CHAPTER 1 INTRODUCTION

1.1 THE TELECOM INDUSTRY HAS BEEN EMERGING

The telecommunications or communications industry is one of the most important business sectors for nations and regions. In the past ten years, many countries have to open their communications market and loosen the limit of competition. Many studies in the literature of the communications industry have discussed about liberalization and localization of telecommunications, such as the influences of liberalization and privatisation (Bortolotti et al. 2002; Zhang 2002; Makhaya and Roberts 2003; McDowell and Lee 2003; Mureithi 2003; Tang and Lee 2003). Their target is to know whether the telecom market will be more efficient if the operator is a corporation.

Because of limited spectrum resources, all economies in the world have tried their best to find out "how to divide spectrums and what kind of policy is the most beneficial to divide spectrums," especially by efficiently controlling and allotting 3G (Third Generation Standard of Cellular Phones). How to charge license fees is also an important issue- for example, allocating spectrum rights by auctions. However, in the topic of resource allotment of spectrums, there is a debate over whether or not there should be a law limiting the amount of operators and mobile communications enterprises, because of serious competition in the Euro-American markets (Choi et al. 2001; Editorial 2003; Lee 2003). Other research topics include the policy of mutual network communications that look at the effect of competition and cooperation within communications technology. Some even wonder how to calculate the economic benefits of communications policies and laws (Yan 2001; Song and Kim 2001; Berra 2003).

According to the literature, resource allotment of spectrums decides the number of wireless telecom operators, and the number of wireless telecom operators affects the degree of competition. Moreover, the policy of wireless spectrums and standards could be a tool to promote the domestic telecom equipment industry. At the same time, a healthy domestic telecom equipment industry can support government to set up its communication standards. Therefore, allocating spectrum rights, competition of telecom operators, and the telecom equipment industry all affect each other. Based on the characteristic of the communications industry, we should observe the industry ecosystem as a whole when we discuss related issues.

The major literatures on communications industrial policy are summarized as follows:

(1) Liberalization and localization of telecommunications: Discussions include the influences of liberalization and privatisation (Bortolotti and D'Souza 2002; Zhang 2002; Trillas 2002; Tang and Lee 2003; McDowell and Lee 2003; Hazlett 2003; Makhaya and Roberts 2003; Chang, Koski and Majumdar 2003; Mureithi 2003).

(2) Resource allotment of spectrums: Because of limited spectrum resources, all economies in the world have tried their best to find out the rule of the spectrum allocation, especially by efficiently controlling and allotting 3G (Third Generation Standard of Cellular Phones). How to charge license fees is also an important issue- for example, allocating spectrum rights by auctions. Moreover, there is still a debate over whether or not there should be a law limiting the amount of operators and mobile communications enterprises, because of serious competition in the Euro-American markets (Lee 2003; Editorial 2003; Bauer 2003; Choi and Lee 2001; Ure 2003).

(3) Others: The policy of mutual network communications looks at how to effect competition and cooperation within communications technology. Some are even wondering how to calculate the economic benefits of communications policies and laws (Yan 2001; Song and Kim 2001; Kim and Litman 1999; Zhang 2002; Berra 2003).

We can see that research covering the communications development of developing countries is still deficient. The literature focuses on the telephone telecommunications market, exchange machine, telecommunications liberalism, and frequency charts, because collecting data is difficult in developing countries such as China (Zhang 2002; Tan 2002). As for the cellular phone industry's quick rise, there are not many related research papers. As a result, analyzing the influence of the communications industrial policy of developing countries on its domestic cellular phone manufacturing industry is quite attractive as the numbers show.

1.2 THE CELLULAR PHONE HAS BECOME MAJOR PRODUCT IN THE HIGH TECH INDUSTRY

The mobile communications industry is one of the most important business sectors for nations and regions. The cellular phone and related product shipments and values have been expanded rapidly. This industry is effectively controlled through many countries' industrial policy and many governments want to build up their domestic cellular phone industries through policy support.

Therefore, recently more and more researchers turn their eyes toward cellular phone end product industry. According to an IDC (International Data Collecting 2005) research report,

the 2005 global quantity of cellular phone shipments reached over 700 million. Their production value surpassed personal computers to become the technology industry's leader. That is a good chance for lately industrialized economies and industrial latecomers to catch up the leader of the technology industry. The communications field is also related to military installations, prompting many countries to support their domestic cellular phone manufacturers through their industrial policy.

As cellular phone and related product shipments and values have been expanded rapidly, communication industries need to coordinate with the communication standards that are related with local markets. Many governments as a result want to build up their domestic cellular phone industries through policy support. For example, the South Korean government combines policy subsidisation and technology acquisitions from Qualcomm to successfully support the developing/extension of its cellular phone manufacturers, Samsung, LG, and Pantech, etc.

Another case, in terms of the MII (Ministry of Information Industry) data, China is the most populous nation in the world at 1.3 billion people. Its cellular phone users numbered over 350 million at the end of 2005, making China the biggest cellular phone market in the world. When the global cellular phone market was just maturing years ago, China's cellular phone users only took up 20% of their domestic market. China's government also started to establish a policy to expedite competition for its domestic cellular phone manufacturers starting from 1999. Foreign cellular phone suppliers as a result began to face limitations by China's policies when they entered China market.

CHAPTER 2 LITERATURE REVIEW

2.1 INDUSTRIAL POLICY LITERATURE REVIEW

On the manufacturing side, in recent decades, a new kind of North-South trade has begun to emerge driven by cheap labour and land cost in the South. The production of more and more basic goods and services, even IT product are being transferred from the high-wage economies of the North to the low-wage economies of the South, and the South countries take the opportunity to build up its manufacturing industries. In addition, the companies of the South gain knowledge of the manufacturing, and they may begin marketing their own brands (Prahalad and Hamel 1990). That is why the South government often establishes the protection policy for domestic industries (Krugman 1979).

As some economic theories show, if the South countries want to build up strong manufacturing industries in the long run, the South government should give the intermediate goods manufacturers investment price subsides or tax credit to enhance capacities and qualities in end products (Brander and Spencer 1985). Organizations are increasingly turning to outsourcing in an attempt to enhance their competitiveness due to globalisation, especially in IT industry. Through outsourcing, manufacturing costs as well as investment in plants and equipments can be reduced (Bettiset al. 1992). Most of EMS (Electronics Manufacturing Service)/ODMs (Original Design Manufacturing) started to move production line to lower labor cost area, such as China and Malaysia.

On the marketing side, researchers also indicated that the typically international industry has some characteristics such as economy of scale, market similarity, comparative advantage, and absence of regulatory restraints (Lessard 2003). In the ICT industry, due to globalisation and the trend in world trade, cellular phones like PCs, have become the popular product sold around the world. Major cellular phone makers, Nokia and Motorola, sell their phones in most of countries with advantage of economies of scale and a firm's comparative advantages.

That’s why although the government of developing economies wants to support its domestic industry by policy, the effect may be a question. In order to compete with foreign leading companies, domestic firms of developing economies should take advantage such as economy of scale or market niche expect policy protection. If the government wants to build up the domestic manufacturing ability in telecom industry, it cannot ignore this trend. However, this issue has been theoretically discussed without empirical evidence. Due to little existing empirical work about the policy outcomes of manufacturing, this study seeks to enhance the understanding about the relationship among the industrial policy, its domestic

cellular phone manufacturing ability, and firms' development strategy in developing economies.

2.2 THE DIFFERENCE BETWEEN THE PC AND CELLULAR PHONE INDUSTRY CHAIN

Figure 1 shows the difference between the PC and cellular phone industry chains. In the PC industry, there is the Wintel platform and Internet Protocol. The software firm Microsoft and the CPU firm Intel have created industrial standards to let third-party firms follow up. PC brand names and manufacturing companies show less difference in product innovations, and so any latecomer can easily catch due to low inside knowledge.

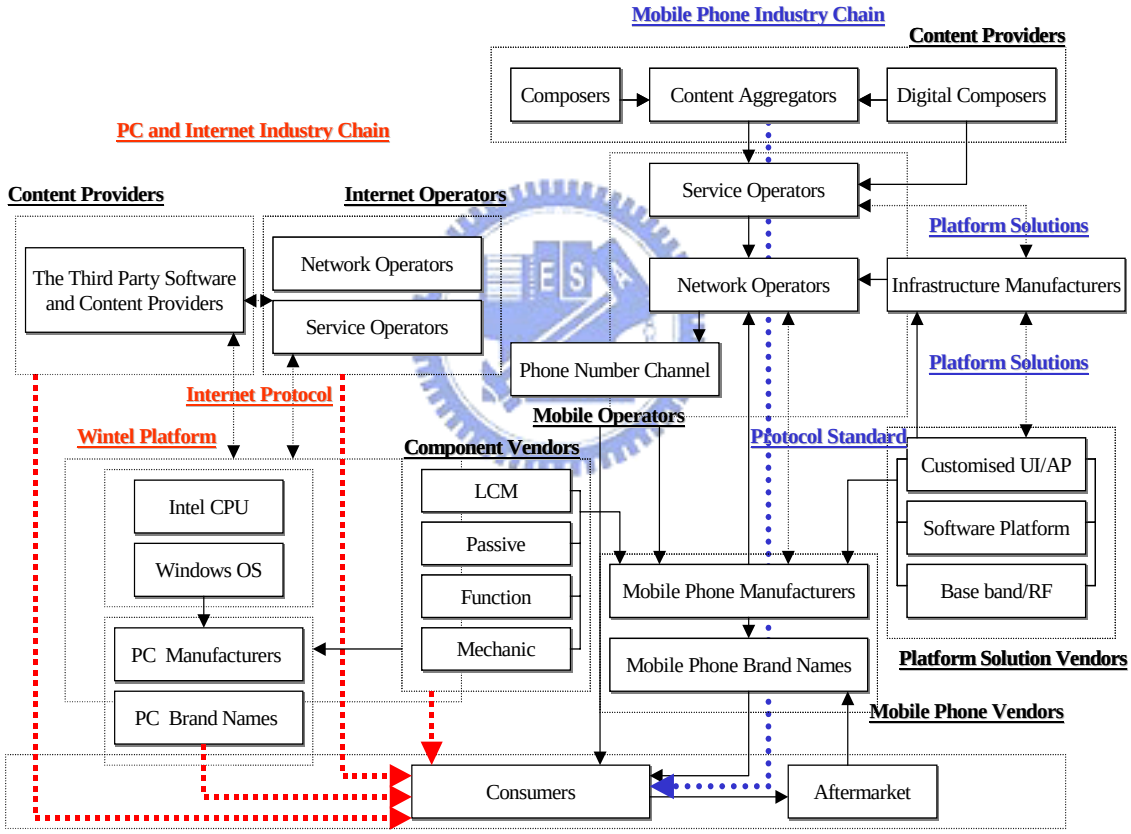


Figure 1. Comparing the PC and cellular phone industry chains

In contrast with the PC industry chain, the communication industries need to coordinate their standards related with the local markets. Therefore, European and American innovative products and applications often lack common standards due to insufficient interaction with carriers. This is why most famous cellular phone companies develop cellular phones,

infrastructure equipments, and management systems at the same time, such as Nokia, Motorola, Ericsson, Siemens, and Alcatel.

With a lack of industrial standards, every company in the cellular phone industry that wants to create a new service has to take care of all operational stages. This industry ecosystem appears like a vertical integration structure and hence the cost-down issue is not the priority here. The market share seldom fluctuates extremely unless the communication protocol is revised.

On the other hand, mobile services move from voice to data ceaselessly. Package and digital services will become the future trend in the third generation of the cellular phone. Table 1 shows the major global cellular phone firms' platform architectures. We find that most major cellular phone companies have their independent platforms, protocol stacks, and developer programs. Cellular phone manufacturers are not as similar as PC companies. They are used to researching and developing the technology and products by themselves, which seems to avoid the outsourcing trend.

In order to reduce cost, companies outsource some businesses to other companies. However, they also need to collect the related information, negotiate contracts, maintain relationships, and supervise ODMs. Therefore, outsourcing does not mean better qualify. It depends on the transaction cost and the outsourcing benefit and which one is bigger (Williamson 1979, 1981).

In the cellular phone industry, due to every telecom operators having a large enough market potential, telecom equipment makers can support by themselves if they get enough operator customers. Therefore, because of the transaction cost, it is not necessary to outsource their business unless under special conditions.

Table 1. Global major cellular phone firms' platform architectures

	Hardware Platform	Protocol Stack	Software Platform	Developer Program
Nokia	Nokia, TI	Nokia	Symbian	Forum Nokia
Motorola	Freescale (Motorola), TI	Motorola	Linux, Symbian, Microsoft	MOTOCODER developer program
Samsung	Agere, Philips, Infineon	Optimacy, Philips	Palm, Symbian, Microsoft	Samsung developer's club
LG	ADI, TI	TTP com.,Condat	Symbian, Microsoft	Developer Portal
SEMC	EMP	Ericsson	Symbian	Sony Ericsson Developer World
Siemens	Infineon	Comneon	Symbian	N/A

Source: ITIS

Figure 2 shows the difference between cellular phone and PC makers' positions. Cellular phone makers will be able to enhance their competition by many ways in the future. For example, they can build up the applications and terminal platforms, and make sure the two can connect with each other. They also can support the content provider or become a developer to promote digital services.

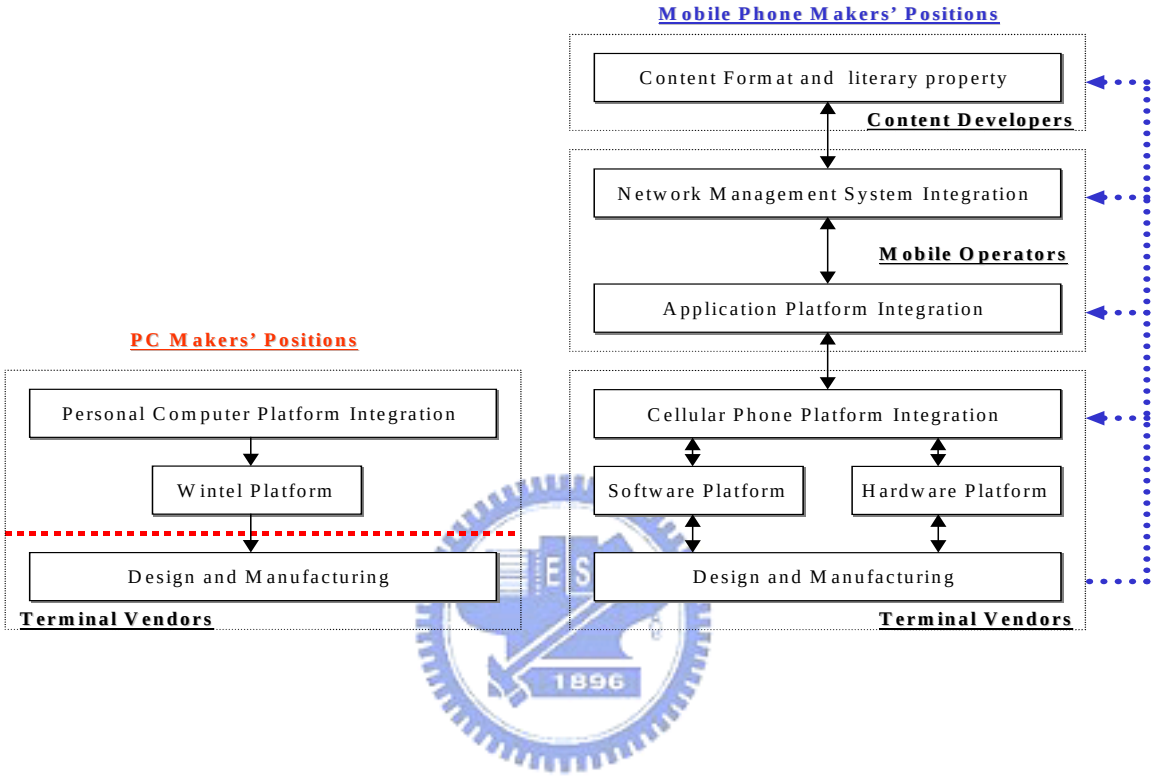


Figure 2. The difference between cellular phone and PC makers' positions

Based on the platform structure, in the global cellular phone industry there is a clear trend of a shortening product life cycle, and cellular phone OEMs are shifting their strategy to 'lower volume, higher mix' in order to use the approach of a lot of models. For example, Motorola launched over 50 new models and Samsung even launched over 150 new ones in 2004 (Hu and Hsu 2007). As a result, if someone can keep the end user demand, it will win the market. That is why the cellular phone market is highly competitive, but Nokia, Samsung, Sony Ericsson, and Motorola still have good profits.

2.3 KEY ISSUES OF THE DEVELOPMENT IN THE CELLULAR PHONE INDUSTRY

Following second-generation cellular phone technology - e.g., GSM (Global System for Mobile Communication) - the cellular phone industry is resembling consumer electronics

products by undergoing dramatic changes fuelled by rapid technological development, innovative applications, and more integrated functions. The cellular phone is the most representative of all 3C (computer, communication, and consumer) products. How have domestic cellular phone firms in the lately industrialised economies achieved success? One of the answers may be in their innovation ability. Fan (2006) studies the innovation capability development of four domestic Chinese firms - Huawei, ZTE, DTT, and GDT. Innovation capability and self-developed technologies are the key areas for Chinese firms to catch up with multinational corporations. It is found that domestic firms should focus on in-house R&D development in order to build their innovation capability, supplemented by external alliances.

