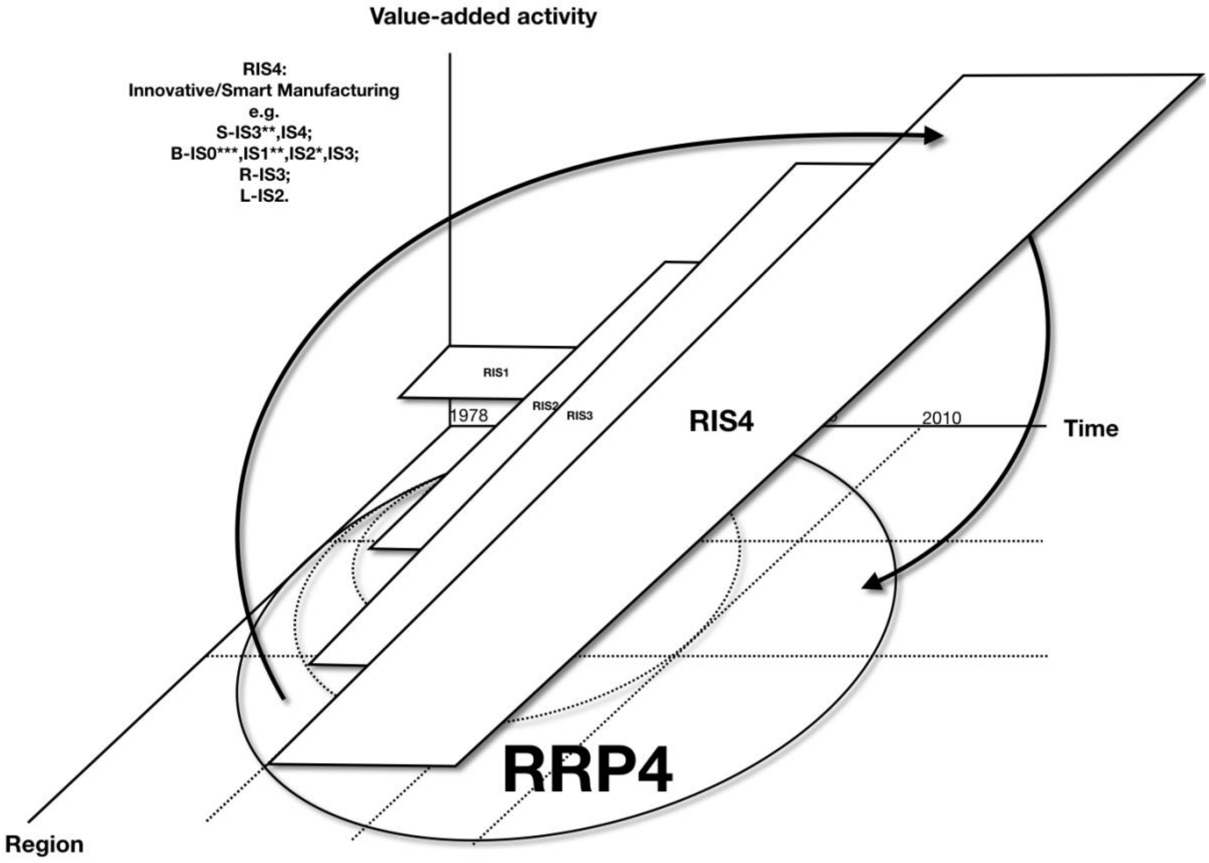


Figure 6-5 Upgrading of the Electronics Industry in Shenzhen

As shown in Figure 6-5, the empirical evidence suggests that the RIS (Regional Industrial Systems) of Shenzhen's electronics industry has mainly gone through four stages.

Firstly, the CMSK kicked off the modernisation process of Shenzhen via the construction of the Shekou Industrial Zone by not only introducing advanced production technologies and management know-how but also laying the foundation of modern institutions and infrastructure. From the late 1970s to the mid-1990s, electronics firms mushroomed in Shenzhen and most of them engaged in labour-intensive processing (RIS1) mainly due to the "3+1" trading mix strategy and foreign enterprises introduced by the local government. Although the Shekou Industrial Zone was revoked in the early 1990s and the "3+1" trading mix was gradually driven out of Shenzhen some years later, they left the city substantial resources for further industrial development. In the late 1980s, more than 100 electronics firms applying the "3+1" strategy for processing household appliances were brought together by SEG and formed the first electronics corporation in Shenzhen (S-IS0). However, from the early 1990s SEG reconfigured its industrial systems and started businesses in the components trading market, joint venture CRT and semiconductor manufacturing rather than continuing producing electronics goods in the "3+1" style.

Secondly, from mid-1990s to mid-2000s, the industrial systems of Shenzhen's electronics industry became more complicated (RIS2), involving both labour-intensive and capital-intensive segments. More generally, the industrial systems from 1995 to 2005 are for contract manufacturing and the technology foundation has been laid during this period. In 1995, because of the local government's call for hi-tech talents and start-ups, many professionals and experienced technicians settled in Shenzhen and started their own businesses. Mr. Chuanfu Wang and Mr. Jingwei Kang, who established BYD and Comtech, are two representatives among the flow of talents to Shenzhen. Although BYD and Comtech specialised in electronics manufacturing and components trading respectively, both have upgraded themselves several times towards higher value-added manufacturing and trading activities in Shenzhen since their establishment.

The first China Hi-Tech Fair (CHTF) in Shenzhen launched four years later is now seen as the turning point in Shenzhen's industrial development, especially for the electronics and ICT industries. Netac was one of the companies that boosted themselves through the first CHTF. The portable storage devices with USB flash memory technology developed by Netac and exhibited at the CHTF has been applied in many other consumer electronics products by local manufacturers in following years, for instance the fashionable and stylish music players used throughout the 2000s. Tencent, with its messenger OICQ, successfully obtained funds for survival from venture capitalist due to its presentation in the CHTF and was able to grow to become a local giant in Internet-related businesses. In addition to the CHTF, starting in 1999 the local government also promoted hi-tech development by setting up industrial zones and offering preferential policies such as subsidies, lower tax rates and rents for hi-tech start-ups. The founder of Lachesis was attracted to set up his first company for consumer electronics in the Nanshan Hi-tech Industrial Zone while the founder of Rapoo, which had mastered wireless technology in computer peripherals, decided to conduct mass production of wireless mice in local factories in the early 2000s. These two companies went through completely different upgrading patterns in later years but one thing they have in common is that they have upgraded to sectors requiring heavy investments in R&D.

Thirdly, from 2005 onwards, the local government has pushed forward the hi-tech-oriented industrial development and industrial systems were driven to upgrade towards higher value-added production with new technologies (RIS3). Although Shenzhen has grown very rapidly economically since the late 1970s, it did not equip itself with a well-established academic institution during the first twenty years of its development. Shenzhen University was the only higher education institution in the city until the early 2000s, and it was not so competitive in terms of academic and research achievements as a number of universities in neighbouring cities Hong Kong and Guangzhou. Thus, the local government actively approached first-tier academic institutions for cooperation in terms of establishing localised branches. The Chinese Academy of Sciences was among the first batch of institutions that decided to set up a subsidiary in Shenzhen, attracted by the mature industrial base of Shenzhen. It then jointly set up the Shenzhen SIAT with the local government and the Chinese University of Hong Kong (CUHK) in 2006. From then on, the SIAT trained postgraduate students in hi-tech domains and conducted scientific research in Shenzhen according to the needs of local companies. The SIAT directly engaged in helping local companies to pursue technological upgrading or indirectly inspired local enterprises such as Mr. Zhu, the founder of Lachesis, to switch his business from traditional consumer electronics manufacturing to the design and production of smart medical devices.

Last but not least, in the 2010s more and more local electronics firms have applied indigenous innovation in their industrial systems and engaged in smart manufacturing that involves high level of automation (RIS4) for more innovative products. BYD, Lachesis and Rapoo are good examples of smart manufacturing that utilises Internet-connected machinery in their production processes. All six companies investigated have witnessed the rise and fall of the “Shanzhai” phenomenon from the early 2000s to the early 2010s, and to a large extent none of them can deny that they have benefited from “Shanzhai” manufacturing. The components trading market owned by SEG has been directly involved in the “Shanzhai” phenomenon and achieved high returns from vendors selling various types of electronics components in Huaqiangbei. The other five companies have more or less learned from the flexibility in “Shanzhai” manufacturing systems and utilised the highly specialised supply chains of electronics components and design houses, themselves legacies of the “Shanzhai” phenomenon. More importantly, “Shanzhai” greatly facilitated indigenous innovation since grassroot innovators or “makers” were able to source components they need for prototype development. With a growing number of makers choosing to settle in Shenzhen, makerspaces were established by firms or the local government to accommodate them while the annual Maker Faire was launched in 2012 to attract makers from all over the world to Shenzhen for idea exchanges or potential collaborations with local grassroot innovators and component manufacturers.