Latecomers sometimes need new technology from outside firms. Hence, researchers also mentioned that firms in developing counties source their formal or informal technology from outside firms. Thus, their technological innovations have progressed by acquiring mature technology from advanced countries and at the same time have increased the absorptive capacity of these technologies (Gil, Bong and Lee 2003; Kim 1997; Kim 1998; Lee, Bae and Lee 1994). Moreover, the empirical results show that firms prefer in-house R&D strategy to technology purchasing. The firm often uses an inertial R&D strategy that keeps up with historical choice patterns (Cho and Yu 2000). This means that governments of developing countries need to do something to help firms acquire new technology or lower developing costs.

Government policy as a result is another important issue. According to the literature, if a government wants to build up a strong domestic industry in the long term, researchers suggest that it should give intermediate goods manufacturers investment subsidies or tax credits to enhance the capacities and qualities of the final goods (Brander and Spencer 1985). This is a major reason why South Korea's manufacturing industry matured up to 1999 (Hitomi 2002).

Aside from enhancing R&D intensity, increasing R&D efficiency is also a way to increase innovative capability. With increasing pressure to create and sustain competitive advantages through technological innovation, technology-based firms increasingly depend on the efficient management of their R&D activities (Bone and Saxon 2000).

2.4 SOUTH KOREAN FIRMS HAVE CATCHED UP IN THE CELLULAR PHONE INDUSTRY

There is still not a common consensus about how to be successful in the cellular industry. In the early stages, South Korean companies were the same as most latecomers, improving on existing product designs, exploiting their cost-down ability, focusing on their process

strengths, and competing on the basis of high quality and low cost. Even Samsung at one time believed that as long as international markets for low-cost, high technology hardware continued to expand, then they could continue to repeat the cycle of being behind the frontier and play catch up in innovation as they had done for many years in mobile telephony. In this scenario, most South Korean firms have yet to achieve international status, particularly in higher prices, more complex products and systems, capital goods, and services (Hobday, Rush and Bessant 2004).

South Korean cellular phone firms now are able to lower the risk and cost of new market creation, R&D expenses, and innovative product development. At the same time, they have improved in R&D efficiency. Samsung and LG lead in new product creation, especially in higher prices and design-intensive products, having surpassed most American, Japanese, and European firms in the cellular phone industry. South Korean cellular phone manufacturers have succeeded in catching up and leapfrogging, including global market shares, export values and company brand names.

Many research papers have provided useful insights and lessons to explain how South Korean firms have faced the changing global environment and accumulated relatively advanced technological and manufacturing capabilities within a short period. The paper also explains the technological capability development process and creates a model for technological and market "catching-up". In this model, technological capability is determined as a function of both technological effort and the existing knowledge base (Lee and Lim 2001; Hitomi 2002).

Most of the previous contributions to this paper's subject lack specialised analysis to South Korea's cellular phone industry. This is especially for the subject of product innovative, since these studies rely a lot on standardised products or mass production of scale economies such as DRAM, Flash, and LCD. The cellular phone industry is a very special object of technology management, because of the integration of computer, consumer, and communications products.

Rapid technological innovations and increasing market competition have created the pressure to develop and introduce new products. To be successful, companies must provide innovative solutions using effective marketing activities, more demand forecasting and an increase in market attractiveness due to environmental changes and government policy (Ahn, Kim and Lee 2005). As the requisite capability complexity for participation in mobile telecommunications has increased, the complexity and extent of vertical and horizontal disintegration in the industry has increased. Where firms have been able to internalise all of their design, production and distribution capabilities in the past, the changing nature of

products has made this business mode impossible (Rice and Galvin 2006).

2.5 TAIWAN DEVELOPED ITS CELLULAR PHONE INDUSTRY THROUGH RECEIVING OUTSOURCING ORDERS

Organizations in the North are also increasingly turning to outsourcing in an attempt to enhance their competitiveness due to globalization, especially in the IT (Information Technology) industry. Through outsourcing, manufacturing costs as well as investment in plants and equipments can be reduced (Bettis et al. 1992). Taiwan's companies have taken this chance to set up their own outsourcing industry, especially in IT manufacturing. Beginning in the early 1970s, computers and the related information industry at first had only a few businesses assembling or copying others' products. After two decades, companies' technology developments had fostered fast-paced industrial growth. This field now forms the largest export industry in Taiwan, with Taiwan now having a world-class computer industry. Moreover, the industry enjoys more than 80% of the global market share for monitors, motherboards, keyboards, mouse, and scanners. Aside from computers, many Taiwanese companies receive outsourcing orders for consumer electronics and communication products, including DVD players, digital cameras, modems and so on (MIC 2005).

There are many factors behind the success of Taiwan's computer industry. In addition to domestic manufacturers' efforts, industrial policy, government-support R&D institutes, international technology transfers, foreign investments, and foreign purchases have all played roles in developing Taiwan's computer industry (Chang et al. 1999). During this period, the ITRI (Industrial Technology Research Institute) has had an important role in promoting Taiwan's companies' R&D ability (Mathews 2002; Jan and Chen 2006; Chu et al. 2006).

It seems strange that Taiwan's IT manufacturing industry has not been so successful in cellular phones, in spite of its dominant market shares in most of the computer, consumer, and communications (3C) products. For instance, Taiwan's notebook PC industry started around 1990 and matured by the end of the 1990s. Its development background is similar to Taiwan's cellular phone industry, but there is a big difference between their growing curves. The cellular phone industry must be a very special object of technology management.

Most previous contributions to this paper's subject lack a specialized analysis on Taiwan's cellular phone industry. This is especially so for the subject of product innovation, since these studies rely a lot on standardized products or mass production of scale economies such as PC, DRAM, Flash, and LCD. South Korea's memory industry, and Taiwan's PC and TFT-LCD industries are the major research topics (Chang 2005; Hu and Hsu 2006).

More and more lately industrialized economies and researchers have recently turned their eyes toward non-standard products such as the semiconductor and cellular phone end product industries, because these industries have been soaring. For instance, Taiwan's wafer foundries have selected the agile strategy to adapt changes in the semiconductor industry. It is a very different strategy compared with the down stream EMS industry that just emphasizes the scale of economies (DeCarolis and Deeds 1999). South Korea's cellular phone industry has strengthened its R&D efficiency and has a high integrated industry chain. China's cellular phone industry is catching up through its domestic market strength and industrial policy protection (Lin et al. 2006).

In the early stages, Taiwan's cellular phone companies were the same as its PC companies, improving on existing product design, exploiting their cost-down ability, and focusing on their process strengths. Before 2000, Taiwan's cellular phone industry still had not broken through the bottleneck and shipments were only 2.2 million units in 1999 (MIC 2005). Some of Taiwan's cellular phone companies started to try new strategies and innovative activities to hold onto business opportunities. Right now there are three main Taiwanese cellular phone ODMs, Arima Communication, HTC, and Compal Communication, and three brand name companies, BenQ-Siemens, OKWAP, and DBTEL.

Hence, how did domestic cellular phone firms in the lately industrialized economies achieve success? Because of the characteristic of the communications industry, how can one enhance the competition of the market and expand the market size? How does the government use its policy to promote the domestic industry by the local market? How do domestic cellular phones or base station firms in the lately industrialized economies achieve success? All of these issues are important for latecomers.

We can learn from East Asian developing economies' experiences by reviewing the chronological development, industry supply chain, and innovation process in the cellular phone industry of this area. China's cellular phone users numbered over 400 million at the end of 2006, making China the biggest cellular phone market in the world. The lessons of China's experience are very valuable. This paper also wants to discuss the R&D activities of Taiwan and Korea's mobile industry and try to find the development pattern. This paper as such is organized as follows: In order to review the chronological development, industry supply chain, and innovation process of East Asian cellular phone industry, we break down the subject into details and examine the know-how of the local firms.

CHAPTER 3 RESEARCH DESIGN

3.1 VARIABLES AND DEFINITIONS

The research variables are defined as follows:

(1) The product type definition (product mix):

In China the official definition of a cellular phone includes the standard system of in GSM, GPRS (general packet radio service), and CDMA (code division multiple access, including IS95A/B, CDMA2000 1X), etc. However, PHS (Personal Handy Phone System) is not included since PHS is considered to be a wireless fixed-line phone by Chinese authorities.

(2) Domestic manufacturers: Chinese makers hold total market share above 50%, including individual proprietorships and joint ventures. Dbtel and Inventec (OKWAP) are viewed as Taiwanese brand manufacturers.

(3) The shipment type definition (form factor):

(3.1) Full System: All components are already surface mounted on the printed circuit board. After assembling the mechanism components, the company takes delivery of goods to the customers who then use the product.

(3.2) Semi Knock Down (SKD): All components are already surface mounted on the printed circuit board. The goods are delivered together with the mechanism components to the customers, and the firm completes the simple assembly work for the customer.

(3.3) Completely Knock Down (CKD): The shipment goes to the customer in component form. The customer they does surface mount technology and assembly.

(4) The technology source for cellular phones:

Before announcing a cellular phone model, the technology of the Chinese cellular phone vendor must come mainly from the following three:

(4.1) The chipset vendor (or cellular phone manufacturer has its own technology): China's cellular phone manufacturers use chip vendors, or reference designs of the chipset to complete product development.

(4.2) Post the brand/SKD/CKD: China's cellular phone manufacturer purchases the finished product/semi-finished product from Taiwanese/South Korean manufacturers.

(4.3) Cellular phone design houses: China's cellular phone manufacturers purchase the design diagram from cellular phone design houses, and then through their own production lines or EMS factories they sell their own end products.

(5) Cellular phone brand type: One brand and two-brand

If the company does not have the licenses, then it will borrow a license from others that have one. Or did not have technology ability but own the domestic sale licenses, post the brand name to the foreign cellular phone products that have the technique but have no the domestic sale licenses. The first way is to market a cellular phone simultaneously with two brand names on it (e.g., BenQ and TCL). The second way is to market the same cellular phone model with different brand names (e.g., BenQ and CECT). Therefore, the possible brand share of a certain cellular phone manufacturer is very high, but it not concerned about the cellular phone from the design, production, or sales end. The cellular phone company only rents a license to earn profits. Therefore, this paper will not use ASP (Average Selling Price) to measure manufacturers' development ability in China's market.

(6) The import and export characteristics of the cellular phone supply chain:

Because China's MII limited imports of cellular phone system products and components, and foreign or Taiwanese companies still do not have enough confidence in China's investment environment, Taiwanese or South Korean cellular phone manufacturers' imports to China's market by CKD/SKD, then used the native production lines to carry on simple construction in China.

(7) Brand share: this paper partitions China's market by the market share of each brand name. In the case of a dual brand sale, we categorize it as a foreign brand name.

(8) Shipment share: this paper calculates each manufacturer's share of full system sales.

(9) Self-production proportion: this paper calculates each manufacturer's SMT production proportion of products over the SKD and full-system levels.

(10) Self-technique proportion: This is the proportion of cellular phones produced by a manufacturer's self-development and purchased reference design sources.

(11) Export quantity: This is each brand manufacturer's export quantity, deducting false export volume from tax-protected zones.

(12) Customer concentration ratio: We use the biggest sales contribution of a customer's business by total sales to evaluate the customer concentration ratio of Taiwanese PCs and cellular phones' ODM/EMS.

(13) ASP (Average Shipment Price): Due to the policy of mobile cellular phone subsidies, if we use Average Selling Price at the retail level to measure the price of cellular phones, then there may be some mistakes about the actual price. Therefore, we use Average Shipment Price to measure the price of cellular phones.

(14) R&D intensity and R&D efficiency: R&D expenditures and R&D expenditures as a percentage of sales are commonly used to represent a film's R&D intensity. The number of patents is often used as an indicator of a firm's knowledge stocks (DcCarolis and Deeds 1999). In the ICT industry, R&D expenses as a part of revenue are an important index to evaluate how a company puts emphasis on innovation. R&D expenditures as a percentage of sales are commonly used to represent a firm's R&D intensity (Lin and Chen, 2005).

Moreover, several efficiency-oriented R&D performance measures such as grant patents per R&D expenditures (Deng, Lev and Narin 1999), the number of patents granted, and R&D spending per patent (Bowonder, Yadav and Kumar 2000) are commonly used in the R&D management and finance literature (Wu, Hung and Lin 2006). The researchers also find R&D intensity has a positive impact on the degree of product diversification (Galan and Sanchez 2006). Therefore, this paper uses R&D intensity and R&D efficiency to measure R&D performance, whereby R&D intensity is measured as R&D expense as a percentage of sales, and R&D efficiency is measured as the number of patents that the firm receives divided by its R&D expenses (in millions of US dollars).

3.2 DATA SOURCES

Current Chinese authorities are still very conservative towards marketing research. A researcher must have a license to carry on investigation activities. For the cellular phone industry or market related data, it is still not easy to the find anyone to obtain data. The more complete data come from three aspects mainly at the present time:

(1) China's State Council, Standardization Administration and MII: The MII periodically (every one to two seasons) announces to investigate data, with the data mainly entrusted to the CCID to carry out the investigation, and MII is the main shareholder of the CCID. CCID's

investigation method is that foreign and domestic vendors need to show production and sales data to the CCID periodically. Although that data are the most complete, native cellular phone manufacturers sometimes have pressure from the policy, and the arithmetic figure reliability is worse. In addition, the data mainly are from the supply side to carry out the calculation. There is no concern about channel inventory and post the brand.

(2) The China's National Statistics Bureau: Many Chinese investigation institutions, such as Beijing All China Marketing Research (ACMR) and Beijing SinoBnet, are established by National Statistics Bureau insiders at first, and at the present time they also cooperate with China's National Statistics Bureau. Relevant cellular phone industry and market data are investigated through the market and retail channels mainly. Although the data is gotten by the demand side, the weakness lies in that it can't control foreign manufacturer shipments of imports and exports. Posting the brand and dual-brand problems also cannot be defined effectively at the same time.

(3) ITIS system of the Taiwan's Ministry of Economic Affairs: The Institute for Information Industry MIC and Industrial Technology Research Institution IEK carry out the investigation, with the target mainly Taiwanese cellular phone manufacturers and Taiwanese cellular phone components manufacturers. The weakness of this dataset is that variable definitions are different from those in China such as PHS is considered as a cellular phone in Taiwan.

There are some sporadic information appearing in annual reports of listed companies, international company reports, import and export data of maritime transportation, data of computer and electronics associations, and investigation reports of international research institutes in the electronics industry, such as IDC and Yano Research Economic Institute (YRI), etc.

3.3 DATA COLLECTION

(1) China's cellular phone industry:

Based on the above resources, we collect data over 1991~2006 for China's mobile service market and telecom equipment manufacturing industry from MII of People's Republic of China, financial statements, and newsletters of these companies. We also collect data over 1999~2006 for China's cellular phone market and industry from MII, Beijing ACMR (All China Marketing Research), Beijing Sino-MR, TRI (Topology Research Institute), and ITIS (Industry & Technology Intelligence Services).

The data of MII mainly entrusted to the CCID to carry out the investigation are mainly from the supply side in order to carry out the calculation. Moreover, Beijing ACMR and Beijing Sino-MR were established by National Statistics Bureau insiders first, and at the present time they also cooperate with China's National Statistics Bureau. Their data are gotten by the demand side and are mainly investigated through the market and retail channels. Finally, TRI and ITIS are Taiwan's research institutes whose targets are mainly Taiwanese cellular phone manufacturers and Taiwanese cellular phone component manufacturers.

We then interviewed upstream and downstream manufacturers in the cellular phone industry to confirm details. On the manufacturer side, we interviewed four Chinese vendors (ZTE, TCL, Konka, and Amoi) and six Taiwanese vendors (Dbtel, BenQ, Inventec (OKWAP), Compal Communication, Lite-On Technology, and Compal Electronics). On the components manufacturering side, we interviewed Merry Electronics which produces an electric shock component (takes delivery of goods mainly to the Chinese market). On the cellular phone channel side, we interviewed CELLSTAR to attain a total of twelve firms. The investigating objects include product managers, research and development department heads, and sales managers. The investigation and interview time period was January to May 2005 and was updated on September to October 2006.

In addition to individual firms' data, we collected data of the major cellular phone, operators and telecom equipment firms in the world from companies' annual reports and newsletters. Our data of cellular phone firms include four global companies, Nokia, Motorola, Samsung, and LG, whose market shares were all more than 5% in 2005, and two China's companies, TCL and Bird, that were the first two domestic firms by market share from 2000 to 2005. BenQ-Siemens and Sony-Ericsson, even though their global market shares were also more than 5% in 2005, were not included as they had merged or been acquired.

Our data of telecom equipment firms include five global companies Nokia, Motorola, Ericsson, Lucent, and Siemens that were the major wireless infrastructure firms, and two China's companies Huawei and ZTE that were the first two domestic firms by sales. Our data also include two of China's mobile service providers China Mobile and China Unicom. We then use the Mann-Whitney test to examine the difference in the R&D intensity between China's and other countries' cellular phone and telecom equipment firms.

(2) South Korea's cellular phone industry:

We collected data of the major cellular phone firms in the world from companies' annual reports and newsletters. Our data include Nokia, Motorola, Samsung, and LG. Their

market shares were all more than 5% in 2005. BenQ-Siemens and Sony-Ericsson, even though their market shares were also more than 5% in 2005, were not included as they had merged or been acquired.

We collected the number of patents from the United States Patent and Trademark office. North America has been the main cellular phone market globally and the United States is the largest market of all countries except for China. Therefore, all the main firms have taken out American and Chinese patents for cellular phones. However, the number of patents in China includes those applying and those already applied, and so we use the number of American patents for cellular phones to measure R&D results. We use the Mann-Whitney test to examine the difference in the R&D performance between South Korean and other countries' cellular phone firms.

(3) Taiwan's cellular phone industry:

We also collected data of the major cellular phone firms in Taiwan from companies' annual reports and newsletters. Our data include CCI, Arima, HTC, FIH, DBTEL, OKWAP, and BenQ. FIH was spun-off by Hon Hai/Foxconn Precision Ind. Co. and listed in Hong Kong. In fact, FIH still likes a Hon Hai/Foxconn's cellular phone business group and includes Chi-Mei Communications and Ambits that were merged by Hon Hai/Foxconn in 2005 and 2004, respectively. Most of its R&D engineers are located in Taiwan. We still view it as a Taiwan-based cellular phone company.

All of these Taiwan's cellular phone companies have full R&D, manufacturing, and testing abilities. Among them, CCI, Arima, HTC, FIH, DBTEL, and OKWAP's sales are more than 90% from cellular phone products. BenQ's product lines include cellular phones, DVD, NB PC, LCD TV, DSC, and so on. FIH and OKWAP have been set up less than 5 years. As a result, it is not suitable for using them to compare with PC companies.

We collected data of the major NB/PC firms in Taiwan from companies' annual reports and newsletters, including Hon Hai/Foxconn, Quanta, Compal, and Inventec. Wistron was spun-off by Acer in 2001, and we can not find enough data that year. Quanta, Compal, and Inventec's sales have more than 90% coming from NB/PC products. We use the Mann-Whitney test to examine the difference in the R&D intensity and customer concentration ratio between Taiwan's NB/PC and cellular phone firms.

3.4 RESEARCH HYPOTHESIS

Figure 3 shows the structure of China's mobile industrial policy as a whole including operators, infrastructure manufacturers, and handset vendors. According to the industrial policy targets, this research puts forward the following research hypothesis.

First, due to the cellular phone market being promoted with competition, this research uses the usage fee of the end user and the level of mobile service industrial concentration to measure the effect of the industrial policy.

Hypothesis 1.1: China's mobile industrial policy (through its support of China Unicom) of reducing the level of industrial concentration has a positive influence.

Hypothesis 1.2: China's mobile industrial policy (through its support of China Unicom) of reducing the usage fee of the end user has a positive influence.

For promoting China's domestic telecom equipment industry, this research uses local vendors' sales and own brand market share to measure the effect of the industrial policy.

Hypothesis 2.1: China's mobile industrial policy of promoting the local vendors' sales has a positive influence.

Hypothesis 2.2: China's mobile industrial policy of promoting locals' own brand market share has a positive influence.

For supporting China's cellular phone industry, this research uses brand share and cellular phone shipments as research variables.

Hypothesis 3.1: China's mobile industrial policy (restriction to produce and licenses to sell) of promoting the domestic brand manufacturer has a positive influence.

Hypothesis 3.2: China's mobile industrial policy (restriction to produce and licences to sell) of promoting domestic manufacturers' shipments has a positive influence.

To raise China's cellular phone ability through technology, this research tests the hypothesis with the proportion of self-assembly and self-R&D.

Hypothesis 4.1: China's mobile industrial policy (restriction to produce and licenses to sell) of raising domestic manufacturers' development and ability has a positive influence.

Hypothesis 4.2: China's mobile industrial policy (restriction to produce and licenses to sell) of promoting domestic manufacturers' production technology has a positive influence.

Finally, for enhancing the exporting ability of China's domestic cellular phone industry to export products, this research uses domestic vendors' export shipment volume as a variable for testing.

Hypothesis 5: China's mobile industrial policy (restriction to produce and licenses to sell) of raising domestic manufacturers' export ability has a positive influence.

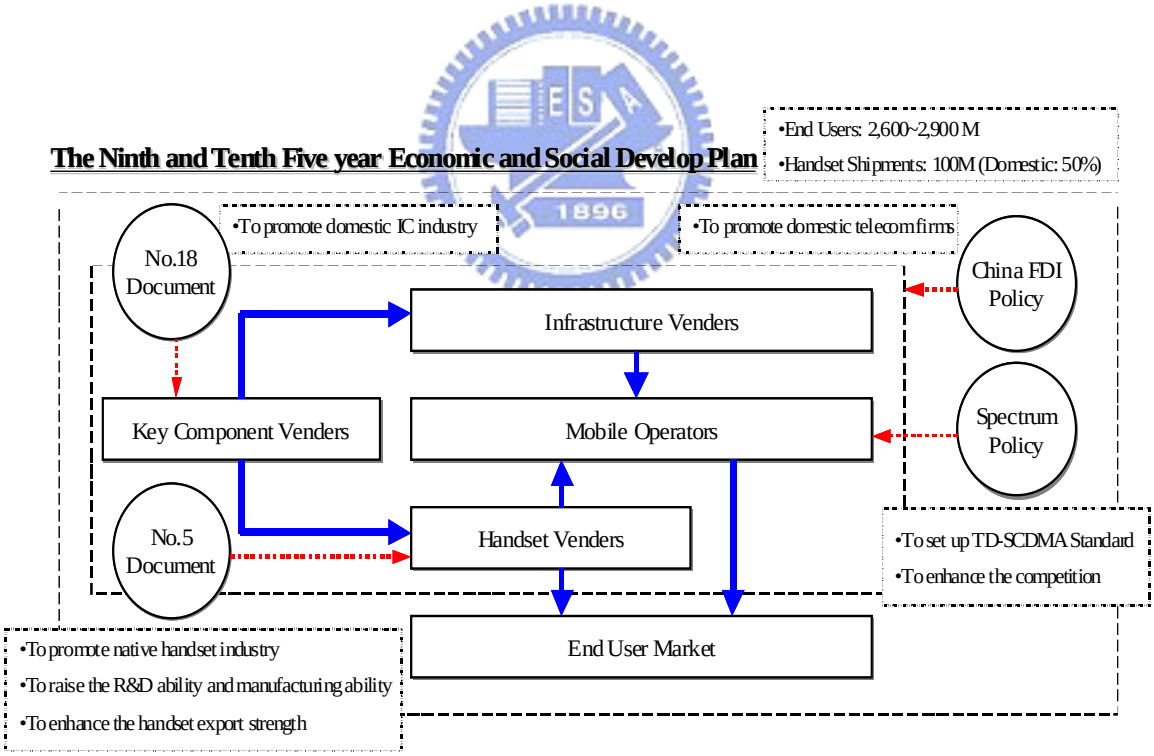


Figure 3. The structure of China's mobile industrial policy

CHAPTER 4 THE POLICY EVOLUTION AND CHINA'S MOBILE INDUSTRY ECOSYSTEM

4.1 THE DEVELOPMENT BACKGROUND OF THE CHINA'S TELECOM INDUSTRY

For the period of China's economic growth, China's FDI (Foreign Direct Investment) policy was divided into three stages: FDI was not allowed before 1978. After an open-door policy in 1978, FDI was promoted in most industries except for telecommunications operations, electricity, railways, and other politically sensitive sectors from 1978 to 1986. Finally, after 1987 China's FDI policy integrated with its industrial policy in order to join WTO (World Trade Organization).

China's FDI policy in the telecommunications industry is synchronized with its general FDI policy. There was no FDI either in China's telecom manufacturing sector or service providers before 1978. China' operators had to buy old-style telecom equipment from domestic vendors. From the early 1980s, China's FDI policy on the telecommunications industry actively encouraged domestic firms to achieve advanced technologies through joint ventures (JV) (Wu and Zhang, 1992; Pitt et al., 1996; Tan, 2002).

At about the same time, the China's former Ministry of Posts and Telecommunications (MPT), which was renamed the Ministry of Information Industry (MII) in 1998, boosted several industrial policies to give priority to the development of telecommunications. For example, 90% of the central government's investment is considered as un-repayable loans (Wu and Zhang, 1992). MII as a fully authorized ministry is more active in promoting the domestic telecom industry through industrial policies including spectrum management, telecom operators' spin-offs, and supporting telecom equipment and cellular phone manufacturing firms after 1998.

4.2 THE PROGRESS OF THE POLICY OF CHINA'S SPECTRUM MANAGEMENT AND MOBILE OPERATOR INDUSTRY

Analogue mobile service has been available in China since 1987 and MPT was the only provider of mobile services. Because of individual provincial MPT purchasing and no unified standard, different communication systems from different vendors existed in different provinces. In 1994 China's government announced that its 2G digital cellular phone standard would follow the GSM (Global System Mobile) standard. In 2000 China's government also adopted the CDMA (Code-Division Multiple Access) standard to allocate its

wireless spectrum.

As China's mobile service emerged in the 2G standard, China's government tried to use its 3G license policy to promote its independent 3G standard TD-SCDMA (Time Division - Synchronous Code Division Multiple Access). In June 1998 China's Academy of Telecommunications Technology (CATT) submitted TD-SCDMA to the International Telecommunication Union (ITU) and was approved by ITU.

In the mobile operator side, in 1998 the MPT was restructured as MII, the establishment of a new independent regulator, and China Telecom was separated from MPT. Since 2000, China Telecom was further split up into four groups according to specific services, and one of them was China Mobile. From that time, China Mobile had been specifically dedicated to cellular phone services that use the GSM standard.

In 1993 due to less than one million mobile phone subscribers, the China's government decided to establish another player, China Unicom, in the mobile industry to compete with China Mobile (the former MPT/China Telecom). The formal establishment of China Unicom was in 1994 and it launched GSM mobile service in 1995. In order to encouraging competition in the industry, China Unicom was allowed to promote CDMA service at the same time in 2000.

After China Mobile and China Unicom built up their GSM/GPRS (General Packet Radio Service), and CDMA system networks aggressively, MII started to make a decision on 3G standards WCDMA (Wideband Code-Division Multiple-Access), CDMA2000, and TD-SCDMA in the past few years. In order to further encourage competition and promote the independent 3G standard, MII plans to grant more 3G licenses to operators such as China Telecom, China Netcom, China Unicom, and China Mobile after China's TD-SCDMA industry is mature.

4.3 CHINA'S COMMUNICATION EQUIPMENT INDUSTRIAL POLICY AND ITS DEVELOPMENT

As Figure 4 shows, being similar with China's FDI general policy, China's mobile telecom equipment industry including base stations and switches is divided into four stages in the past twenty years: equipment import, JV encouragement, JV encouragement and promoting domestic suppliers, and equipment exports. Because China Mobile (the former MPT/China Telecom) had a mission to promote domestic telecom vendors by 2000, using the enormous market as a bargaining power, JV encouragement was the main way to introduce advanced technology from foreign industrial leaders such as Siemens, Motorola, and Alcatel. Based

on the China's market size, domestic telecom vendors use the channel advantage to exchange technology.

Object	Policy	~1987	1994	1995	1999	2000	2001	2002	2004	2006~
Spectrum	License Rule	1G	GSM			GSM/CDMA				3G
Operators	Telecom Law	China Telecom		China Telecom/ China Union		China Mobile/ China Union		WTO/FDI Open		3G
IC Design	No.18 Document	Import Encouragement					Tax Refund & R&D Support			TD-SCDMA
COE Vender	FDI in COE	Import	JV Encouragement			JV and Domestic Suppliers			Export & TD-SCDMA	
CPE Vender	No.5 Document	Import Encouragement					Licenses		Quality	Open

Figure 4. The development steps of China's mobile industry by an industrial policy view

After 2000, MII started to introduce CDMA technology to further enhance domestic firms' ability. Following up the WTO agreement and MII's interposition, Qualcomm agreed to charge only a 2.5% license fee for China's domestic firms such as ZTE, Huawei, and Eastern to produce and sell CDMA telecom equipment and cellular phones. This ratio is lower than Qualcomm charging 5~8% for global manufacturers.

After the process of technology transfer from foreign firms in telecom equipment, several domestic firms such as Great Dragon, Datang, ZTE, Huawei, and Eastern telecom companies have built up their R&D and sales ability. Huawei and ZTE have exported telecom equipment to developing countries actively since 2002. In the future, MII can continue to guide technology transfer by choosing 3G standards flexibly including WCDMA, CDMA2000, and TD-SCDMA. The MII policy is to ensure that TD-SCDMA is commercially operable as soon as possible and to promote domestic firms leading the TD-SCDMA industry at the same time.

As for China's communications IC industry, its related policies are a part of China's semiconductor industrial policy, which was named as 'No. 18 Document'. Subsidies for R&D budgets and free interest loans are the main ways to support domestics IC design houses. China's IC design houses have already 0.13～0.25 micron design ability in 2006. Their product lines include WLAN (Wireless Local Area Network), SIM (Subscriber Identity Module), and GSM/GPRS/TD-SCDMA IC (Integrated Circuit).

4.4 THE PROGRESS OF THE POLICY DEVELOPMENT OF CHINA'S CELLULAR PHONE INDUSTRY

According to the plan of Ministry of Information Technology of China, the development of China's cellular phone industry can be traced back to 1998. The primary plan of MII was to establish a main policy for the independent knowledge property rights of the cellular phone industry in China.

After a specific meeting over the development of China's cellular phone industry was held by China's State Council in August 1998, MII coordinated the arrangement of various kinds of proposals covering strategy and policy. The issues included expediting technology transfers from foreign joint ventures and establishing research and development of cellular phones to promote 10 China GSM cellular phone suppliers, including Bird and TCL. In January 1999, China's State Council approved the 'No. 5 Document'. This was the beginning of how China's government promoted its domestic cellular phone suppliers by setting up its industry. The three stages of China's industrial policy on cellular phone are as follows (State Council of the People's Republic of China 1995; 2001):

(1) First stage: Using the market to exchange funds and technology (around year 2000)

The development of China's cellular phone industry can also be divided into three stages on the whole. By 1999, huge and latent business opportunities in China and cheap labour and land attracted the foreign investment into China. This strategy was to "exchange technology with the market." After 1999, in order to protect native manufacturers, the policy restricted foreign businesses with various investment limits and trade obstacles to help expand China's domestic cellular phone industry.

(2) Second stage: Propping up China's domestic cellular phone industry proactively (2000~2004)

The MII instructed seven items at the end of 1998, indicating support for domestic manufacturing abilities by attracting foreign investment. The 1998 MII policy guidelines are as follows.

(2.1) No longer allowing foreign companies to establish new individual proprietorships or joint venture factories, but still welcoming get core technology from foreign companies

(2.2) A foreign company must establish a research and development centre

(2.3) A joint venture factory must transfer technology quickly

(2.4) Import restrictions (reducing whole products as imports)

(2.5) Giving priority towards purchases of native products (establishing the laws to push national enterprises to purchase domestic products)

(2.6) Reducing taxes and giving out loans and subsidies

According to the above guides in 1999, MII carried out various control measures on the following grounds: MII once again put forward measures for propping up native manufacturers in November 1999, adopting the policy to limit foreign manufacturers of cellular phones in China's domestic products and sales, in principle forbidding the import of any GSM cellular phones. For foreign individual proprietorships and joint ventures, MII also enhanced the technology transfers, requesting foreign companies producing cellular phones in China with at least 60% for export to source at least 50% of their product components locally by the end of 2001. A company's sales quota is decided by its export ratio and localization of components.

(3) Third stage: Competition after market opening (2005~present)

After joining WTO in December 2001, China promised to relax the ceiling of foreign ownership in any domestic cellular phone company, increasing it from 25% in 2002, to 35% in 2003, and to 49% since 2005. China also plans to cancel foreign individual proprietorships and joint venture manufacturers in order to acquire domestic market share, such that they must transfer their technology. This will result in domestic cellular phone vendors in China losing the protection umbrella. After 2005, domestic companies with competitive ability can export their products to the overseas market (Ministry of Information Technology of China 1999).

For tariffs on key components, China's authorities will put into practice the reduction of import tariff rates for key electronics components. The average tariff for key components in China's communications market was 13.3% in 2000 and then declined to 0% in 2003. Since 2005 there has been no tariff imposed on telecommunications products.

4.5 CHINA'S CELLULAR PHONE INDUSTRIAL POLICY AND ITS CURRENT CONDITION

In the past years, cellular phone manufacturers in China have faced the following regulations:

(1) Restriction of building factories:

China's government has developed specific enterprises and established a certification system. It is also its so-called macro control policy.

(2) Restriction of production and sales:

MII distributed 50 cellular phone manufacturer licenses in total. Among these licenses, GSM cellular phone licenses were issued to 13 joint ventures and 17 domestic enterprises. Twenty licenses for CDMA were also issued. Except for Motorola as a foreign capital enterprise, all the other licensed firms are domestic enterprises.

(3) Restriction of product certifications:

Before companies can sell their products in China, cellular phone manufacturers must get approval from both the Standardization Administration of China and the Examination Centre of MII for new models' development. The product must pass the examination of full type approval (FTA), model number approval, an electromagnetism compatible test, and an examination of connection with a network.