In a nutshell, the upgrading of the electronics industry in Shenzhen that proceeds from labour-intensive processing to capital-intensive contract manufacturing, then to more technology-intensive production and innovation-driven smart manufacturing. Such finding resonates Shenzhen’s three-phase industrial development identified in the Practical Review (Chapter 2) and provides more details about the transitions. For each transition during the industrial upgrading journey, there co-exist two types of changes, namely the transformation of established industrial systems and the emergence of new industrial systems. Although upgrading strategies applied by case firms on their industrial systems at different stages can be identified according to the GVC or GPN framework review in Chapter 3, the general term of industrial upgrading at regional level should be more clearly defined. Moreover, the upgrading of one region-specific industry achieved by a succession of processes practiced by firms is inseparable from the region’s resource pool evolution (from RRP1 to RRP4). Besides the milestone events that lay the foundation for different types of regional resources, local companies continuously embed their industrial systems into the resource pool to enrich the regional resources. Hence, there also co-exist existing resources strengthening and new resources creation throughout the resource pool evolution. To fully understand regional industrial upgrading, it is necessary to combine the evolution of local resources with upgrading processes of firms within the industry. As shown in Figure 6-6, the regional industrial upgrading is actually an iterative co-evolutionary process between the regional industrial system (RIS) and the regional resource pool (RRP).

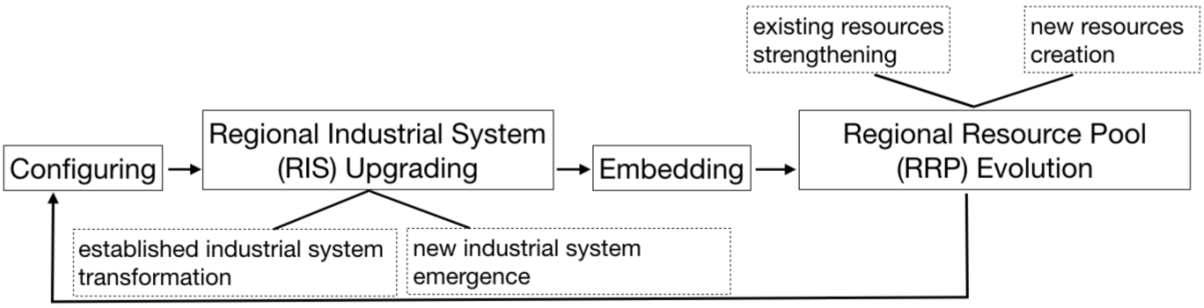


Figure 6-6 Regional Industrial Upgrading: An Iterative Process

Therefore, regional industrial upgrading can be understood as *a process by which a region-specific industry moves towards higher value-added offerings (products or services) through established industrial systems transformation and/or new industrial systems emergence based on regional resources*. The configuring and embedding mechanisms for their co-evolution will be presented in the following section.

6.3 Towards an Understanding of a Region-based Business Ecosystem (RBE): the Co-evolution between a Region-specific Industry and the Regional Resource Pool

With findings of regional resource pool evolution and industrial upgrading (6.1 and 6.2) obtained from the empirical work, the initial conceptual framework (as shown in Figure 3-23) has been enriched and extended to a more comprehensive framework of a region-based business ecosystem (see Figure 6-7).

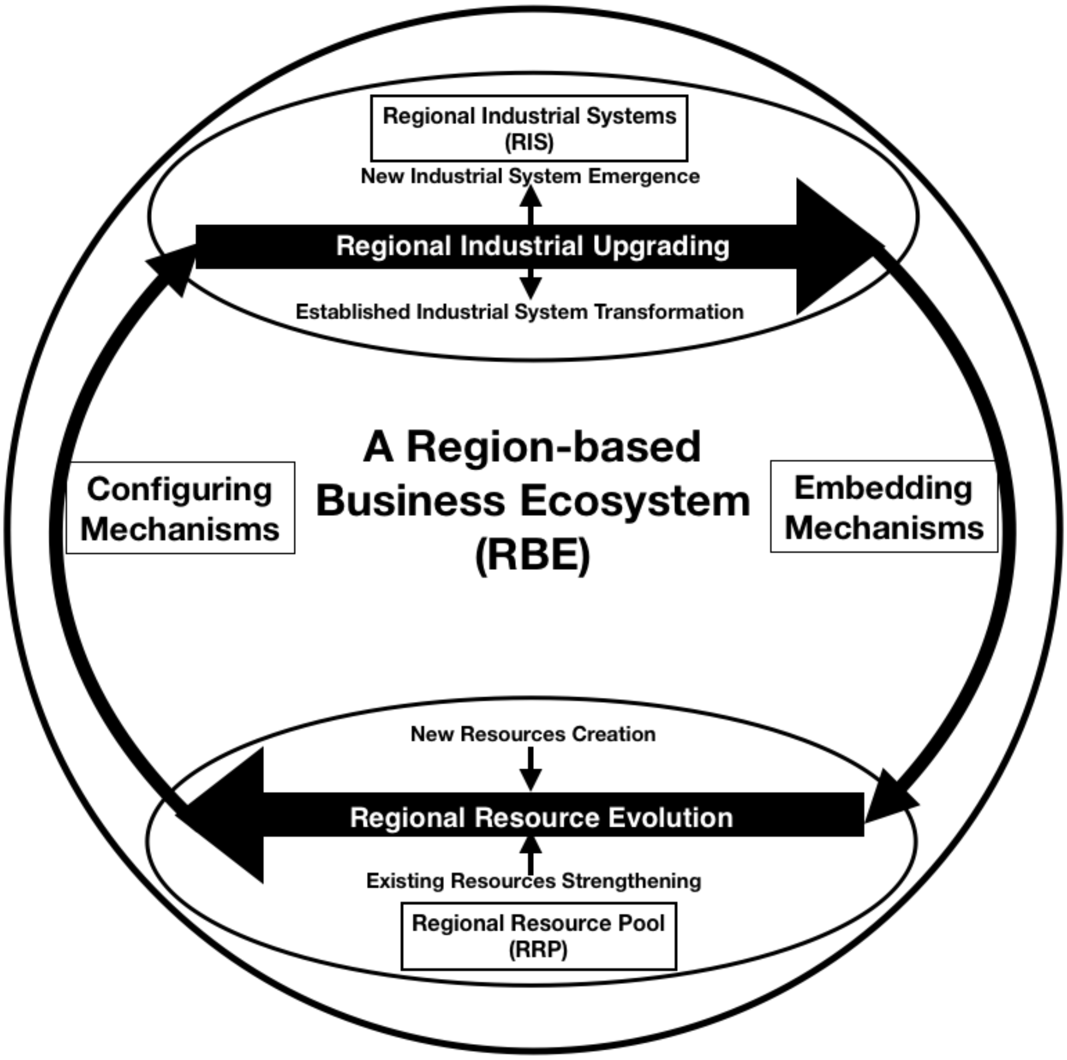


Figure 6-7 The Conceptual Framework of a Region-based Business Ecosystem (RBE)

From the cross-case analysis of company cases (section 5. 4), the co-evolution mechanisms can be summarised as two main types: configuring mechanisms and embedding mechanisms (see Figure 5-34). On the one hand, configuring mechanisms (see Table 6-1) summarise methods through which regional resources can be configured or reconfigured into a new industrial system or used to improve the performance of an existing industrial system. Firstly, to create new resources for the emergence a new sector, the government should act as the facilitator for the commercialisation of local innovations while enterprises should search for nascent resources in the region and incorporate those with development potential into their production. Secondly, new resources in the region can be used for the transformation of an established sector if enterprises start new businesses in an established sector by applying these nascent resources. Thirdly, for existing resources to be useful in developing a new sector, enterprises should invest in improving the quality of their own resources and/or actively seek collaborators with technologies in the region. Fourthly, to enhance the transformation of an established sector, enterprises can also figure out existing but not fully exploited resources in the region and apply them in their production.