Therefore, the development of China's cellular phone industry is also divided into four stages on the whole. By 1999, huge and latent business opportunities in China and cheap labour and land attracted foreign investment into the country. In January 1999, China's State Council approved the 'No. 5 Document' including restriction of building factories, production, and sales. MII distributed 50 cellular phone manufacturer licenses in total. Among these licenses, GSM cellular phone licenses were issued to 13 joint ventures and 17 domestic enterprises. Twenty licenses for CDMA were also issued. Except for Motorola as a foreign capital enterprise, all other licensed firms are domestic enterprises. MII then enhanced the policy protection in 2002. Finally, MII released 'No. 5 Document' after 2005 to build up a fair competition environment between domestic and foreign firms (Xie and White, 2006).

CHAPTER 5 EFFECTS OF INDUSTRIAL POLICY ON R&D ACTIVITIES AND DEVELOPING STRATEGIES OF CHINA'S MOBILE INDUSTRY

5.1 DATA DESCRIPTION AND HYPOTHESIS TESTING

Our data provides information infrastructure on China's cellular phone industry and market. On the supply side, China became the largest cellular phone making country in the world from 1999 to 2004. Both foreign and local vendors' shipments in China have grown rapidly in recent years.

Our data presents China's domestic market share by quarters, and China's domestic vendors' cellular phones that were manufactured by their own SMT (surface mounted technology) line and the technology sources from local vendors for each period have grown a lot. If we use the ratio concept, then we will find that domestic vendors' total shipments and the proportion of SMT and technology are still lower. That is why after 2004, foreign vendors saw advantages of technology, with Nokia, Motorola and Samsung gaining market share quickly.

On the demand side, from 1998 to 2004, China has emerged as the largest mobile subscriber market in the world. According to an In-Stat report, mobile subscribers in China have grown to 272m in 2004, representing a hefty CAGR of over 50% for the period. The burgeoning growth of China's mobile subscribers has resulted in a rapid rise in mobile phone shipments.

Then we use MANOVA (Multivariate Analysis of Variance) to test the influences of China's communications industrial policy on its domestic cellular phone manufacturing industry. Each hypothesis is then tested by ANOVA (Analysis of Variance).

Hypotheses 1.1 & 1.2 Testing Results:

China's mobile industrial policy supports China Unicom to compete with China Mobile in order to increase market competition. Our data shows that the industrial policy of reducing market concentration significantly reduced usage fees. Figure 5 shows that the market share of China Mobile has been decreasing. From 1991 to 2005, China has emerged as the largest mobile subscriber market in the world. The number of mobile subscribers in China has grown to be more than 350 million in 2005.

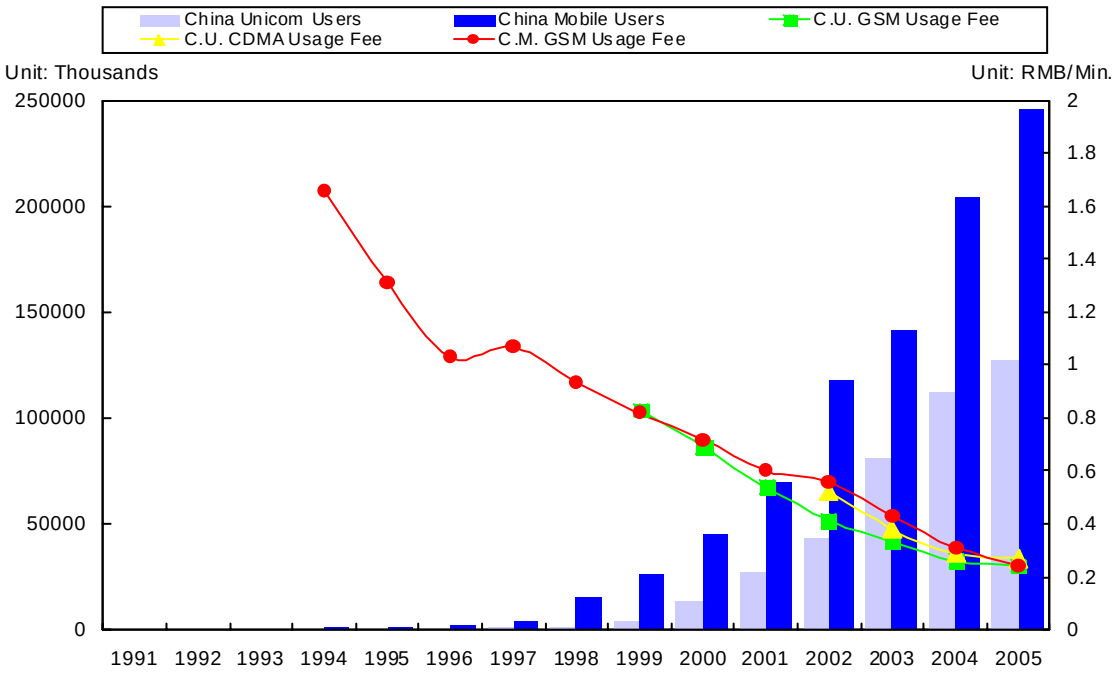


Figure 5. The growth of China's cellular phone users and the decline of the usage fee (Source: MII; Financial statements and newsletters of these companies)

Hypotheses 2.1 & 2.2 Testing Results:

The burgeoning growth of China's mobile subscribers has resulted in a rapid rise in building wireless infrastructure equipment including switches, base stations, network management systems, and so on. China's domestic telecom vendors such as Huawei and ZTE exchange technology through JV and channel advantages. From the newsletters of these companies, in the advanced 3G/3.5G technology, Huawei's WCDMA/HSPA (High-Speed Packet Access), ZTE's CDMA 2000 1x EVDO, and Datang's TD-SCDMA have matured.

Our data shows the effect of the industrial policy of promoting sales and the market shares of China's local telecom equipment vendors are both significant. The data also shows that the export and sales ability of China's major local telecom equipment vendors have been expanding quickly in the past years (Figure 6).

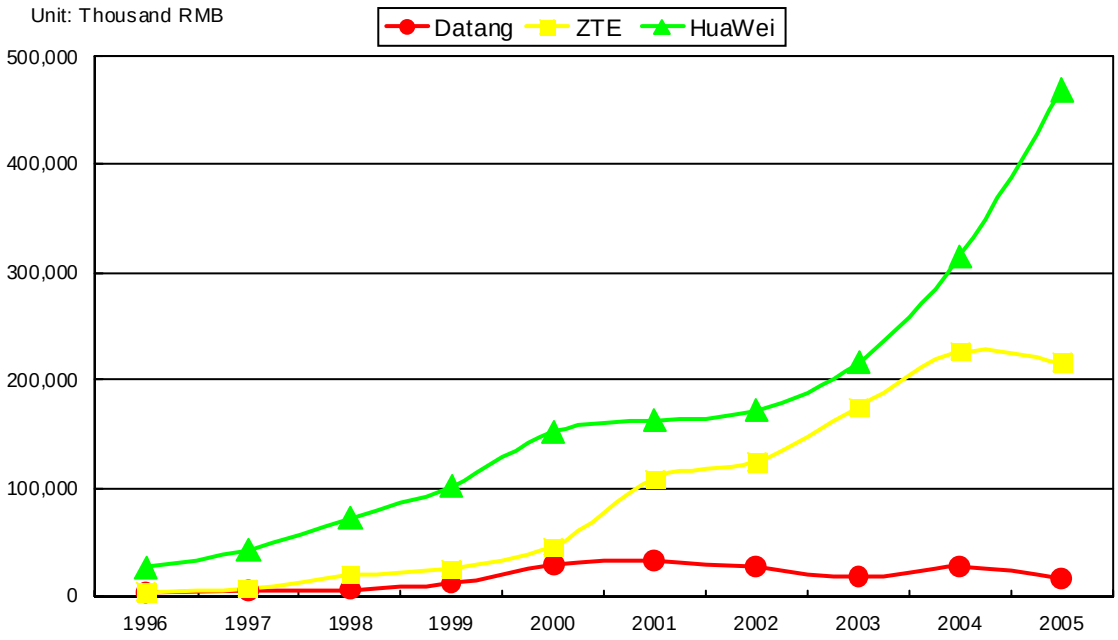


Figure 6. The growth of major Chinese telecom firms' sales (Source: MII; Financial statements and newsletters of these companies)

Hypotheses 3.1& 3.2 Testing Results:

After China became the largest cellular phone making country in the world, both foreign and local vendors' shipments in China have grown rapidly in recent years. The total shipments grew to more than 300 million in 2005 (Figure 7).

On the own brand shipment side, China's cellular phone industrial policy of supporting its native brand manufacturers does have a positive influence, and according to our data it is significant. If we use local vendors' market share to check, our test also shows that the influence of the policy is significant.

On the shipment volume side, China's cellular phone industrial policy of supporting its domestic manufacturers does have a positive influence, and according to our data it is significant. If we use local maker shipments to account for total shipments, our test also shows that the influence of the policy is significant.

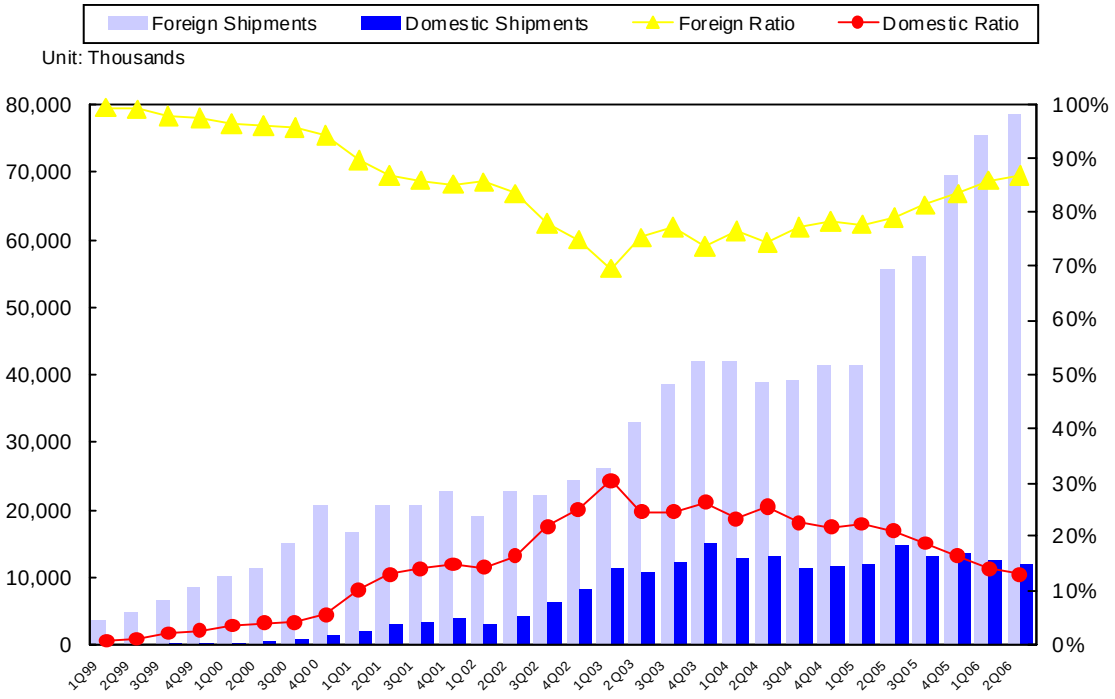


Figure 7. The production shipments and shipment ratio of China's local vendors

Hypotheses 4.1 & 4.2 Testing Results:

For the shipments by local vendors' SMT-Line self-assemble, China's cellular phone industrial policy of supporting its domestic manufacturers to develop their own ability is a positive influence, and according to our data it is significant.

If we use local makers' SMT-Line self-assemble shipments to account for total local maker shipments, due to local vendors depending on outsourcing or posting a brand strategy, we think the ratio will be lower. Our test shows a negative influence of the policy being significant.

On the technology source from the local vendor side, China's cellular phone industrial policy has a positive influence of supporting domestic manufacturers to develop their own technology ability, and according to our data it is significant.

If we use local makers' own technology shipments to account for total local makers' shipments, due to local vendors depending on outsourcing or posting a brand strategy, we think the ratio will be lower. Our test shows that the negative influence of the policy is significant.

Combining the result of Hypotheses 3 & 4 Testing, during the 1999~2006 period, China's cellular phone industrial policy of promoting its domestic brand manufacturers has some significantly positive influences such as promoting the shipment volume, own brand shipment, and local vendors' market share. However, because of the industrial policy protection, gaining market share was a top priority for China's cellular phone manufacturers. China's cellular phone industrial policy meant that domestic vendors ignored enhancing their innovative capacities.

We also find that domestic vendors' total shipments and the proportion of SMT and technology are still low. Since local vendors depend on outsourcing or posting a brand strategy, the ratio of local makers' SMT-Line self-assemble shipments to total local makers' shipments significantly declines. Similarly, because local vendors heavily depend on strategies of outsourcing or posting a brand strategy, the ratio of local makers' own technology shipments to total local makers' shipments significantly decreases.

Hypothesis 5 Testing Results:

Our data shows the effect of industrial policy of promoting export shipments and the export shipment ratio of local vendors. On the shipment volume side, China's cellular phone industrial policy of supporting its domestic manufacturers has a positive influence, and according to our data it is significant. Our test also shows that the positive influence of the policy on the export shipment ratio is significant (Figure 8).

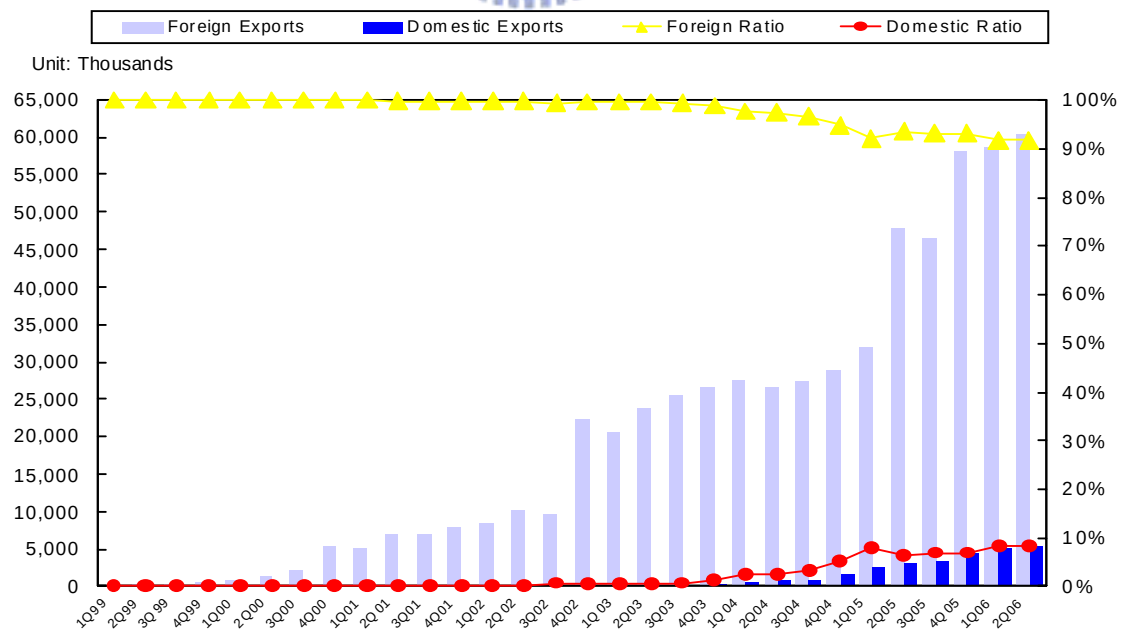


Figure 8. The export shipments and shipment ratio of China's local vendors

5.2 R&D ACTIVITIES

After China Unicom and China Mobile became the largest CDMA and GSM operators in the world, MII promoted its domestic manufacturing industry aggressively. Because of industrial policy support, both domestic cellular phone and telecom equipment industries have grown rapidly. However, aside from gaining market share, China's cellular phone and telecom equipment firms have different R&D activities in this period. Comparing with telecom equipment firms, China's cellular phone industrial policy pushed domestic vendors to ignore enhancing their innovative capacities.

There has been a gap in R&D intensity between China's and global major cellular phone firms in the past years. For example, TCL Communication and Ningbo Bird, the first two leaders of China's domestic cellular phone industry, saw R&D expenses between 5.10% and 0.82% as a part of revenue. During the same time, major foreign cellular phone firms have been paying more attention to R&D. Nokia, Motorola, Samsung, and LG's R&D intensity were about 5% to 10%.

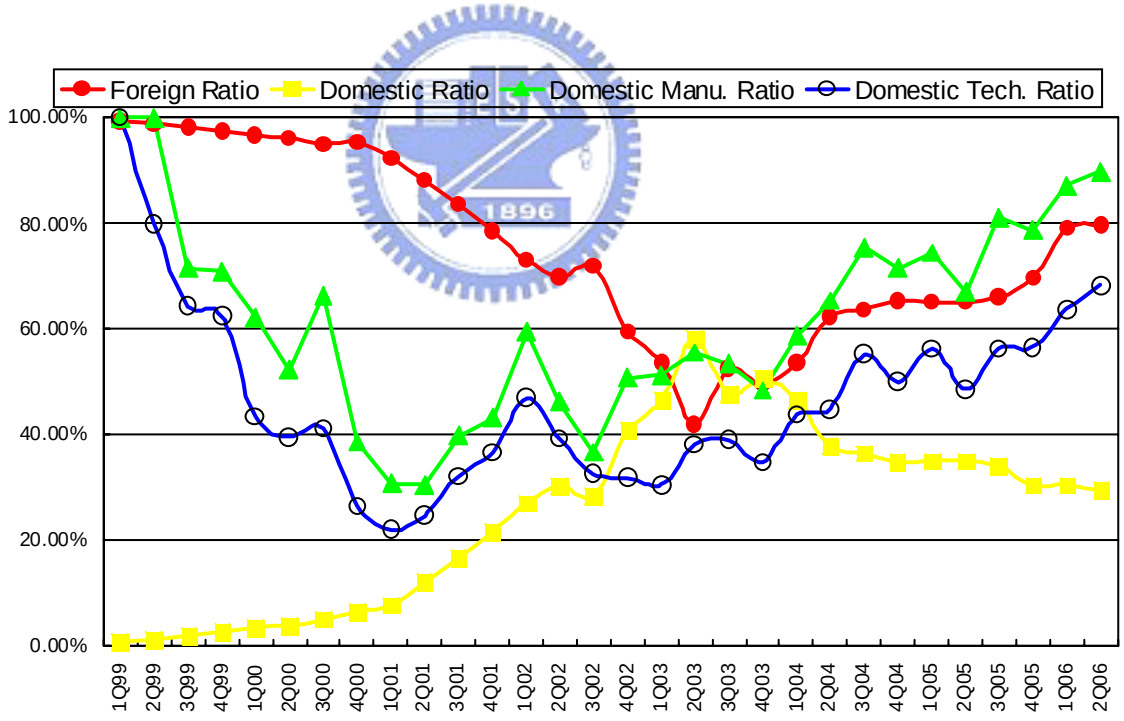


Figure 9. The market share, manufacturing and technology ratios of China's local vendors

Related to Western and South Korean products, some key weaknesses of China's firms include a lack of innovative experience and low R&D investments. As a result, higher defect rates damaging brand perception have become domestic vendors' Achilles heel. That

is why after 2004, foreign vendors saw advantages of technology, with Nokia, Motorola, and Samsung gaining market share quickly (Figures 9 and 10).

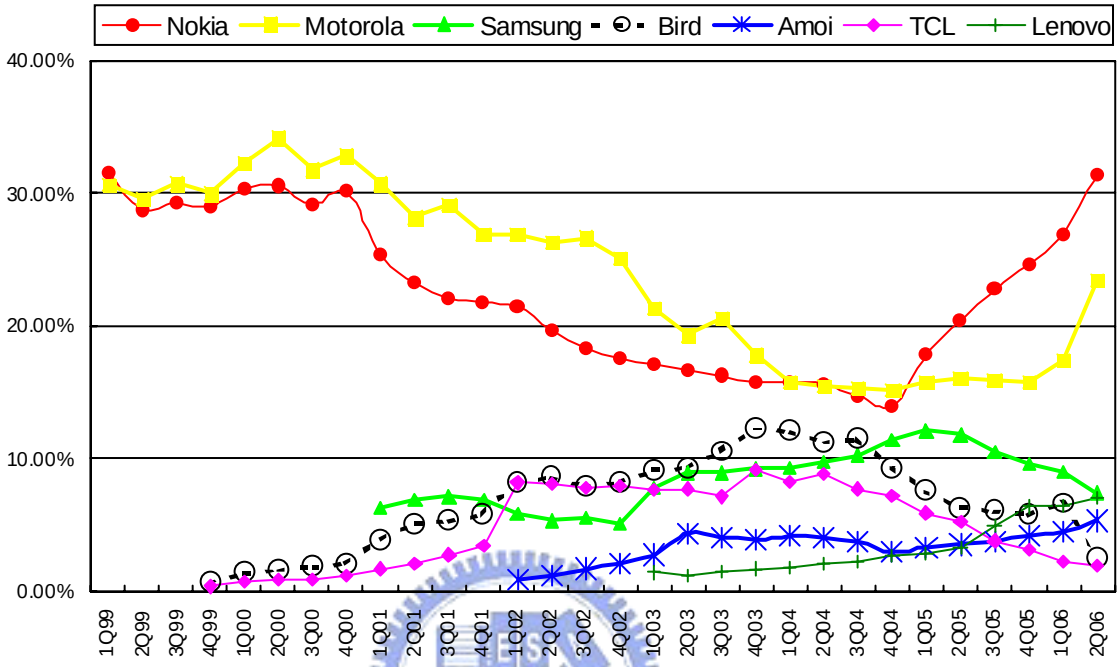


Figure 10. Market shares of China's major cellular phone players (Source: Sino-MR; TRI)

From 2004, Nokia initiated an aggressive price war in China to secure a dominant market share. At the same time, Motorola, Samsung, and Sony-Ericsson launched new handset models with advanced technological features, such as camera phones with higher pixels, more resolution colour display, GPS, and Bluetooth. In the past year, around 500 new models have entered the Chinese market, but domestic handset vendors are slow in new product rollout and lack mobile phones with new applications. In fact, after hitting over 50% market share in 2003, the market share of local handset makers has started to trend down step by step. In order to conquer their products' defects, alliances between Chinese domestic handset vendors and global brand vendors have emerged as a very significant development, such as between TCL and Alcatel.

We also used different communications firms to compare the effects of industrial policy on innovative activities. Huawei and ZTE are the first two telecom equipment firms in China. Their product lines include base stations, switches, and routers. They were promoted by China's telecom industrial policy, because of their central official equipment. Huawei and ZTE's R&D expenses of revenue were about 10%.

Comparing with Huawei and ZTE, China's major telecom equipment firms have higher R&D intensity than China's major cellular phone firms. The development of China's telecom equipment industry is highly related with China's operators, such as China Unicom. Huawei and ZTE have to enhance their innovative ability to compete with foreign firms in the telecom bidding market. Therefore, we can see firms' different innovative activities with different backgrounds.

Table 2. The structure of China's domestic TD-SCDMA industry

	Standard	IC	Smart Antenna	Device	Infrastructure	Testing
Domestic Vendors	Datang	Spreadtrum T3G (Datang) Commit (Potevio) Vimicro LHWT	Haitian Tongyu	TCL Bird Amoi Konka Huawei ZTE Lenovo Haier UTStarcom	Huawei ZTE Potevio FiberHome Datang UTStarcom	Zhongyou Zhongchuang

Table 3. The growth of China's domestic communication IC vendors (Unit: Million USD)

Communication IC Vendors	2002	2003	2004	2005	Startup
Datang Microelectronics Technology	26	78	94	72	1998
Vimicro Microelectronics	5	20	53	96	1999
Beijing LHWT Microelectronics	-	14	-	-	2001
Spreadtrum Communications	-	-	13	25	2001
Domestic industrial market share	0.78%	2.14%	2.18%	2.22%	

Source: CCID

Table 4. ANOVA test of industrial policy for reducing the level of industrial concentration and the usage fee of China's cellular phone users

	Mean of industrial concentration	P-level	Means of the usage fee	P-level
~1994	1.0000	0.0001***	1.6600	0.0003***
1995~2000	0.9403		0.9800	
2001~2005	0.7290		0.4280	

Note: *** represents significance at 1% level

Table 5. ANOVA test of industrial policy for promoting sales and the market share of China's local telecom equipment vendors (Unit: Thousand RMB)

	Mean of China's local telecom equipment vendors' sales	P-level	Mean of China's local telecom equipment vendors' market share	P-level
~1998	60,937	0.0053***	0.0403	0.0004***
1999~2001	222,537		0.0972	
2002~2005	500,390		0.1738	

Note: *** represents significance at 1% level

Table 6. The export and sales ability of China's major local telecom equipment vendors (Unit: Thousand RMB)

	2000	2001	2002	2003	2004	2005
Huawei Sales	1,520,000	1,622,895	1,721,420	2,166,990	3,152,126	4,696,689
Huawei Export	70,000	99,873	225,014	371,205	855,300	1,733,430
Export Ratio	4.61%	6.15%	13.07%	17.13%	27.13%	36.91%
ZTE Sales	452,343	1,092,614	1,245,389	1,745,705	2,269,815	2,157,592
ZTE Export	24,144	35,314	37,891	216,864	637,632	926,443
Export Ratio	5.34%	3.23%	3.04%	12.42%	28.09%	42.94%

Source: MII; Financial statements and newsletters of these companies.

Table 7. ANOVA test of industrial policy for promoting the shipment of China's cellular phone industry (Unit: Thousands)

	Mean of total shipments	P-value	Mean of domestic shipments	P- value	Mean of the domestic shipment ratio	P- value
1999.1Q~1999.4Q	6,050	<0.0001***	115	<0.0001***	0.0166	<0.0001***
2000.1Q~2001.4Q	19,163		1,898		0.0874	
2002.1Q~2004.4Q	42,446		10,079		0.2314	
2005.1Q~2006.2Q	75,988		12,985		0.1762	

Note: *** represents significance at 1% level

Table 8. ANOVA test of industrial policy for promoting assembly shipments by local vendors' own SMT-Line (Unit: Thousands)

	Shipment Mean of Self-assembly	P-value	Self-owned SMT Ratio Mean	P-value
1999.1Q~1999.4Q	88	<0.0001***	0.8557	<0.0001***
2000.1Q~2001.4Q	750		0.4532	
2002.1Q~2004.4Q	5,771		0.5600	
2005.1Q~2006.2Q	10,292		0.7970	

Note: *** represents significance at 1% level

Table 9. ANOVA test of industrial policy for promoting the self-owned technology ratio and the technology source from local vendors (Unit: Thousands)

	Mean of Tech. Source From Local Vendors	P-value	Mean of Self-owned Tech. Ratio	P-value
1999.1Q~1999.4Q	78	<0.0001***	0.7670	<0.0001***
2000.1Q~2001.4Q	588		0.3326	
2002.1Q~2004.4Q	4,100		0.4053	
2005.1Q~2006.2Q	7,508		0.5824	

Note: *** represents significance at 1% level

Table 10. ANOVA test of industrial policy for promoting local brand vendors' shipments and market shares (Unit: Thousands)

	Mean of local brand vendors' shipments	P-value	Mean of local brand vendors' market shares	P-value
1999.1Q~1999.4Q	100	<0.0001***	0.0163	<0.0001***
2000.1Q~2001.4Q	1,199		0.0953	
2002.1Q~2004.4Q	6,700		0.4035	
2005.1Q~2006.2Q	6,543		0.3233	

Note: *** represents significance at 1% level

Table 11. ANOVA test of industrial policy for promoting the export shipments and the export shipment ratio of local vendors (Unit: Thousands)

	Mean of local vendors' export shipments	P-value	Mean of the local vendors' export shipment ratio	P-value
1999.1Q~1999.4Q	0	<0.0001***	0.0000	<0.0001***
2000.1Q~2001.4Q	4		0.0005	
2002.1Q~2004.4Q	403		0.0151	
2005.1Q~2006.2Q	4,103		0.0747	

Note: *** represents significance at 1% level

Table 12. F-test of the variation of two normal distributions for comparing with different ratios at different steps (1999.1Q~1999.4Q:; 2000.1Q~2001.4Q:; 2002.1Q~2004.4Q: Ⅲ ; 2005.1Q~2006.2Q: Ⅳ)

Mean of the domestic shipment ratio	Self-owned SMT ratio mean	Mean of Self-owned tech. ratio	Mean of local brand vendors' market shares	Mean of local vendors' export shipment ratio
Ⅰ ≠ Ⅱ	Ⅰ = Ⅱ	Ⅰ ≠ Ⅱ	Ⅰ ≠ Ⅱ	Ⅰ ≠ Ⅱ
(P=0.0096***)	(P=0.2934)	(P=0.0438**)	(P=0.0034***)	(P=0.0000***)
Ⅱ = Ⅲ	Ⅱ = Ⅲ	Ⅱ = Ⅲ	Ⅱ = Ⅲ	Ⅱ ≠ Ⅲ
(P=0.3393)	(P=0.2534)	(P=0.4309)	(P=0.1619)	(P=0.0000***)
Ⅲ = Ⅳ	Ⅲ = Ⅳ	Ⅲ = Ⅳ	Ⅲ ≠ Ⅳ	Ⅲ = Ⅳ
(P=0.3887)	(P=0.2897)	(P=0.4120)	(P=0.0046***)	(P=0.0755)

Note: *** represents significance at 1% level; ** represents significance at 5% level

Table 13. t-test of the mean of two normal distributions for comparing with different ratios at different steps (1999.1Q~1999.4Q: Ⅰ ; 2000.1Q~2001.4Q: Ⅱ ; 2002.1Q~2004.4Q: Ⅲ ; 2005.1Q~2006.2Q: Ⅳ)

Mean of the domestic shipment ratio	Self-owned SMT ratio mean	Mean of Self-owned tech. ratio	Mean of local brand vendors' market shares	Mean of local vendors' export shipment ratio
Ⅱ > Ⅰ	Ⅰ > Ⅱ	Ⅰ > Ⅱ	Ⅱ > Ⅰ	Ⅰ = Ⅱ
(P=0.0041***)	(P=0.0011***)	(P=0.0090***)	(P=0.0127**)	(P=0.0804)
Ⅲ > Ⅱ	Ⅱ = Ⅲ	Ⅱ = Ⅲ	Ⅲ > Ⅱ	Ⅲ > Ⅱ
(P=0.0000***)	(P=0.0679)	(P=0.0585)	(P=0.0000***)	(P=0.0079***)
Ⅲ > Ⅳ	Ⅳ > Ⅲ	Ⅳ > Ⅲ	Ⅲ > Ⅳ	Ⅳ > Ⅲ
(P=0.0162**)	(P=0.0003***)	(P=0.0002***)	(P=0.0175**)	(P=0.0000***)

Note: *** represents significance at 1% level; ** represents significance at 5% level

Table 14. Hypothesis testing results

Policy Target	Hypothesis	Results
To promote China's cellular phone market	China's industrial policy reduces the level of industrial concentration	+
	China's industrial policy reduces the usage fee of the end user	+
To promote China's local telecom equipment industry	China's industrial policy promotes local vendors' shipments (by sales)	+
	China's industrial policy promotes local vendors' own brand shipments (by market share)	+
To promote China's local cellular phone industry	China's industrial policy promotes local vendors' own brand shipments (by volume)	+
	China's industrial policy promotes local vendors' own brand shipments (by ratio)	+
To raise China's cellular phone industry from development and production of technology	China's industrial policy promotes local vendors' manufacturing ability (by volume)	+
	China's industrial policy promotes local vendors' manufacturing ability (by ratio)	–
	China's industrial policy promotes local vendors' technical ability (by volume)	+
	China's industrial policy promotes local vendors' technical ability (by ratio)	–
To enhance the export strength of China's cellular phones	China's industrial policy promotes local vendors' exporting ability (by volume)	+
	China's industrial policy promotes local vendors' exporting ability (by ratio)	+

Table 15. R&D spending of revenue of major cellular phone vendors in the world

	2000	2001	2002	2003	2004	2005
Nokia R&D Spending of Revenue	5.97%	6.89%	8.14%	8.44%	8.49%	9.38%
Motorola R&D Spending of Revenue	8.28%	9.69%	9.27%	10.13%	9.52%	10.41%
Samsung R&D Spending of Revenue	5.86%	5.88%	5.83%	6.00%	8.37%	10.08%
LG R&D Spending of Revenue	4.76%	4.47%	4.03%	3.91%	5.04%	6.02%
TCL R&D Spending of Revenue	2.51%	2.58%	1.08%	1.27%	2.99%	4.87%
Bird R&D Spending of Revenue	0.82%	1.24%	1.73%	2.88%	5.10%	1.66%

Source: MII; Financial statements and newsletters of these companies.

Table 16. The P-values of Mann-Whitney test of R&D intensities between Chinese and other foreign firms

	Nokia	Motorola	Samsung	LG
TCL	0.0039***	0.00394***	0.00394***	0.0250**
Bird	0.0039***	0.00394***	0.00394***	0.0374**

Note: *** represents significance at 1% level; ** represents significance at 5% level.

Table 17. R&D spending of revenue of major telecom equipment vendors in the world

	2000	2001	2002	2003	2004	2005
Ericsson R&D Spending of Revenue	15.77%	19.09%	20.12%	24.25%	17.75%	16.11%
Nokia R&D Spending of Revenue	13.10%	15.10%	15.20%	27.40%	18.57%	17.84%
Motorola R&D Spending of Revenue	11.95%	14.00%	13.90%	13.95%	11.90%	10.50%
Lucent R&D Spending of Revenue	10.99%	16.53%	18.75%	17.57%	14.04%	12.47%
Siemens R&D Spending of Revenue	10.20%	10.60%	11.50%	11.40%	11.30%	10.30%
Huawei R&D Spending of Revenue	13.62%	18.79%	17.75%	14.69%	12.60%	10.10%
ZTE R&D Spending of Revenue	11.96%	10.34%	9.49%	7.63%	9.92%	9.08%

Source: MII; CSFB; Unstrung Insider; Financial statements and newsletters of these companies.