Table 6-1 Configuring Mechanisms

Configuring Mechanisms	Resource Creation	Resource Strengthening
New Industrial System Emergence	• The government provides (institutional/financial/ technological) support for the implementation or commercialisation of indigenous innovations • Enterprises incorporate nascent resources in the region into their production	• Enterprises invest in improving own resources and/or actively approach established technology owners for collaboration
Established Industrial System Transformation	• Enterprises start own businesses in an established sector by applying nascent resources in the region	• Enterprises incorporate already established but idle or underexplored resources in the region into their production

On the other hand, embedding mechanisms (see Table 6-2) outline techniques to show how industrial systems can embed themselves into the resources pool and then affect resources in the region. Firstly, once a new sector emerges, enterprises can follow the market trend and expand their businesses into this new sector in order to create new resources. Secondly, during the transformation of an established sector, new resources may emerge if enterprises and the government obey the market principle when faced with rising competitions and risks. Thirdly, enterprises within a new sector can practice their application of established resources and make them flexible to leverage. Fourthly, existing resources can be strengthened if enterprises within an established sector expand their influence over these resources during the transformation of the sector.

Table 6-2 Embedding mechanisms

Embedding Mechansims	New Industrial System Emergence	Established Industrial System Transformation
Resource Creation	• Enterprises expanded their businesses according to market trends	• Enterprises and the government follow the market principles for competition and risk
Resource Strengthening	• Enterprises cultivate the flexibility for their application of local established resources	• Enterprises expand its influence over local established resources

A Region-based Business Ecosystem is illustrated as a three-dimensional model in Figure 6-8, with four main constructs, namely, the regional industrial systems, regional resources pool, and configuring and embedding mechanisms. The co-evolution between the regional resource pool and industrial systems through configuring and embedding mechanisms results in new industrial system emergence and established industrial system transformation. Referring to Figure 6-6, regional industrial upgrading is actually an iterative process and we are able to observe the phenomenon of regional industrial systems upgrading and resource pool evolution in the following logic. Once a new idea or technological innovation emerges in the region, fragmented resources in the regional resource pool at time n (RRP_n) are organised by local enterprises or the government and transformed into a new industrial system and/or strengthened the established industrial system through the configuring mechanism (1). Then the original regional industrial system (RIS_n) is upgraded to RIS_{n+1} with new industrial system(s) added in or existing industrial system(s) consolidated (2). During the upgrading process from RIS_n to RIS_{n+1}, industrial systems gradually exert impacts on the regional resource pool through the embedding mechanism (3), thereby inducing some new resources and/or strengthening some existing resources in the region. This leads to the evolution of the regional resource pool from RRP_n to RRP_{n+1} (4). Afterwards, a new round of iteration will take place from RRP_{n+1}.

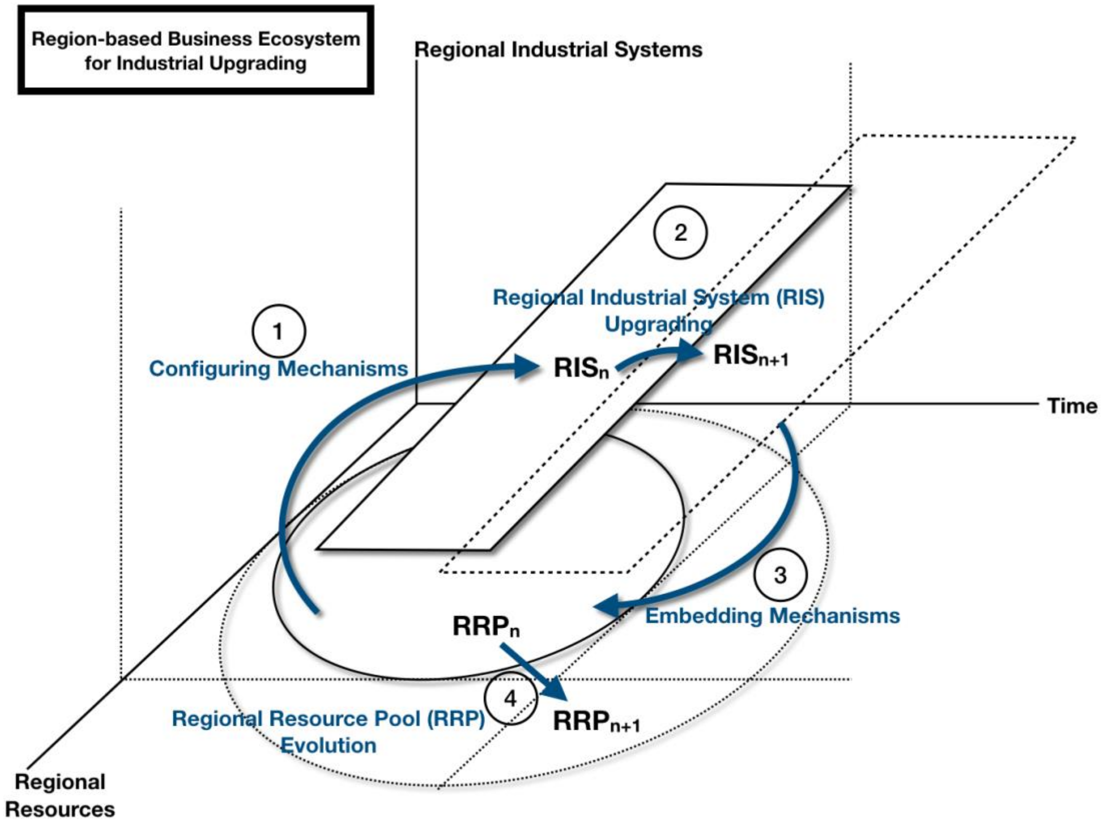


Figure 6-8 The Conceptual Model of a Region-based Business Ecosystem (RBE)

Such underlying mechanisms of the co-evolution between regional industrial systems and resources are the main functions of the region-based business ecosystem. Therefore, a Region-based Business Ecosystem can be understood as *a regional community with industrial systems and the resource pool that are co-evolving with each other for regional industrial upgrading.*

6.4 Nurture a Region-based Business Ecosystem for Regional Industrial Upgrading

For a developing region to nurture such a business ecosystem to enhance the upgrading of a region-specific industry, local enterprises and the government should primarily focus on the local resource pool. Based on existing resources, what kinds of new resources can they create and what kinds of resources can they strengthen should they be considered for the top spot according to the urban and industrial development plan of the region and business plans of companies. With the enrichment of the regional resource pool, companies or the government can then differentiate and screen out resources that could be useful for the industrialisation or commercialisation of a new technology or indigenous innovation emerges in the region. By applying the configuring mechanisms, companies and/or the government can integrate these resources around the new technology or innovation into a new or established industrial system in the region. As these industrial systems develop, they can interact with and have an impact on other local resources via the embedding mechanisms. Then the local resource pool will be further enriched, with resources emerged or strengthened due to either resource evolution or feedback impacts from the development of industrial systems. Enterprises and the government can start a new round of screening for resources that can be configured or reconfigured into an industrial system that is in pace with the market and technology trend.

When such iterations between the regional resource pool and industrial systems are established and keep moving in cycles within a region, a Region-based Business Ecosystem is said to have been nurtured and the corresponding region-specific industry constituted by these industrial systems is able to upgrade correspondingly and continuously. Both enterprises and the government play an essential role in triggering changes in the regional resource pool, leveraging and integrating resources for the industrial system and maintaining the operation of configuring and embedding mechanisms.

Chapter 7 Discussions and Conclusions

This chapter presents how the research questions have been addressed and how the research findings contribute to theory and practice. The dissertation concludes by sketching its limitations and pointing to potential avenues for future research.

7.1 Summary of Research Findings

The main findings of this research are summarised as a conceptual framework and a three-dimensional dynamic model (as shown in Figure 7-1) in addressing the research gaps identified. These findings can be combined as a total approach to regional industrial upgrading.

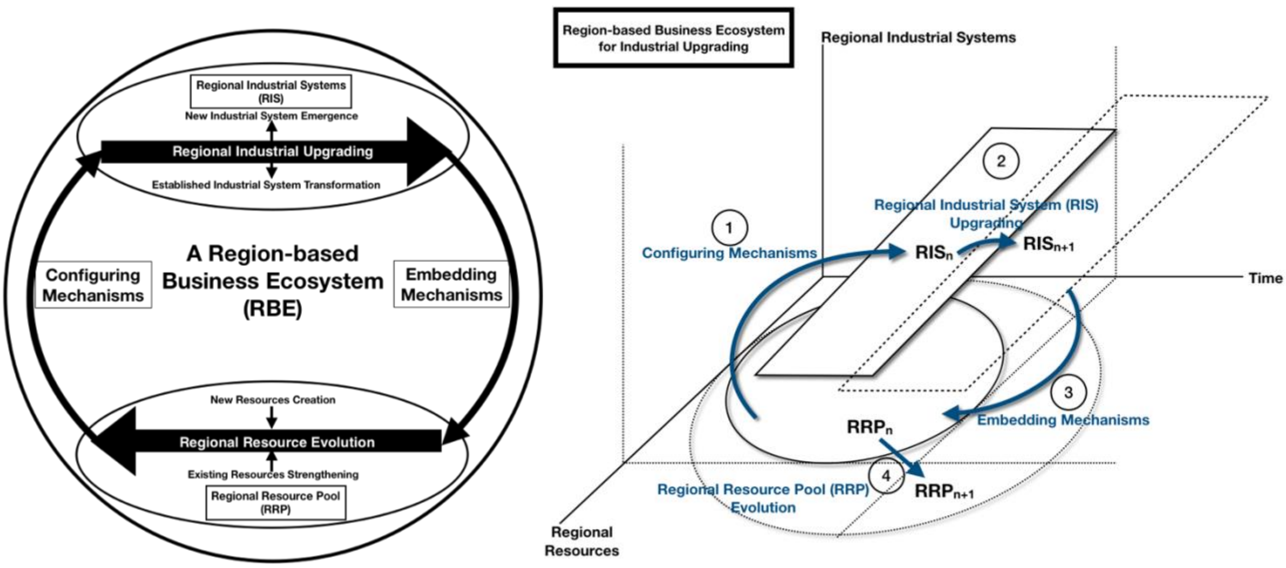


Figure 7-1 The Conceptual Framework and Dynamic Model of the Region-based Business Ecosystem

Firstly, to understand the pattern of regional resource pool evolution, milestone events that laid the foundation for the transformation of Shenzhen in the past 40 years have been analysed and a generic three-stage pattern has been synthesised. From combinations of governmental, industrial and financial resources towards interactions among financial, industrial, governmental, research, intermediary and educational resources, Shenzhen has transformed itself from an underdeveloped region relying on low value-added manufacturing activities to a technological hub known as "China's Silicon Valley".

Secondly, to understand regional industrial upgrading as a process, upgrading patterns of industrial systems from case companies are combined with the three-stage resource pool evolution and a generic four-phase process has been developed. Based on resources created and strengthened from the regional resource pool evolution, regional industrial upgrading can be understood as *a process by which a region-specific industry moves towards higher value-added offerings (products or services) through established industrial systems transformation and/or new industrial systems emergence based on regional resources*.

Thirdly, to understand the underlying mechanisms for regional industrial upgrading, the co-evolution processes between regional industrial systems and resource pool have been investigated under a region-based business ecosystem framework, and two types of mechanisms (configuring and embedding) have been identified. Such co-evolutionary mechanisms, along with the regional industrial systems and resource pool, can jointly define the region-based business ecosystem as *a regional community with industrial systems and the resource pool that are co-evolving with each other for regional industrial upgrading.* A three-dimensional Region-based Business Ecosystem model is developed for the analysis of how fragmented resources in the region can be integrated and configured into an industrial system and how the industrial system, transformed or nurtured, can embed itself back in the regional resource pool and become a new or strengthened form of resource.

Finally, to nurture a region-based business ecosystem, configuring and embedding mechanisms should be established to link the regional resource pool and industrial systems and enable them to co-evolve with each other and enhance regional industrial upgrading. Based on the empirical evidence, these configuring and embedding mechanisms of co-evolution are mainly driven by local enterprises and the government.

7.2 Theoretical Contributions

This research mainly contributes to two emerging theoretical domains: industrial upgrading and business ecosystem. By shedding light on the understanding of a region-based business ecosystem with a holistic and dynamic model and the reciprocity between industrial systems in a region and regional resources, the empirical work has addressed theoretical gaps identified from the literature review and structured around the initial conceptual framework in Figure 3-23.

Firstly, it provides an analytical framework to understand regional industrial upgrading per se as an iterative process between regional industrial systems and resource pool, which also addresses the gap in the evolution of regional resources. Besides resources created and strengthened from milestone events in the region, the regional resource pool is reinforced over time as the interactions between industrial systems and resources recur and accumulate. This regionalised process is especially important for developing regions in shifting from low to high value-added manufacturing activities. However, previous literature suffers from showing the overwhelming importance of the international context (Yoruk, 2014) and lacking explanation regarding industrial upgrading as a multi-level process (Radosevic & Yoruk, 2016).

Industrial upgrading is a phenomenon that takes place in both developed and developing countries or regions and has been analysed from the global and local perspectives. For developed countries or regions to pursue industrial upgrading, most of them have transferred their low value-added manufacturing activities or industries to developing countries or regions according to the Global Value Chain (GVC) (Ernst, 2000, 2001, 2002b; Gereffi, Humphrey, Kaplinsky, & Sturgeon, 2001) or Global Production Network (GPN) (Coe et al., 2008; Hess &

Coe, 2006). Then they have devoted local resources into innovations and the cultivation of hi-tech industries, with national or regional innovation systems being established (Doloreux & Parto, 2005; Ernst, 2002a; Lundvall, 2007). For developing countries or regions to build up their industrial systems by undertaking industrial transfers from the developed world, they will reach the limit when they grow to a point similar to developed countries or regions and faced the same challenges of further industrial upgrading. It might not be easy for them to make industrial transfers and building innovation systems as extant literature suggests because of the differences in local resources between the developed and developing countries or regions. There are also certain types of resources that cannot be easily transplanted. For instance, in the developing world, the quality of research and education resources cannot be significantly improved in the short run.

Shenzhen provides a good example in challenging the path dependency of industrial upgrading from the lens of the developed world. It has gone through a process of being an underdeveloped region with poor local resources to a hi-tech modern city with a well-established regional innovation system in a matter of a mere four decades. The resource pool evolution of Shenzhen in three phases is the basis for the upgrading of local industries, especially the electronics industry, which has been the economic engine for the city's development since its establishment in the late 1970s. Although the typology of firm-level upgrading strategies (Humphrey & Schmitz, 2000) and industry-level upgrading trajectories (Ernst, 2008) can be applied to understand how local firms and industries to upgrade their industrial systems at a certain period of time, the process of regional-level industrial upgrading over time and its relations with the regional resource pool have not been revealed. The region-based business ecosystem model developed in this research (Figure 7-1) can therefore effectively address the regional-level upgrading issue by offering a dynamic view of how regional industrial systems and resources are iteratively strengthened over time through reciprocal interactions. This dynamic view partly resonates with prior work on local upgrading in globalising latecomer regions (Liu, 2017; Yeung & Coe, 2015), but differs from them by emphasising the region's evolving endogenous forces for industrial upgrading.

Secondly, this research expands the boundary of a business ecosystem to a regional level and reveals how a region evolves over time through the co-evolution between industrial systems and resources in a region. Besides the two main components delineated by the region-based business ecosystem model, namely the regional industrial systems and resource pool, the co-evolutionary mechanisms for their reciprocal interactions are addressed.

Previous research on ecosystems mainly focuses on the static structures of value co-creation arrangements established around a firm (Li, 2009; Moore, 2006) or for an industry (Iansiti & Levien, 2004a; Kim, Lee, & Han, 2010) and how firms can adjust their strategies in corresponding ecosystems (Adner, 2012, 2017; Iansiti & Levien, 2004a, 2004b). As a metaphor drawn from complexity theory and evolutionary ecology for the complex and operational dynamics of highly interconnected networks of organisations (Iansiti & Levien, 2002), business ecosystem can be applied to mimic a region for the understanding of interplays between industrial systems and resources throughout the regional development. The region-based business ecosystem model connects the upgrading process of regional industrial systems and regional resource evolution process with configuring and embedding mechanisms, forming an iterative loop that drives the region to grow based on a region-specific industry. This also offers an alternative explanation for endogenous long-term regional growth, which complements the theory of regional growth systems that focus on the interaction between available capital assets and institutional infrastructure (Huggins & Thompson, 2017). In recent years, witnessing the rise of some regions in developing countries onto the world stage, for instance Shenzhen and its electronics industry that now has a global impact, the region-based business ecosystem offers new insights for continuous urban and industrial development.