Table 18. The P-values of Mann-Whitney test of R&D intensities between Chinese and other foreign firms

	Ericsson	Nokia	Motorola	Lucent	Siemens
Huawei	0.0453**	0.2002	0.3367	1.0000	0.0547
ZTE	0.0039***	0.0039***	0.0163**	0.0065***	0.1093

Note: *** represents significance at 1% level; ** represents significance at 5% level.

Table 19. The P-values of Mann-Whitney test of R&D intensities between Chinese telecom equipment and cellular phone firms

	Huawei	ZTE
TCL	0.0039***	0.0039***
Bird	0.0039***	0.0039***

Note: *** represents significance at 1% level.

CHAPTER 6 OUTLOOK FOR SOUTH KOREA'S CELLULAR PHONE INDUSTRY IN THE PAST YEARS

6.1 SOUTH KOREA'S MOBILE MARKET LED GLOBAL TRENDS

In second-generation (2G) cellular phone technology, South Korea's government decided to follow the CDMA system specification standard in 1996. Since 2001 South Korea has been the second largest CDMA market in the world. South Korea's mobile subscriber market grew quickly from 1996 to 2001 because of cellular phone subsidies (Kim, Byun and Park 2004; Lee, Bae and Lee 1994).

Because of its maturing market, South Korea's mobile subscriber growth rate has begun to decline in recent years. From 2002, the growth rate of its domestic cellular phone market declined to less than 5%. Given the slowing demand in South Korea, SKT, the biggest telecommunications operator there, announced that it's 3G service would be based on CDMA2000 1xEV-DO technology in November 2002. This allowed mobile operators to expand in data services.

As 3G services have emerged in South Korea, including SKT, KTF, and LGT, most of South Korea's major mobile operators have followed the CDMA2000 system. Recently South Korea also promoted WCDMA and CDMA2000 1xEV-DO at the same time. Although the market had matured, the brisk sales of high gross profit margin 3G phones incited domestic vendors to launch 3G phones and multimedia cellular phones to replace existing 2G/2.5G series cellular phones. This allowed them to chase additional earnings growth. Thus, mobile phones with colour screens, cameras, MP3 (MPEG Audio Layer III) players, GPS (Global Positioning System), and TV tuner functions are now quite popular. Colour display and camera cellular phones accounted for 95% of the total shipments in 2005.

South Korea has been a leader over other cellular phone markets compared to other economies. In 2002, when cellular phones with colour displays, CSTN, or TFT LCD only accounted for 24% of total global shipments, colour cellular phone shipments in South Korea's market accounted for more than 50%. In 2003, when cellular phones with camera modules only accounted for 15.2% of total global shipments, camera cellular phone shipments in South Korea's market accounted for more than 50%. SK Telecom (SKT), Korea Telecom Freetel (KTF), and LG Telecom (LGT) have been very aggressive in promoting MP3 player services from 2004 to now, such as SKT MelOn and LGT musicON. As a result, MP3 player cellular phones accounted for close to 85% of total new models in Korea in 2005, while only enjoying a market share of 15% globally (Table 20).

Table 20. The milestones of South Korean cellular phone industry

Time	Cellular Phone Industrial Milestone	Innovative Cellular Phone Product	Domestic Market Index	Global Total Market Index
1983	Start to manufacture 1G cellular phone			
1991	Cooperate with Qualcomm (CDMA)			
1996			CDMA service announcement	
1999		Music phone		
2000	Cooperate with Microsoft and Palm (OS)	Dual-display phone Camera phone TV phone		
2002	Cooperate with Symbian (OS)	VOD (video on demand) phone	Colour phone accounts for over 50%	Colour phone accounts for 24%
	Cooperate with Mitsubishi (camera module solution)	CDMA2000 1x EV-DO and WCDMA 3G phone	3G service announcement	
2003	Cooperate with Infineon (smart-phone chipset solution)	1, 2 mega pixels camera phone	Camera phone accounts for over 50%	Camera phone accounts for 15.2%
	Cooperate with Datang (TD-SCDMA)	Video phone		
	Cooperate with Philips (TD-SCDMA)			
2004	Cooperate with Intel (WiMAX)	3, 4, 7 mega pixels camera phone DMB phone MP3 phone	Colour and camera phone account for over 95%	Camera phone accounts for 30.8%; Colour phone accounts for 62.5%
2005	Cooperate with Lucent (HSDPA)	TD-SCDMA /GSM/WCDMA phone	MP3 phone account for 85%; 3G phone accounts for over 50%	MP3 phone account for 15%; 3G phone accounts for 10%

Source: Financial statements and newsletters of South Korean companies, IDC.

6.2 DEVELOPMENT HISTORY OF SOUTH KOREAN CELLULAR PHONE FIRMS

This study, about developing economies in settings like South Korea, presents the result of how technology evolves through the initiation stage, the internalisation stage, and the generation stage at the industry and firm levels. In order to promote technological innovation, firms conduct not only in-house R&D, but also form closer technological partnerships with other firms, universities and government research institutes. Through the internalisation process, latecomers can produce their own products and decrease their dependency on foreign technologies for manufacturing products (Chung, Bae and Kim 2003; Lee et al. 1988).

Table 20 shows development path and catch-up strategies of South Korean cellular phone firms. South Korean firms started to manufacture cellular phones in 1983; later than Nokia (1968) and Motorola (1973). At the same time, South Korea's industry was establishing a new research infrastructure in the 1980s. Since the beginning of the 1980s, many corporate research institutes have been established which have become major players in South Korea's innovation system. Many of South Korea's big enterprises are able to compete with the world's best enterprises in maintaining technological leadership (Chung 2001). Even so, that is not enough to develop a competitive cellular phone industry. The Base-Band cellular phone solution is a key point.

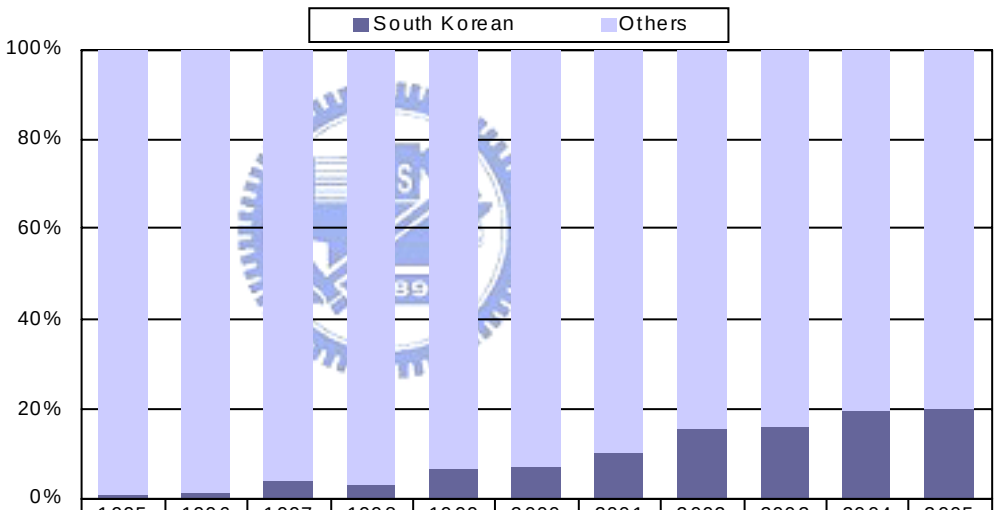
South Korea's government decided to cooperate with Qualcomm (U.S.), the biggest CDMA IC design house, to develop CDMA cellular phones in 1991. The CDMA standard, just behind GSM, is the second most widely-used 2G standard in the world. This decision helped South Korean firms capture market share, such as the U.S. and China markets. This was the same strategy used by some of the large cellular phone firms, such as Ericsson and Nokia, changing alliance formations over the industry life cycle in response to changing organisational needs and industry imperatives (Rice and Galvin 2006).

South Korean cooperation with Qualcomm produced mobile services based on CDMA, CDMA2000, CDMA2000 1x, and CDMA2000 1xEV-DO technologies, step by step from 2G to 3G after 1996. Because the design platform had been developed by Qualcomm and South Korea's cellular phone market is closed, operators always place an order with local vendors such as Samsung or LG as a first priority. As a result, South Korea's CDMA series cellular phone manufacturers developed their brand names based on how quickly the domestic market grew. On the domestic cellular phone market share side, the condition whereby South Korean firms were market leaders remained almost unchanged after 2G. There were more than fifty cellular phone manufacturers in South Korea in 2003, including Samsung

Electronics, LG Electronics, Pantech & Curitel Communications (spun off from Hynix Semiconductor), and other small and medium-sized companies.

6.3 SOUTH KOREAN CELLULAR PHONE MAKERS' GLOBAL MARKET SHARE AND EXPORT VALUE

Figure 11 and Figure 12 show the South Korean cellular phone makers' global market share and export value. On the global market share side, from 1998 to 2005, Samsung and LG very quickly achieved remarkable global market share. They even hit a market share of over 20% of total global shipments in 2005 and were only behind Finland's Nokia. According to cellular phone maker data, Samsung, just behind Nokia and Motorola, was the third largest company by market share in 2005, with LG having the fifth largest market share.



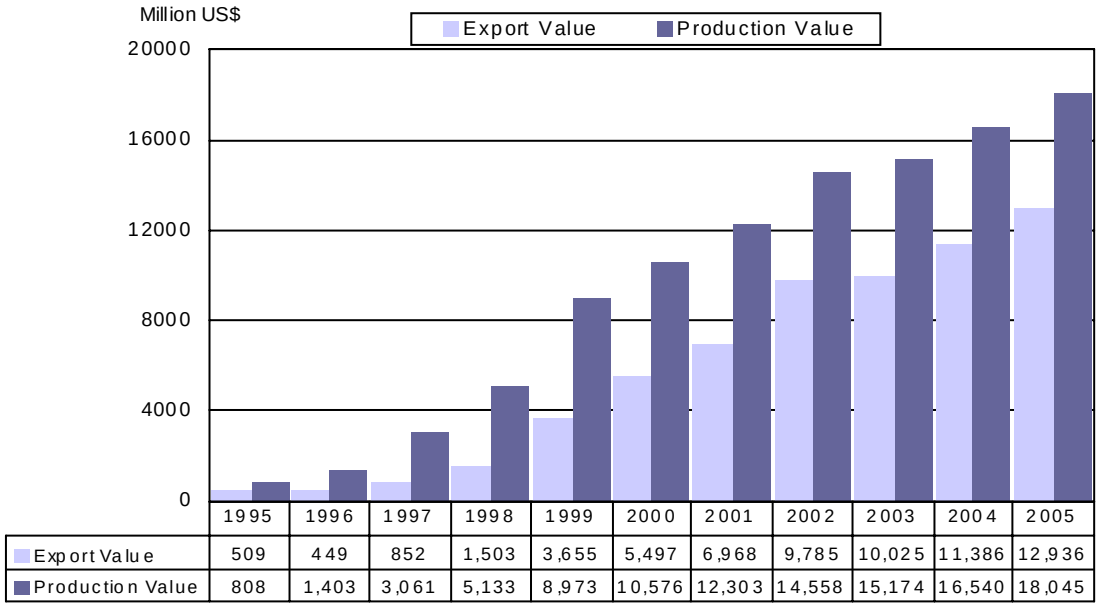
	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Others	99.20%	98.80%	96.30%	96.80%	93.40%	93.10%	89.80%	84.60%	84.40%	80.80%	79.90%
South Korean	0.80%	1.20%	3.70%	3.20%	6.60%	6.90%	10.20%	15.40%	15.60%	19.20%	20.10%

Figure 11. South Korean cellular phones' worldwide market share by shipments

Source: Dataquest

On the cellular phone export side, before 1998 almost no cellular phones were exported from South Korea. Since the beginning of 1999, the cellular phone export value from there began to increase dramatically, especially in CDMA series cellular phones. Aside from CDMA phones, Samsung Electronics, LG Electronics and Pantech & Curitel, the first three cellular phone domestic brands, also developed GSM/GPRS/WCDMA cellular phone products at the same time. In 2005 the export value of South Korean cellular phones reached US$12.94 billion, with a 71.69% share of total production value and a growth rate of

13.61%.



	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Export Value	509	449	852	1,503	3,655	5,497	6,968	9,785	10,025	11,386	12,936
Production Value	808	1,403	3,061	5,133	8,973	10,576	12,303	14,558	15,174	16,540	18,045

Figure 12. South Korean cellular phones' export value and total value

Source: KISDI

CHAPTER 7 INTRODUCTION SOUTH KOREA'S CELLULAR PHONE INDUSTRIAL INNOVATION MODEL

7.1 R&D EMPLOYEES, R&D INTENSITY AND PRODUCT ASP

In the ICT industry R&D expense as a part of revenue is an important index to evaluate how a company emphasises innovation. Another index that usually has a high correlation with R&D expense is R&D engineers as a part of the total employees. In order to catch up to foreign world market leaders, Samsung Electronics expanded from 12,000 R&D engineers in 1997, to more than 20,000 in 2003, and 27,000 in 2005. There were 7,000 cellular phone R&D engineers in 2005 among its total R&D team. The ratio of R&D engineers to total employees was 22% in 1997, moving to 36% in 2005.

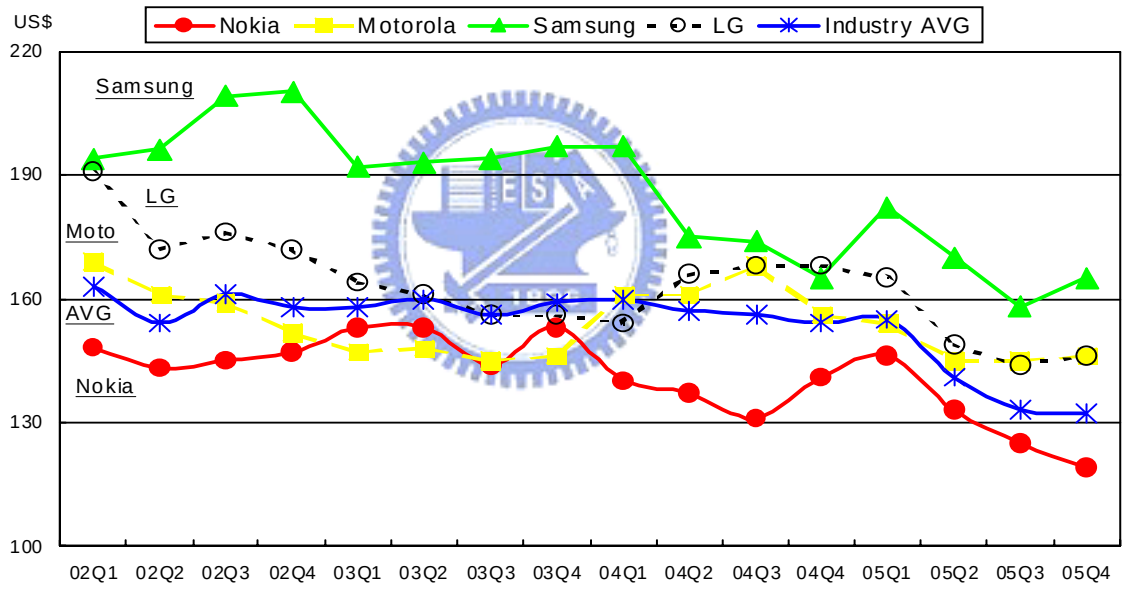


Figure 13. Product ASP of major cellular phone vendors in the world

Source: Financial statements and newsletters of these companies

Figure 13 shows the cellular phone ASP of the major vendors in the world. We find that Korea's cellular phone makers, such as Samsung and LG, do not use the low cost oriented strategy to gain market share. On the contrary, they focus their attention on the global mid-to-high end cellular phone market. Samsung's ASP, for the most part, is above US$180 and the highest in the industry. In contrast with Samsung, the industry's average ASP is under US$160 from 2002 to 2005.

Table 21 shows the P-values of the Mann-Whitney test of the cellular phone ASP between

South Korean and other foreign firms. The result shows a significant ASP between South Korean and other foreign firms. Compared with Samsung's high-end focus, LG mainly aims at the mid-to-high end market as well while Nokia, Motorola, BenQ-Siemens, and Alcatel have a relatively wider range of product lines.

Table 21. The P-values of Mann-Whitney test of the cellular phone ASP between South Korean and other foreign firms

	Nokia	Motorola	Industry AVG
Samsung	< 0.00001***	<0.00001***	<0.00001***
LG	<0.00001***	0.02918**	0.02875**

Note: *** represents significance at 1% level; ** represents significance at 5% level.

As low-end products are the major part of sales growth, and price wars have erupted in this market, the ASP and operating margins of cellular phone firms have decreased. Major global brand cellular phone companies are divided into two categories in terms of their profit capacity. The first category group is Samsung and Nokia, whose profitability maintained around 20-25% before 2004. The other group includes Motorola, Siemens (its cellular phone division was acquired by BenQ in 2005), and other small and medium-sized companies with profitability below 10% (Table 22).

Researchers suggest that companies put more R&D resources to raise the quality of products (Galan and Sanchez 2006). However, in spite of Samsung's high-end focus, there is no evidence that Samsung's R&D expenses and intensity are superior to Nokia or Motorola.