7.3 Practical Contributions

For practitioners, this research provides a mapping and analytical tool for regional industrial upgrading. According to the region-based business ecosystem (RBE) framework and model (see Figure 7-1), Figure 7-2 and 7-3 illustrate the operation of such an ecosystem without and with resources from outside the region.

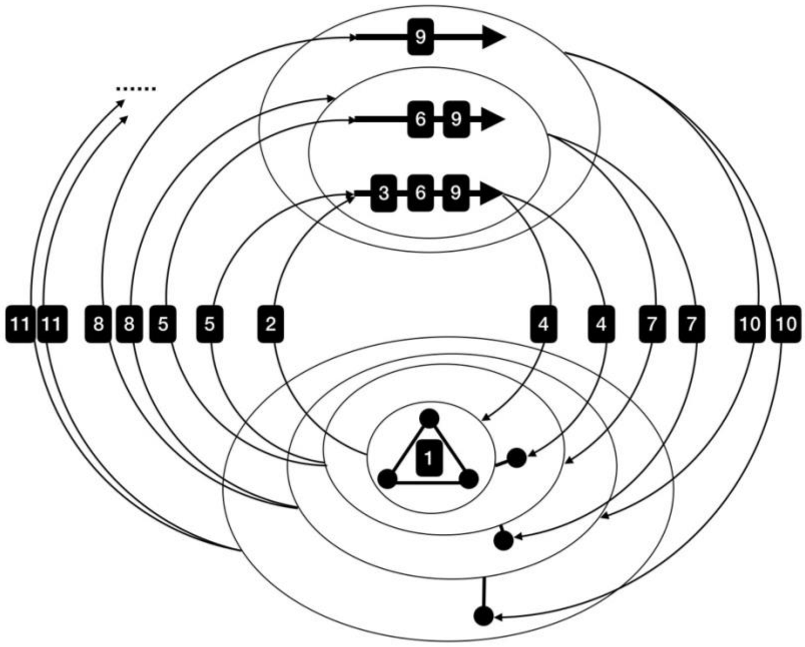


Figure 7-2 The Ideal Operation of a RBE (with Endogenous Resources only)

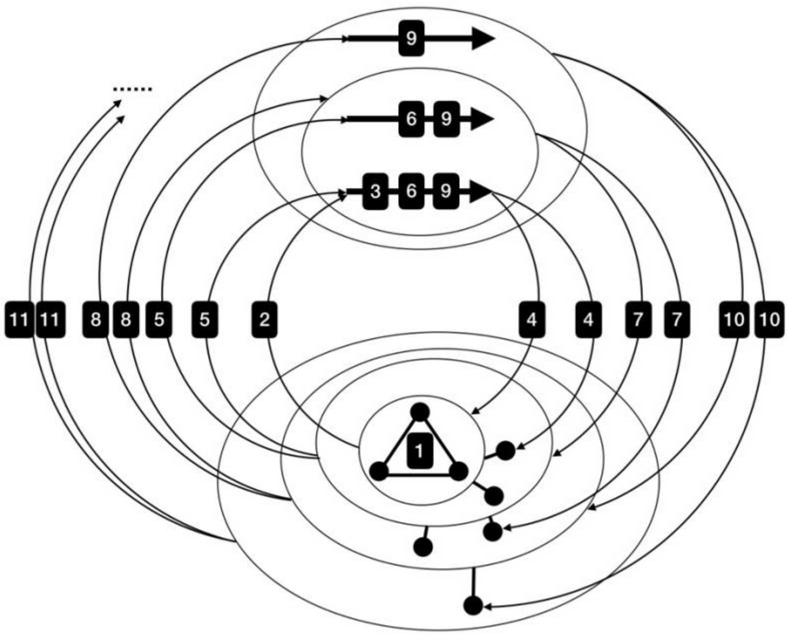


Figure 7-3 The Ideal Operation of a RBE (with both Endogenous and Exogenous Resources)

For an underdeveloped region that has no established industrial systems, the first thing to do is organise the resources it already has (1) and then configure them into an industrial system (2) for production and business value creation. For most developing regions, this task is done by the local government. As the industrial system develops (3), it will embed itself back in the resource pool to strengthen existing resources or induce a new type of resources to emerge in the region (4). Then the resources within the upgraded resource pool can be reorganised and reconfigured into a new industrial system or have an impact on the established one (5). Then, with the gradual development of both industrial systems in the region (6), ideally the established industrial system will be upgraded (but in practice it could collapse) and the emergence of the new industrial system will create new business value for the region. Then these industrial systems will embed themselves into the resource pool to strengthen existing resources or create new resources in the region (7). Afterwards, reconfiguration (8) (10) and re-embedding (9) (11) will successively take place between the regional industry that consists of different industrial systems and the regional resource pool with its wide range of resources. Whether there is a new resource coming from outside the region or not, the region-based business ecosystem will function with the same iterative logic. The region will be able to grow economically with more value created from the upgrading of this region-specific industry, which is actually driven by the co-evolution between the regional resources and industrial systems that constitute the industry.

Based on the ideal operation of such a region-based business ecosystem, a practical mapping tool can be developed for firms or regional governments to use in decision making for industrial development and governance. For firms in a region that wishes to improve its industrial systems, this mapping tool can help them identify where they are, what kind of resources they can access for the cultivation of a new industrial system or the consolidation of established one(s). For a regional government that aims to upgrade a local industry, this mapping tool can assist it in identifying what kind of industrial systems already exist in the region and regional resources it can organise and configure to strengthen an established industrial system or nurture a new industrial system. If the firm or government is planning to create a completely new industry in the region, a detailed assessment of the resources necessary for the new industry and the embedded industrial system(s) needs to be conducted before using this mapping tool. This sometimes also applies to the creation of new industrial system(s) in an existing industry.

Moreover, to pursue the upgrading of a region-specific industry under the context of highly fragmented and specialised manufacturing activities, firms and local government should collaborate following an ecosystem logic to enhance resource strengthening and creation, which may result in established industry transformation and/or new industry emergence and in turn feed back onto the local resource pool.

It is important to note that since the RBE framework and model are derived from the case of Shenzhen and its electronics industry only, they are not yet generalisable to prescribe solutions for companies and governments under completely different institutional context. However, the mapping and analytical tool can be applied by enterprises or government officials in other fast developing regions in China, for instance in Hangzhou of Zhejiang Province. The iterative and dynamic logic of the RBE can help companies to better understand the relationship between their industrial systems and resources they can leverage in the region, thereby supporting them in making management decisions. For regional governments, the RBE framework can help them to design appropriate governance styles for different industries in the region.

7.4 Limitations and Future Research

Industrial upgrading and business ecosystem are two emerging theoretical domains explored by this research and according to their multi-disciplinary nature, there are many rich potential avenues for future research. This research has revealed the scarcity in viewing industrial upgrading as a discipline and endeavoured to set up a research framework for industrial upgrading by applying business ecosystem logic under the regional context. Although the research findings have a number of theoretical and practical implications in these two areas, there are nonetheless limitations that could be addressed in future studies.

Firstly, the findings of this research are mainly drawn from an analysis of the electronics industry in Shenzhen, which is unique and thus may not be so easily generalisable to other regions. Shenzhen is a special region in China, and as the latest UN-Habitat report (UN-Habitat, 2019) mentioned, it has experienced rapid economic, social and environmental transformation in the past 40 years and is now characterised as an innovative, inclusive, young and hi-tech city. The electronics industry is one long-lasting economic pillar for the development of Shenzhen and therefore contains rich case materials for research in industrial upgrading and regional development. To test and extend the generalisability of the research findings, further studies should be conducted in other regions with a similar economic and institutional context to Shenzhen. Other regions in the Chinese mainland, for example Hangzhou where a strong ICT industry has emerged and rapidly developed in the past two decades, would be a good starting point for testing the region-based business ecosystem mechanisms. Then other regions in developing countries with fast rising industries, such as those cities in South-East Asia (especially Vietnam) which to a great extent resemble China's industrial development path, can also be investigated to enhance the generalisability of region-based business ecosystem.

Secondly, the region-based business ecosystem explored in this research mainly focuses on how to facilitate the upgrading of a region-specific industry. However, in practice the function of a region-based business ecosystem is not restricted to enhance an already established industry in the region. All business activities in a region with value creation could be analysed by applying the region-based business ecosystem framework with new mechanisms developed and explored.

Thirdly, region-based business ecosystems are not immutable since they may expand, shrink or even transplant according to geographical or institutional changes. The most recent development of cross-region co-operation in China, known as the Great Bay Area (GBA) project linking the PRD with Hong Kong and Macao Special Administrative Regions (SARs), also offers opportunities for industrial upgrading across regions and has immense potential for comparison between and integration of different region-based business ecosystems.

Finally, the operation of a region-based business ecosystem may not be as ideal as expected in practice. The iterative loop might be broken according to unexpected changes from institutional, political and/or technological perspectives. After the breaking down of established iterations, the methods or strategies required to reorganise and incorporate regional industrial systems and resources into a new iterative loop could be a promising new research area.

References

Adner, R. (2006). Match Your Innovation Strategy to Your Innovation Ecosystem. *Harvard Business Review*.

Adner, R. (2012). *The Wide Lens: A New Strategy for Innovation*. *Penguin UK*.

Adner, R. (2017). Ecosystem as Structure: An Actionable Construct for Strategy. *Journal of Management*, *43*(1), 39–58.

Adner, R., & Kapoor, R. (2010). Value creation in innovation ecosystems: how the structure of technological interdependence affects firm performance in new technology generations. *Strategic Management Journal*, *31*, 306–333.

Akamatsu, K. (1962). A Historical Pattern of Economic Growth in Developing Countries. *The Developing Economies*, *1*, 3–25.

Autio, E. (1998). Evaluation of RTD in regional systems of innovation. *European Planning Studies*, *6*(2), 131–140.

Autio, E., & Thomas, Llewellyn, D. W. (2014). Innovation ecosystems: Implications for innovation management. *The Oxford Handbook of Innovation Management*, (January), 204–228.

Bair, J. (2005). Global Capitalism and Commodity Chains: Looking Back, Going Forward. *Competition & Change*, *9*(2), 153–180.

Bair, J., & Gereffi, G. (2001). Local clusters in global chains: The causes and consequences of export dynamism in Torreon's Blue Jeans industry. *World Development*, *29*(11), 1885–1903.

Bair, J., & Gereffi, G. (2003). Upgrading, uneven development, and jobs in the north american apparel industry. *Global Networks*, *2*, 143–169.

Bamber, P., Fernandez-Stark, K., Gereffi, G., & Guinn, A. (2014). Connecting Local

Producers in Developing Countries to Regional and Global Value Chains. *Organisation for Economic Co-Opetration an Development*, (August 2015), 1–51.

Barney, J. (1991). Firm Resources and Sustained Competitive Advantage. *Journal of Management*, *17*(1), 99–120.

Bathelt, H., & Glückler, J. (2003). Toward a relational economic geography. *Journal of Economic Geography*, *3*(2), 117–144.

Bathelt, H., & Glückler, J. (2005). Resources in economic geography: From substantive concepts towards a relational perspective. *Environment and Planning A*, *37*(9), 1545–1563.

Becattini, G. (1990). *The Marshallian industrial distirct as a socioeconomic notion*. *Industrial Districts: A New Approach to Industrial Change*. Retrieved from http://books.google.com/books?id=xGlAbFVnHK4C&pgis=1

Belussi, F., & Caldari, K. (2009). At the origin of the industrial district : Alfred Marshall and the Cambridge school, (November), 335–355.

Benjamin, S., Kaplan, D., & Schroeder, D. (2013). National, Regional, and Sectoral Systems of Innovation – An overview.

Best, M. H., & Garnsey, E. (1999). Edith penrose, 1914-1996, *109*, 187–201.

Breslin, D. (2011). Reviewing a Generalized Darwinist Approach to Studying Socio-Economic Change. *International Journal of Management Reviews*, *13*.

Bryman, A. (2015). *Social research methods*. Oxford university press.

Chan, S. (1993). *East Asian dynamism: Growth, order, and security in the Pacific Region*. Westview Press.

Chen, L., & Xue, L. (2010). Global Production Network and the Upgrading of China's Integrated Circuit Industry. *China and World Economy*, *18*(6), 109–126.

Coe, N. M., Dicken, P., & Hess, M. (2008). Introduction: Global production networks - Debates and challenges. *Journal of Economic Geography*, *8*(3), 267–269.

Coe, N. M., Hess, M., Yeung, H. W., Dicken, P., & Henderson, J. (2004). “Globalizing” Regional Development: A Global Production Networks Perspective. *Transactions of the Institute of British Geographers*, *29*(4), 468–484.

Comte, A. (1853). *The Positivist Philosophy*.

Cooke, P. (1998). Regional innovation systems: an evolutionary approach. In *Regional innovation systems: the role of governance in a globalized world* (pp. 1–18). Routledge, London.

Cooke, P., De Laurentis, C., Todtling, F., & Trippl, M. (2007). *Regional knowledge economies: markets, clusters and innovation*. Edward Elgar Publishing.

Cooke, P., & Piccaluga, A. (2004). *Regional economies as knowledge laboratories*. Edward Elgar Publishing.

Corbetta, P. (2003). *Social Research : Theory , Methods and Techniques*. London: Sage.

Della Porta, D., & Keating, M. (2008). *Approaches and methodologies in the social sciences: A pluralist perspective*. Cambridge University Press.

Dicken, P., & Henderson, J. (2005). *Making the Connections: Global Production Networks in Britain, East Asia and Eastern Europe*.

Doloreux, D., & Parto, S. (2005). Regional innovation systems: Current discourse and unresolved issues. *Technology in Society*, *27*(2), 133–153.

Dopfer, K., Foster, J., & Potts, J. (2004). Micro-meso-macro. *Journal of Evolutionary Economics*, *14*(3), 263–279.

Easterby-Smith, M., Thorpe, R., & Jackson, P. R. (2012). *Management research*. Sage.

Eisenhardt, K. M. (1989). Building Theories from Case Research. *The Academy of Management Review*, *14*(4), 532–550.

Eisenhardt, K. M., & Graebner, M. E. (2007). Theory Building from Cases : Opportunities and Challenges. *Academy of Management Journal*, *50*(1), 25–32.

Eisenhardt, K. M., Graebner, M. E., & Sonensheim, S. (2016). From the Editors: Grand Challenges and Inductive Methods: Rigor Without Rigor Mortis. *Academy of Management Journal*, *59*(4), 1113–1123.

Ernst, D. (2000). *Catching-up and Post-Crisis Industrial Upgrading: Searching for New Sources of Growth in Korea's Electronics Industry*.

Ernst, D. (2001). *Moving Beyond the Commodity Trap? Trade Adjustment and Industrial Upgrading in East Asia's Electronics Industry*. *East-West Center Working Papers* (Vol. 10).

Ernst, D. (2002a). Global production networks and the changing geography of innovation systems. Implications for developing countries. *Economics of Innovation and New Technology*, *11*(6), 497–523.

Ernst, D. (2002b). *Global Production Networks in East Asian's Electronics Industry and Upgrading Perspectives in Malaysia*.

Ernst, D. (2004). Global production networks in East Asia's electronics industry and upgrading prospects in Malaysia. *Global Production Networking and Technological Change in East Asia*, *476*, 89–157.

Ernst, D. (2008). *Can Chinese IT Firms Develop Innovative Capabilities Within Global Knowledge Networks?*

Ernst, D., & Kim, L. (2001). *Global Production Networks, Knowledge Diffusion, and Local Capability Formation. A Conceptual Framework*.

Ernst, D., & Kim, L. (2002). Global production networks, knowledge diffusion, and local capability formation. *Research Policy*, *31*, 1417–1429.

Etzkowitz, H., & Leydesdorff, L. (2000). The dynamics of innovation: from National Systems and "Mode 2" to a Triple Helix of university–industry–government relations. *Research Policy*, *29*(2), 109–123.

Florida, R., Adler, P., & Mellander, C. (2017). The city as innovation machine. *Regional*

Studies, *51*(1), 86–96.

Fransman, M. (2018). Innovation Ecosystems , New Waves of Industrialisation , and the Implications for China *. In *Innovation Ecosystems Increasing Competitiveness*.

Frederick, S. (2016). Global Value Chains: Concept & Tools. Retrieved from https://globalvaluechains.org/concept-tools

Garnsey, E., & Leong, Y. Y. (2008). Combining resource-based and evolutionary theory to explain the genesis of bio-networks. *Industry & Innovation*, *15*(6), 669–686.