Table 22 shows a comparison of R&D expenses, R&D intensity, and revenue of major cellular phone vendors in the world. Samsung increased its R&D expense from 5.86% in 2000 to 10.08% in 2005. Tables 23 and 24 show the P-values of the Mann-Whitney tests for R&D intensity and R&D expenses between South Korean and other foreign firms. The P-values represents a significant gap between South Korean and other foreign firms. The R&D intensity and R&D expenses of South Korean firms were significantly lower than other foreign firms in the past. However, South Korean firms are beginning to catch up and even to leapfrog.

Table 22. R&D expenses and revenue of major cellular phone vendors in the world

(Million US$)	2000	2001	2002	2003	2004	2005
Samsung Cellular Phone Revenue	5168	6769	10202	11920	17085	16849
Samsung Cellular Phone R&D Expenses	302	399	595	710	1430	1700
R&D Spending of Revenue (%)	5.86	5.88	5.83	6.00	8.37	10.08
Operating Margin (%)	12.00	17.00	26.80	20.50	15.00	12.00
LG Cellular Phone Revenue	1248	2191	2814	4355	7265	7421
LG Cellular Phone R&D Expenses	59	98	113	170	366	447
R&D Spending of Revenue (%)	4.76	4.47	4.03	3.91	5.04	6.02
Operating Margin (%)	-	10.00	9.75	4.80	6.30	6.90
Nokia Cellular Phone Revenue	24076	25532	27789	29342	27595	33184
Nokia Cellular Phone R&D Expenses	1437	1759	2261	2477	2342	3113
R&D Spending of Revenue (%)	5.97	6.89	8.14	8.44	8.49	9.38
Cellular Phone Operating Margin (%)	22.30	20.10	22.80	23.60	17.80	13.60
Motorola Cellular Phone Revenue	13267	10448	10847	10978	16823	17800
Motorola Cellular Phone R&D Expenses	1098	1012	1006	1112	1602	1853
R&D Spending of Revenue (%)	8.28	9.69	9.27	10.13	9.52	10.41
Operating Margin (%)	4.00	-3.10	7.30	4.80	10.40	11.50

Source: Financial statements and newsletters of these companies.

Table 23. The P-values of Mann-Whitney test of R&D intensities between South Korean and other foreign firms

	Nokia	Motorola
Samsung	0.240260	0.0411256**
LG	0.004329***	0.0021645***

Note: *** represents significance at 1% level; ** represents significance at 5% level.

Table 24. The P-values of Mann-Whitney test of R&D expenses between South Korean and other foreign firms

	Nokia	Motorola
Samsung	0.0043290***	0.1796536
LG	0.0021645***	0.0021645***

Note: *** represents significance at 1% level.

Therefore, we explained how South Korean firms achieve competitiveness by comparing R&D efficiencies. Table 25 shows the comparison with R&D efficiency of major cellular phone vendors in the world. Table 26 shows the P-values of Mann-Whitney test of R&D efficiencies between South Korean and other foreign firms. We find that the R&D efficiencies of South Korean firms were higher than other foreign firms. South Korean firms are able to gain more patents under the same R&D resources.

Table 25. R&D efficiency of major cellular phone vendors in the world

(Million US$)	2000	2001	2002	2003	2004	2005
Samsung Cellular Phone Patents	469	479	406	392	444	379
Samsung Cellular Phone R&D Expenses	302	399	595	710	1430	1700
Samsung R&D Efficiency	1.5530	1.2005	0.6824	0.5521	0.3105	0.2229
Samsung R&D Efficiency (Logarithm)	0.1912	0.0794	-0.1660	-0.2580	-0.5079	-0.6519
LG Cellular Phone Patents	94	117	141	144	192	163
LG Cellular Phone R&D Expenses	59	98	113	170	366	447
LG R&D Efficiency	1.5932	1.1939	1.2478	0.8471	0.5246	0.3647
LG R&D Efficiency (Logarithm)	0.2023	0.0770	0.0961	-0.0721	-0.2802	-0.4381
Nokia Cellular Phone Patents	350	402	503	628	711	542
Nokia Cellular Phone R&D Expenses	1437	1759	2261	2477	2342	3113
Nokia R&D Efficiency	0.2436	0.2285	0.2225	0.2535	0.3036	0.1741
Nokia R&D Efficiency (Logarithm)	-0.6133	-0.6411	-0.6527	-0.5960	-0.5177	-0.7592
Motorola Cellular Phone Patents	663	441	350	302	333	280
Motorola Cellular Phone R&D Expenses	1098	1012	1006	1112	1602	1853
Motorola R&D Efficiency	0.6038	0.4358	0.3479	0.2716	0.2079	0.1511
Motorola R&D Efficiency (Logarithm)	-0.2191	-0.3607	-0.4585	-0.5661	-0.5672	-0.8207

Source: United States Patent and Trademark Office and financial statements and newsletters of these companies.

Table 26. The P-values of Mann-Whitney test of R&D efficiencies between South Korean and other foreign firms

	Nokia	Motorola
Samsung	0.025974**	0.1320346
LG	0.002165***	0.0151515**

Note: *** represents significance at 1% level; ** represents significance at 5% level.

Moreover, the South Korean manufacturing strategy is very different from that used by western firms. Samsung and LG do not have an outsourcing strategy, except for a few very low-end products, such as CDMA phones that target China's market. From 1999 to 2004, South Korea was only behind China as the second largest cellular phone manufacturing base in the world.

7.2 INNOVATION MODELS OF NEW PRODUCTS HAVE LED GLOBAL TRENDS

In order to keep its product image in the high-end market, Samsung and LG are increasingly bringing new product generations to the global market place. According to them, cellular phone vendors have been looking for ways to differentiate their products from those of the competition. One way is to offer added functions or applications to a cellular phone's capabilities. For instance, currently one can receive voice and data messages with cellular phones, take pictures, enjoy music, get stock quotes and check e-mail and such. The near future functions such as bar code scanning, optical character recognition and even the ability to monitor physical health will be part of the standard cell phone repertoire (Kumar and Zahn 2003).

Table 20 shows that Korean makers catch up through alliances with foreign firms. Although these foreign firms have advanced technology, they are not the first-tier players in market share (IDC, 2005). The resource-based and transaction cost theories predict that small companies or latecomers tend to catch up the industrial leaders via alliances (Prahalad and Hamel 1990; Anderson, Hakansson and Johanson 1994). As a result, South Korean innovative cellular phones have let the global trend. As with Japanese cellular phones, Korean cellular phones have integrated many extra functions, such as GPS, TV tuner, fingerprint identification, smart card, and so on. South Korean cellular phones are the top two with the highest proportion of products equipped with colour screens, camera functions, and MP3 players in the global market.

Industry design is another quality weapon of South Korean firms. South Korean phones have popularised clamshell cellular phones and slide cellular phones and have challenged Nokia's bar phone. Like Japanese cellular phones again, South Korean cellular phones often have innovative industry design, such as hinges, sockets, accessories and connectors to change one's literal realisation of the cellular phone.

Based on Qualcomm's reference design solution, South Korean firms now offer added functions or applications to a cellular phone's capabilities. The abilities of integrating new components, creating interesting applications, and realizing the innovative idea are key

factors to design fancy models (Galan and Sanchez 2006). Table 27 shows the number of major cellular phone vendors' new models in 2003. Samsung presented 133 models in 2003, which is around 3 times of Nokia and around 2 times of Motorola. According to the company newsletter, Samsung presented 164 models in 2005 and kept its position as having the most models in the industry. To a certain extent, offering models means increasing marketing power and reducing leading time. On the other hand, firms that design more models have more time-to-market ability.

Table 27. The number of major cellular phone vendors' new models in 2003

	Samsung	LG	Nokia	Motorola
2003	133	112	46	65

Source: Financial statements and newsletters of these companies.

7.3 ACHIEVING INNOVATIVE CAPABILITY THROUGH AN INTEGRATED INDUSTRY CHAIN

Why do South Korean cellular phone firms have higher R&D efficiency? One of the reasons is their highly integrated industry chain. Many technology-based small firms in South Korea were spun off from Samsung and LG Electronics and received support from venture capital companies and government policies (Lee 2000). Therefore, South Korean up-stream component vendors have been enriching and improving their business with the stable growth of South Korea's mobile phone industry.

Figure 14 shows South Korea's cellular phone industrial supply chain. The industry chain includes display components, electronic components, peripherals, multimedia function components and so on. Except for base band and radio frequency chips, most of the key parts can be supplied by domestic vendors, even including camera modules, GPS modules, TV tuners, and MP3 player modules.

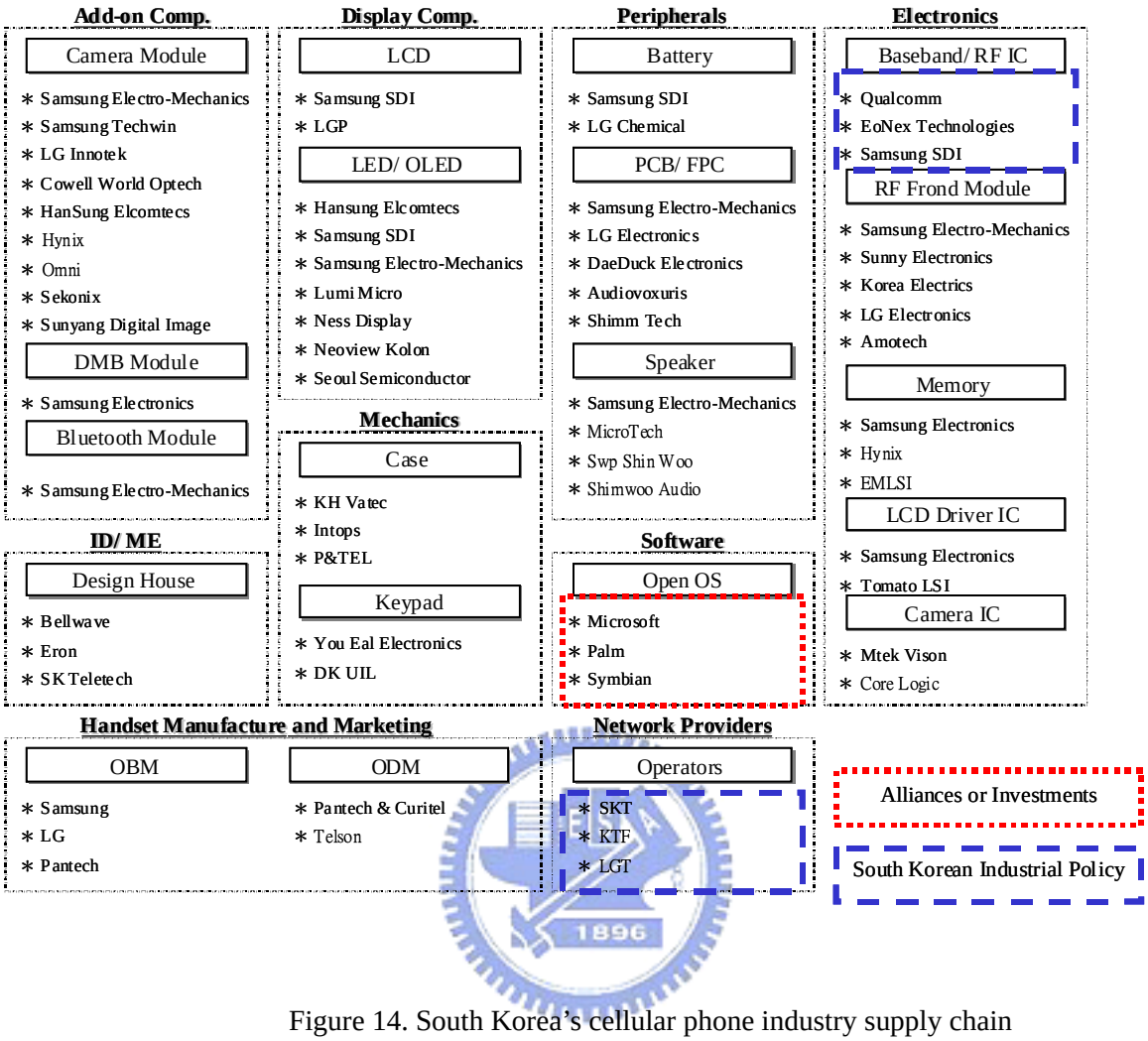


Figure 14. South Korea's cellular phone industry supply chain

Table 28 shows a comparison of vendors' cost control ability. Samsung purchases most of its cellular phone components from its own business group. Nokia and Motorola have a different strategy using large-scale outsourcing except for core components such as base band chips. Due to the highly integrated industry chain, Samsung has more BOM (Bill of Material) competitive cost advantages and lacks material shortages. Moreover, competition among component vendors and the complete interaction between upstream and downstream can help South Korean cellular phone firms have a better chance to use the newest components first and apply resources more flexibly.

Table 28. Comparison of vendors' cost control ability

Bill of Materials		US$	Percentage	Samsung	Nokia	Motorola
Electronics	Base band	7.0	10.2		◎	◎
	Memory	7.0	10.2	◎		
	RF+PA	5.0	7.3			
	RF Frond Module	1.5	2.2	◎		
Peripherals	RF Shielding	0.3	0.4			
	Connector	1.0	1.5			
	Speaker	0.5	0.7	◎		
	Microphone	0.4	0.6			
	Audio	0.2	0.3			
	PCB/FPC	3.0	4.4	◎		
	Battery	5.5	8.0	◎		
Mechanics	Mechanics Parts					
	Cover	8.0	11.7			
	Housing					
	Keyboard					
Add-on Comp.	Dual Display	18.0	26.3	◎		
	Camera Module	6.0	8.8	◎		
	Backend IC	5.0	7.3			
Total BOM Cost (%)		68.4	100.0			
Cost Control (%)				60.6	10.2	10.2

Notes: ◎ cellular phone makers can buy this kind of components in house.

Source: MIC, financial statements and newsletters of these companies.

The highly vertically integrated structure helps Samsung create the internal resource interaction, allowing more innovative chances. For example, the idea of a cellular phone with camera modules came from combining cellular phones and digital cameras in 2000. Conversely to Samsung, Nokia and Motorola do not have this kind of technology and product line. Their cellular phone camera modules are instead outsourced.

7.4 CATCHING UP THROUGH A MORE INTERACTIVE AND COMPETITIVE ECOSYSTEM

South Korea's cellular phone industrial ecosystem has also created a better innovative environment. Figure 15 shows the cellular phone distribution channels in South Korea. These manufacturers supply cellular phones to the mobile communications carriers as well as selling them via their own electronics retail shops. There are more than 9500 dealers that sell as retail stores tied to mobile communications carriers in Korea (Choi, Lee and Chung 2001).

South Korean carriers give dealers mobile cellular phone subsidies and commissions for each subscriber, but there is some difference among South Korean, Japanese, and western carriers. Japanese carriers, such as NTT DoCoMo and KDDI, are paternalistic operators. They have great influence and control over the whole industry chain, from cellular phone marketing research, product design, production schedule, sales, after-market, and even to brand promotion. In the Japanese market the brand of operators is shown on the cellular phones, and so cellular phone providers, such as NEC or Sharp, play a subordinate role. However, because of the close relationship with operators, Japanese cellular phones are often innovative and creative.

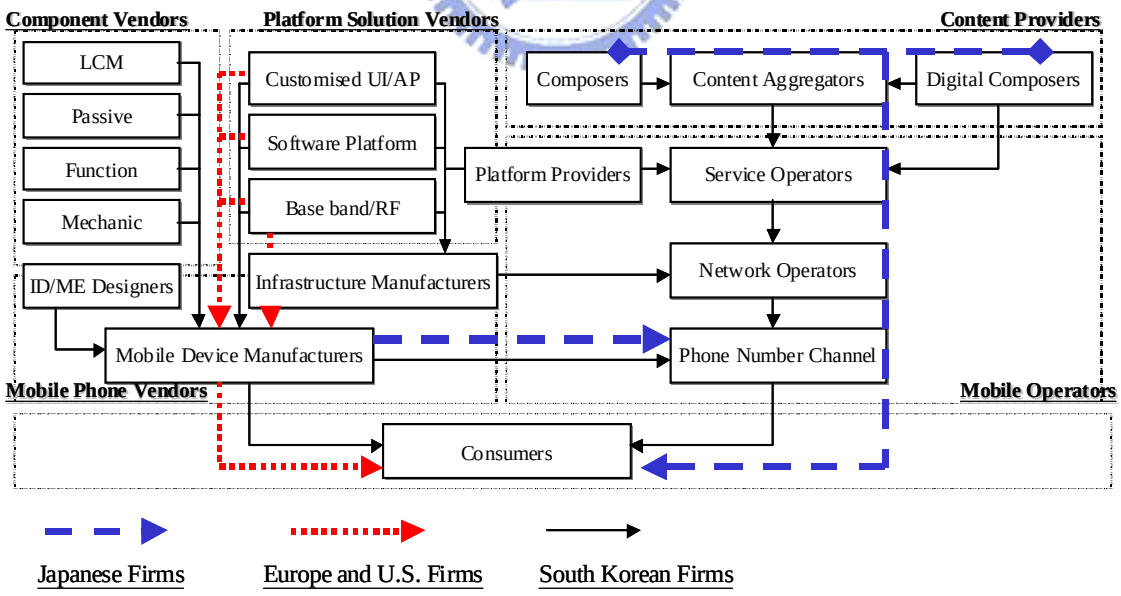


Figure 15. Distribution channels of mobile cellular phones in South Korea

Conversely, in Europe and the U.S. cellular phone vendors are independent of the carriers,

such as Nokia and Motorola. Europe and the U.S. carriers such as Vodafone are not like Japanese carriers, as Japan's business development is mainly decided by promotions and influenced by operators. In Europe and the U.S. carriers focus on mobile services and maintain their own base stations. Europe and U.S. cellular phone vendors are different from Japanese cellular phone providers. Nokia and Motorola designed and promoted their cellular phones around the world and had much know-how about brand management. Because of the lack of interaction with carriers, European and US innovative products and applications often to face the problem of a common standard.