Gephart, R. P. (2004). Qualitative research and the Academy of Management Journal. *Academy of Management Journal*, *47*(4), 454–462.

Gereffi, G. (1994). The organisation of buyer-driven global commodity chains: how US retailers shape overseas production networks.

Gereffi, G. (1999). International trade and industrial upgrading in the apparel commodity chain. *Journal of International Economics*, *48*(1), 37–70.

Gereffi, G. (2005). The Global Economy: Organisation, Governance, and Development. In *The Handbook of Economic Sociology*.

Gereffi, G., & Fernandez-Stark, K. (2016). GLOBAL VALUE CHAIN ANALYSIS: A PRIMER Second Edition >> GVC >> PG. 3, (July). Retrieved from http://www.cggc.duke.edu/

Gereffi, G., Humphrey, J., Kaplinsky, R., & Sturgeon, T. J. (2001). Introduction : Globalisation, Value Chains and Development. *IDS Bulletin*, *32*(3), 1–8.

Gereffi, G., Humphrey, J., & Sturgeon, T. (2005). The governance of global value chains. *Review of International Political Economy*, *12*(1), 78–104.

Gereffi, G., & Korzeniewicz, M. (1994). *Commodity chains and global capitalism*. ABC-CLIO.

Gioia, D. A., Corley, K. G., & Hamilton, A. L. (2012). Seeking Qualitative Rigor in Inductive Research: Notes on the Gioia Methodology. *Organizational Research*

Methods, *16*(1), 15–31.

Glückler, J. (2007). Economic geography and the evolution of networks. *Journal of Economic Geography*, *7*(5), 619–634.

Gunderson, L. H., & Holling, C. S. (2002). *Panarchy: Understanding Transformations in Human and Natural Systems*. Island Press.

Henderson, J., Dicken, P., & Hess, M. (2002). Global production networks and the analysis of economic development. *Review of International Political Economy*, *9*(3), 436–464.

Herriot, R. E., & Firestone, W. A. (1983). Multisite Qualitative Policy Research: Optimizing Description and Generalizability. *Educational Researcher*, *12*(2), 14–19.

Hess, M., & Coe, N. M. (2006). Making connections: Global production networks, standards, and embeddedness in the mobile-telecommunications industry. *Environment and Planning A*, *38*(7), 1205–1227.

Hilletofth, P. (2009). How to develop a differentiated supply chain strategy. *Industrial Management & Data Systems*, *109*(1), 16–33.

Hobday, M. (1994). Export-led Technology Development in the Four Dragons: The Case of Electronics. *Development and Change*, *25*(2), 333–361.

Hobday, M. (1995a). East Asian latecomer firms: Learning the technology of electronics. *World Development*, *23*(7), 1171–1193.

Hobday, M. (1995b). Innovation in East Asia: Diversity and development. *Technovation*, *15*(2), 55–63.

Hobday, M. (1998). *Latecomer catch-up strategies in electronics: Samsung of Korea and ACER of Taiwan*. *Asia Pacific Business Review* (Vol. 4).

Hobday, M. (2001). The Electronics Industries of the Asia – Pacific : for Economic Development, 13–29.

Holling, C. S. (2001). Understanding the complexity of economic, ecological, and social systems. *Ecosystems*, *4*(5), 390–405.

Hopkins, T. K., & Wallerstein, I. (1986). Commodity Chains in the World-Economy Prior to 1800. *Review (Fernand Braudel Center)*, *10*(1), 157–170.

Hu, L., & Jiao, J. J. (2010). Modeling the influences of land reclamation on groundwater systems: A case study in Shekou peninsula, Shenzhen, China. *Engineering Geology*, *114*(3–4), 144–153.

Huggins, R., & Thompson, P. (2017). Introducing regional competitiveness and development: Contemporary theories and perspectives. In *Handbook of Regions and Competitiveness: Contemporary Theories and Perspectives on Economic Development* (pp. 1–31).

Humphrey, J. (2004). *Upgrading in Global Value Chains*. *SSRN Electronic Journal*.

Humphrey, J., & Schmitz, H. (2000). Governance and Upgrading: Linking industrial clusters and GVC research. *IDS Working Paper*, *120*, 1–37.

Humphrey, J., & Schmitz, H. (2002). How does insertion in global value chains affect upgrading in industrial clusters? *Regional Studies*, *36*(9), 16.

Iammarino, S. (2005). An evolutionary integrated view of regional systems of innovation: Concepts, measures and historical perspectives. *European Planning Studies*, *13*(4), 497–519.

Iansiti, M., & Levien, R. (2002). *The new operational dynamiccs of business ecosystems: Implications for policy, operations and technology strategy.*

Iansiti, M., & Levien, R. (2004a). Keystones and dominators: framing operating and technology strategy in a business ecosystem. *Harvard Business School, Working Paper*, 3–61.

Iansiti, M., & Levien, R. (2004b). Strategy as Ecology. *Harvard Business Review*, *82*(3).

Kaplinsky, R., & Morris, M. (2000). A Handbook for Value Chain, (September).

Kaplinsky, R., Morris, M., & Readman, J. (2002). Understanding Upgrading Using Value Chain Analysis. *Bam 2002*, 1–13.

Kerlinger, F. N., & Lee, H. B. (1999). Foundations of behavioral research.

Ketels, C. (2013). Recent research on competitiveness and clusters: What are the implications for regional policy? *Cambridge Journal of Regions, Economy and Society*, *6*(2), 269–284.

Kim, H., Lee, J.-N., & Han, J. (2010). The role of IT in business ecosystems. *Communications of the ACM*, *53*(5), 151.

Kojima, K. (2000). The “flying geese” model of Asian economic development: Origin, theoretical extensions, and regional policy implications. *Journal of Asian Economics*, *11*(4), 375–401.

Korhonen, P. (1994). *Japan and the Pacific free trade area*. Routledge.

Langley, A. (1999). Strategies for Theorizing from Process Data. *The Academy of Management Review*, *24*(4), 691–710.

Lee, C.-K., & Hung, S.-C. (2014). Institutional Entrepreneurship in the Informal Economy: China’s Shan-Zhai Mobile Phones. *Strategic Entrepreneurship Journal*, (8), 16–36.

Lee, C.-M. (2000). *The Silicon Valley edge: A habitat for innovation and entrepreneurship*. Stanford University Press.

Li, P., Bathelt, H., & Wang, J. (2012). Network dynamics and cluster evolution: Changing trajectories of the aluminium extrusion industry in Dali, China. *Journal of Economic Geography*, *12*(1), 127–155.

Li, Y. R. (2009). The technological roadmap of Cisco’s business ecosystem. *Technovation*, *29*(5), 379–386.

Lindtner, S., Greenspan, A., & Li, D. (2015). Designed in Shenzhen: Shanzhai Manufacturing and Maker Entrepreneurs. *Aarhus Series on Human Centered Computing*, *1*(1), 12.

Liu, Y. (2017). The dynamics of local upgrading in globalizing latecomer regions: a geographical analysis. *Regional Studies*, *51*(6), 880–893.

Lundvall, B. Å. (2007). National innovation systems - Analytical concept and development tool. *Industry and Innovation*, *14*(1), 95–119.

Marshall, A. (1890). Principles of economics. Macmillan Press Ltd, London.

Marshall, A. (1920). Principles of economics.

Martin, R., & Sunley, P. (2003). Deconstructing clusters: chaotic concept or policy panacea? *Journal of Economic Geography*, *3*(1), 5–35.

Martin, R., & Sunley, P. (2011). Conceptualizing Cluster Evolution: Beyond the Life Cycle Model? *Regional Studies*, *45*(10), 1299–1318.

Martin, R., & Sunley, P. (2012). Forms of emergence and the evolution of economic landscapes. *Journal of Economic Behavior and Organization*, *82*(2–3), 338–351.

Miles, M. B., & Huberman, A. M. (1994). *Qualitative data analysis: An expanded sourcebook*. Sage.

Miscioscia, L. (2001). *EMS evolution has given rise to true virtual OEMs*. *EBN, April* (Vol. 2).

Moore, J. F. (1993). Predators and prey: a new ecology of competition. *Harvard Business Review*, *71*(3), 75–86.

Moore, J. F. (1996). *The death of competition: leadership and strategy in the age of business ecosystems*. HarperCollins Publishers.

Moore, J. F. (1998). The Rise of a New Corporate Form. *The Washington Quarterly*, *21*(1), 167–181.

Moore, J. F. (2006). Business ecosystems and the view from the firm, *51*(1).

Ng, H. Y. (2016). *Business Ecosystem Transformation Process : Evolution of Singapore Precision Modules and Components Sector*. University of Cambridge.

O'Donnell, M. A., Wong, W., & Bach, J. (2017). *Learning from Shenzhen: China's post-Mao experiment from special zone to model city*. University of Chicago Press.

Oh, D. S., Phillips, F., Park, S., & Lee, E. (2016). Innovation ecosystems: A critical examination. *Technovation*, *54*, 1–6.

Ozawa, T. (2003). Pax Americana-led macro-clustering and ¯ ying-geese-style catch-up in East Asia : mechanisms of regionalized endogenous growth. *Journal of Asian Economics*, *13*, 699–713.

Paniccia, I. (2006). Cutting through the chaos: towards a new typology of industrial districts and clusters. In *Clusters and Regional Development* (pp. 108–132). Routledge.

Penrose, E. T. (1959). *The Theory of the Growth of the Firm*. Oxford University Press.

Porter, M. (1990). The Competitive Advantage of Nations. *Harvard Business Review*, *68*, 73–93.

Porter, M. (1998). Cluster and the new economics of competition.

Porter, M. E. (1985). *Competitive advantage : creating and sustaining superior performance*. New York :London: Free Press ;Collier Macmillan,.

Porter, M. E. (1986). *Competition in global industries*. Harvard Business Press.

Porter, M. E., & Ketels, C. (2009). Clusters and Industrial Districts: Common Roots, Different Perspectives. In *A Handbook of Industrial Districts*.

President's Council of Advisors on Science and Technology (U.S.). (2004). *Sustaining the nation's innovation ecosystems : information technology manufacturing and competitiveness*.

Radosevic, S., & Yoruk, E. (2016). Why do we need a theory and metrics of technology upgrading? *Asian Journal of Technology Innovation*, *24*, 8–32.

Rong, K. (2011). *Nurturing business ecosystems from firm perspectives : lifecycle, nurturing process, construct, configuration pattern*. University of Cambridge.

Rong, K., Hu, G., Lin, Y., Shi, Y., & Guo, L. (2015). Understanding business ecosystem using a 6C framework in Internet-of-Things-based sectors. *International Journal of Production Economics*, *159*, 41–55.

Rong, K., Lin, Y., Li, B., Burström, T., Butel, L., & Yu, J. (2018). Business ecosystem research agenda: More dynamic, more embedded, and more internationalized. *Asian Business and Management*, *17*(3), 167–182.

Rong, K., & Shi, Y. (2009). Constructing Business Ecosystem from Firm Perspective: Cases in High-tech Industry. *MEDES '09: Proceedings of the International Conference on Management of Emergent Digital Ecosystems*, 417–421.

Rong, K., & Shi, Y. (2014). *Business ecosystems : constructs, configurations, and the nurturing process*. Basingstoke : Palgrave Macmillan.

Rong, K., Shi, Y., Shang, T., Chen, Y., & Hao, H. (2017). Organizing business ecosystems in emerging electric vehicle industry: Structure, mechanism, and integrated configuration. *Energy Policy*, *107*(288), 234–247.

Rong, K., Shi, Y., & Yu, J. (2013). Nurturing business ecosystems to deal with industry uncertainties. *Industrial Management & Data Systems*, *113*(3), 385–402.

Sainsbury, D. (2007). *The race to the top: A review of government's science and innovation policies*. HM Stationery office.

Saxenian, A. (1994). Regional advantage: culture and competition in Silicon Valley and Route 128. Harvard University Press.

Sayer, A. (1991). Behind the locality debate: deconstructing geography's dualisms. *Environment and Planning A*, *23*(2), 283–308.

Shang, T. (2014). *Business Ecosystem Capabilities: Exploration of the Emerging Electric Vehicle Industry*. University of Cambridge.

Shang, T., & Shi, Y. (2013). Rethinking the conceptual framework for business ecosystems: the evolutionary processes and key building blocks. In *European Academy of Management Conference*.

Shi, X., & Shi, Y. (2017). Unpacking Entrepreneurial Ecosystem Health. *Academy of Management Proceedings*, *2017*(1), 16215.

Shi, Yongjiang. (1998). *International manufacturing networks: configuration, capability and transformation*. University of Cambridge.

Shi, Yongjiang. (2004). A Roadmap of Manufacturing System Evolution : from product competitive advantage towards collaborative value creation. In *Evolution of Supply Chain Management: Symbiosis of Adaptive Value Networks and ICT*. Academic Publisher.

Shi, Yongjiang, Fleet, D., & Gregory, M. (2005). Global manufacturing virtual network and its position in manufacturing systems. *The 7th Annual International Manufacturing Symposium, Institute for Manufacturing, Dept. of Engineering, University of Cambridge*, 197–205.

Shi, Yongliang, & Gregory, M. (1998). International manufacturing networks—to develop global competitive capabilities. *Journal of Operations Management*, *16*, 195–214.

Shi, Yongliang, & Gregory, M. (2002). Global Manufacturing Virtual Network (GMVN): Its Dynamic Position in the Spectrum of Manufacturing Collaborations. In *Managing Virtual Web Organizations in the 21st Century: Issues and Challenges* (pp. 184–197).

Shigehisa, K. (2004). The Flying Geese Paradigm: A critical study of its application to East Asian regional development Shigehisa.

Storper, M. (2013). *Keys to the city: How economics, institutions, social interaction, and politics shape development*. Princeton University Press.

Teece, D. J. (2016). Business ecosystem. *The Palgrave Encyclopedia of Strategic Management*, 151–154.

Thomas, L. D. W., & Autio, E. (2012). Modeling the ecosystem: A meta-synthesis of ecosystem and related literatures. *DRUID 2012, June 19-21, CBS, Copenhagen, Denmark.*, 28.

UN-Habitat. (2019). *The story of shenzhen-Its Economic, Social and Environmental Transformation*.

Wang, P. (2009). An Integrative Framework for Understanding the Innovation Ecosystem. *Advancing the Study of Innovation and Globalization in Organizations*, 301–314.

Watanabe, C., & Fukuda, K. (2005). *National Innovation Ecosystems: The Similarity and Disparity of Japan–US Techology Policy Systems toward a Service- Oriented Economy*.

World Economic Forum. (2016). *China's Innovation Ecosystem*. Retrieved from http://www3.weforum.org/docs/WEF_GAC_On_China_Innovation_WhitePaper_2016.pdf

Yeung, H. W. (2009). Regional Development and the Competitive Dynamics of Global Production Networks: An East Asian Perspective. *Regional Studies*, *43*(3), 325–351.

Yeung, H. W. chung, & Coe, N. M. (2015). Toward a Dynamic Theory of Global Production Networks. *Economic Geography*, *91*(1), 29–58.

Yin, R. (1984). *Case Study Research*. CA: Sage.

Yin, R. (2018). *Case study Research and Applications: Design and Methods*. Sage publications.

Yin, R. K. (2009). Case study research: Design and methods, 4th. *Thousand Oaks*. Sage Inc CA.

Yoruk, D. E. (2014). Firm-level upgrading in low-and-medium-technology industries in emerging markets: the role of learning in networks. University of Sussex.

Zhu, S., & Shi, Y. (2010). Shanzhai manufacturing – an alternative innovation phenomenon in China: Its value chain and implications for Chinese science and technology policies. *Journal of Science and Technology Policy in China*, *1*(1), 29–49.

https://www.webuildvalue.com/en/reportage/pearl-river-delta-infrastructure-for-china-megacity.html (Source of Figure 2-1) https://www.ft.com/content/fe5976d8-ab81-11e8-94bd-cba20d67390c (Source of Figure 2-2)

Guangdong Statistical Yearbook 2000-2018:

http://stats.gd.gov.cn/gdtjnj/index.html

http://stats.gd.gov.cn/gdtjnj/content/post_1424903.html

Statistical Yearbook of China's Electronics and Information Industry, 2016:

https://www.yearbookchina.com/naviBooklist-n3018062635-1.html

https://tech.hqew.com/news_1346032

http://stic.sz.gov.cn/kjfw/rkx/rkxcgsjk/201711/P020171101399161490676.pdf

http://www.chinadaily.com.cn/dfpd/2010-07/19/content_11020642.htm

https://www.inc.com/will-yakowicz/shenzhen-city-of-electronics.html

Appendix

Appendix 1 From Raw Data to Research Findings