South Korea's cellular phone ecosystem is quite eclectic. South Korean mobile carriers combine Japanese advantages with Europe and U.S. strengths. In South Korea's market, because CDMA cellular phones do not have SIM cards, when end users want to change mobile phone carriers, they usually have to change cellular phones. Hence, cellular phone vendors have to maintain cooperation with operators. For example, SKT has vertical integration capability and can control and influence its product distribution channels. The relationship is through guidance and management instead of control. Both sides are like cooperating partners. Therefore, although cellular phone makers have to gain support from operators, brand cellular phone companies still have the most power, such as product development, decision-making, channel management, pricing, and promotion (Kim, Byun and Park 2004; Berra 2003; Song and Kim 2001).

Compared with Japanese and western cellular phone makers, South Korean vendors interact with operators and manage their own brands at the same time. In the domestic market, South Korean cellular phone makers are like Japanese firms, but in foreign markets, they have become like Nokia or Motorola.

South Korea's cellular phone ecosystem is also full of internal and external competition. Through spin-offs, alliances and investments, business groups have similar products or functions even at different subsidiaries, such as cellular phone design houses, camera modules, and displays. Together with ambient small companies, cellular phone firms like Samsung or LG can purchase competitive and creative components due to internal and external competition. Domestic R&D engineers and ID (Industrial Design) designers in South Korean cellular phone firms also face competitive projects that come from similar internal and external units.

South Korean cellular phone firms, through external alliances and a global layout, have more chances for innovation. We note the important business cooperation in South Korea's cellular phone industry in Table 20. It has concentrated its attention on building up partnerships with chip vendors, operation system software vendors, and base station makers.

All of these fields are where South Korean firms are weak and lack a supply chain. Of course, South Korean firms took support from their government to negotiate with these technology sources.

The partnership targets of South Korean mobile manufacturers also include foreign operators, such as Verizon Wireless (CDMA2000 1x EV-DO), China Union (CDMA2000 1x), and Vodafone (WCDMA), especially as 3G has started to develop in the U.S. and Europe. We also see the global layout of Samsung and LG in Table 29. The localisation of design and R&D is an important strategy of Samsung and LG. Exports of EV-DO and WCDMA phones serve to improve their margins and constant strong sales growth can be attributed to a significant increase in sales to China, the U.S., and Europe from new models launched after 2003.

Table 29. The worldwide layout of Samsung and LG

Samsung Electronics Cellular Phone		
R&D Centre	Manufactures	World Design Centre
Sao Paulo, Brazil	Sao Paulo, Brazil	Shanghai, China
Beijing, China	Shenzhun, China	Tokyo, Japan
Tel Aviv, Israel	Tianjin, China	Seoul, South Korea
Seoul, South Korea	Gumi, South Korea	London, UK
London, UK	Tijunan, Mexico	Los Angeles, U.S.
Dallas, U.S.		San Francisco, US
LG Electronics Cellular Phone		
R&D Centre	Manufactures	World Design Centre
Yantai, China	Sao Paulo, Brazil	Beijing, China
Dublin, Ireland	Guangzhou, China	Dublin, Ireland
Milano, Italy	Yantai, China	Milano, Italy
Seoul, South Korea	Seoul, South Korea	Tokyo, Japan
New Jersey, U.S.	Monterrey, Mexico	Seoul, South Korea
		New Jersey, U.S.

Source: Samsung Electronics and LG Electronics.

7.5 SOUTH KOREA'S CELLULAR PHONE INDUSTRIAL INNOVATION MODEL

Innovative ability is the key success factor for South Korean cellular phone firms. Figure 16 shows South Korean cellular phone models with innovation processes. South Korean firms' innovative power comes from three sources. First, cellular phone subsidies deployed new technologies such as mobile internet and colour LCD cellular phone, as well as the early diffusion of the upcoming IMT-2000 service (Kim, Byun and Park 2004). South Korean cellular phone makers have experiences of interaction with operators and receive information of services and applications from the service providers. For instance, South Korean operators have already rolled out 3G services with CDMA20001x EV-DO and WCDMA, and this has helped Samsung and LG to promote their 3G mobile phones around the world.

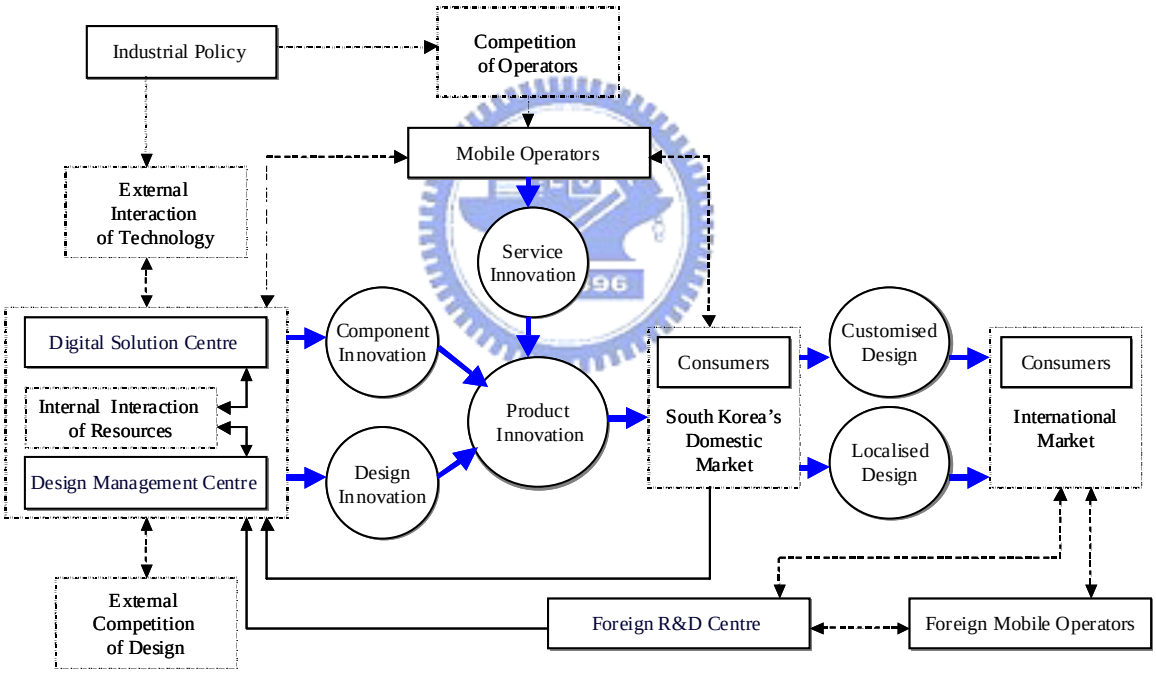


Figure 16. South Korea's cellular phone model of innovation process

The second success factor is internal and external competition, including design and component innovation. Cellular phone product innovations also bring operators other values. End users are interested in new services and may be stimulated by an attractive cellular phone design. This can also help the customers form a habit of using specific embedded applications in the cellular phone.

After successful domestic experiences in innovative products, South Korean cellular phone makers have used through customised designs with foreign mobile operators and foreign R&D centres to localise design and modifications to meet foreign market demand. South Korean cellular phone makers are then able to get feedback from global customers and start the innovation process all over again for the next model.

CHAPTER 8 OUTLOOK FOR TAIWAN'S CELLULAR PHONE INDUSTRY IN THE PAST TEN YEARS

8.1 THE GROWTH OF TAIWAN'S CELLULAR PHONE SHIPMENTS AND THE INDUSTRIAL HISTORY

Figure 17 shows Taiwan's cellular phone, NB PC, and DT PC's global market shares. On the global market share side, from 1996 to 2005, NB PC and DT PC achieved remarkable global market shares very quickly.

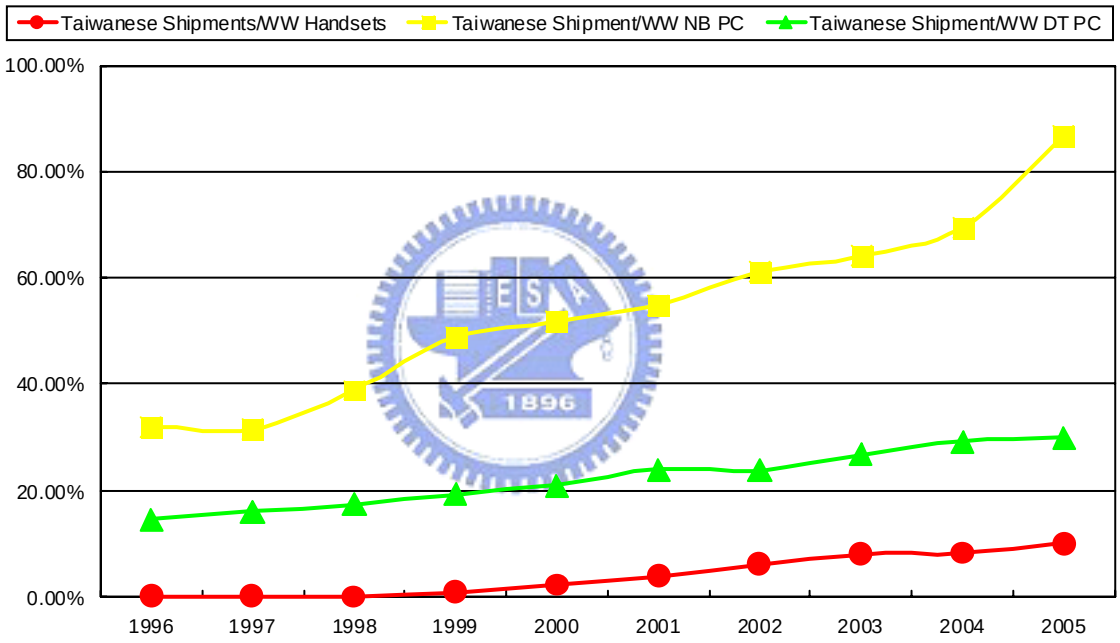


Figure 17. Taiwanese PC and cellular phone's global market share by shipments (Source: IDC, III)

In the PC industry, in order to cost down and improve time to market, it is common sense that OEMs select an outsourcing strategy. Over 80% of the PCs are manufactured by EMS/ODM, among which most are by Taiwan's ODMs, but this is not the case in the cellular phone industry. With a lack of common standards such as PC's Wintel, the cellular phone is not a standardized product. Instead, the cellular phone is a consumer product. Its product features and quality are more important than the cost. Major global cellular phone OEMs have no plans to reduce their in-house R&D efforts for new product development.

Under this background, we can separate Taiwan's cellular phone industrial history into three stages: Before 1999, many of Taiwan's IT ODMs started to develop their cellular phone businesses, such as GVC, Acer, and DBTEL. They did not easily receive outsourcing orders from foreign firms.

From 1999 to 2004, due to the emergence of China's cellular phone market, and Alcatel and Motorola's technology support, some of Taiwan's cellular phone makers developed strongly, such as DBTEL, BenQ, and Lite-on. Taiwan 's cellular phone ODMs previously enjoyed solid margins from strong exports to China's domestic cellular phone OEMs in 2002-2004 (such as Ningbo Bird, TCL, and Konka). At the same time, Taiwan's cellular phone makers received more and more outsourcing orders from global cellular phone OEMs. Even Nokia outsourced orders of its Clam Shell style to BenQ and CDMA's cellular phones went to FIH in order to target China's market opportunity.

After 2005, Taiwan 's cellular phone makers have been becoming more and more matured. The first three cellular phone EMS/ODMs FIH, CCI and Arima, they have major clients Nokia, Motorola and Sony-Ericsson, respectively. BenQ merged Siemens's cellular phone business group in 2005 and becomes the sixth brand name company in the cellular phone industry.

Table 30. The P-values of the Mann-Whitney U test of the ratio of Taiwanese firms receiving outsourcing orders between PCs and cellular phones

	NB PC	DT PC
Cellular phone	0.0002***	0.0002***

Note: *** represents significance at the 1% level.

8.2 DEVELOPMENT HISTORY OF TAIWAN'S MAJOR CELLULAR PHONE FIRMS

In PC industry, Taiwan ODMs dominate the industry, and while Taiwan's NB/PC shipments over 80% of global shipments, respectively. However, for cellular phones, Taiwan's companies were latecomers while South Korean ODMs are ahead. Most of Taiwan's cellular phone makers were matured until the recent years.

(1) FIH:

FIH was spin-off by Hon Hai/Foxconn. Hon Hai/Foxconn started by making PC

components, such as connectors and cases. In recent years, Hon Hai/Foxconn paid attention to telecom industry. The first, Hon Hai/Foxconn's acquisition of Nokia's component supplier, Eimo Corporation, further enhanced their relationship. Now FIH has been a major case supplier to Nokia for many years.

The second, starting in 2000, Hon Hai/Foxconn has been aggressively targeting to win Nokia's business, and built a plant next to Nokia's "Starnet" cellular phone industrial park in Beijing. On the other hand, after Hon Hai/Foxconn's acquisition of Motorola's Mexico CDMA plant in 2003, Hon Hai/Foxconn is getting CDMA technology and officially entering the CDMA cellular phone industry. With the great success of Hon Hai/Foxconn's cellular phone business, the company spun off its handset division in fourth quarter 2004 and to list on the Hong Kong stock exchange.

Then FIH merged Chi-Mei Communication in 2005, so after three years of making PCBA (Printed Circuit Board Assembly) with low value-added and low profitability, FIH finally started to produce three complete models of GSM cellular phones in the second quarter of 2005 for Nokia, mostly for the China market. Right now Flextronics and Elcoteq Network are FIH's major competitors.

(2) Compal Communications (CCI):

Compal Communication (CCI) was from Taiwan Compal Group's cellular phone ODM business group. CCI uses TI's chipset solutions and manufactures mainly for Motorola. CCI was the No.3 cellular phone maker in Taiwan by volume and guidance of 8.3 million units in 2004, and shipped over 13m units for Motorola and became the leader in the Taiwan's cellular phone ODM business by volume in 2005.

Although about 80% of CCI's shipments in 2004 were Motorola low-end phones, CCI's ASPs and margins are better than FIH and Arima Communication. Because CCI is the only Motorola-certified testing centre in Asia, and has the in-house source code and the high-level R&D ability. After 2005, CCI merged Compal Group's cellular phone ODM business group and become stronger in order to compete with FIH. The company has more than 800 engineers located in Taiwan now. In our view, CCI will be one of the technology leaders among the Taiwan's cellular phone ODMs.

(3) Arima Communications:

Arima was set up in 1999 and has been soaring from 2001. Arima was the No. 2 cellular phone manufacturer in Taiwan by volume in 2004. Arima shipped 10.1 million cellular

phone units in 2003 and 10.05 million units in 2004. The company major produced cellular phones for Sony-Ericsson.

Arima's cellular phones projects are close to an EMS basis. That's why Arima's margins are lower than those of its Taiwan's competitors. Arima tried to enhance its R&D capability from 2003 to being closer to a typical ODM instead of an assembly-intensive EMS. Arima's R&D manpower is about 500 people right now.

(4) BenQ-Siemens (BenQ):

BenQ started its cellular phone business before 1995 and was Taiwan's No.1 cellular phone manufacturer by volumes before 2004. BenQ shipped 11.6 million cellular phone units in 2003 and 12.8 million units in 2004. BenQ mainly produced the low-end phone for Motorola in 2003, and Motorola as the key ODM customer accounting for over 60% of total volume.

Because BenQ developed its own brand business, Motorola cut their outsourcing relationship with BenQ after 2004. BenQ shifted to Nokia and South Korea's Kyocera. In order to develop more new models for BenQ's product roadmap, the company has about 700 engineers globally before merged Siemens's cellular phone business, and major manufacturing facilities are located in China, Malaysia, and Mexico.

After 2005, BenQ has been focusing on its own brand business, especially in emerging markets such as Russia, Latin America, Eastern Europe, India, and China. Then BenQ merged Siemens's cellular phone business group in 2005 and becomes the sixth brand name company in the cellular phone industry. BenQ's branded cellular phone business has seen excellent progress, and it also has successfully entered retail channels in developing markets.

(5) High Tech Computer Corp. (HTC):

Founded in 1997, High Tech Computer Corp. (HTC) is a technology provider specializing in converged mobile devices, such as PDA (Personal Digital Assistant). HTC designs, manufactures and markets innovative Smart Phone and PDA Phone devices. Before 2002, PDA was its major product line. Then HTC started its customized Smart Phone for mobile operators directly. It uses Microsoft's handset software platform that is an open operation system to design its cellular phones that can use third parties' resource and deal with the enhanced data service.

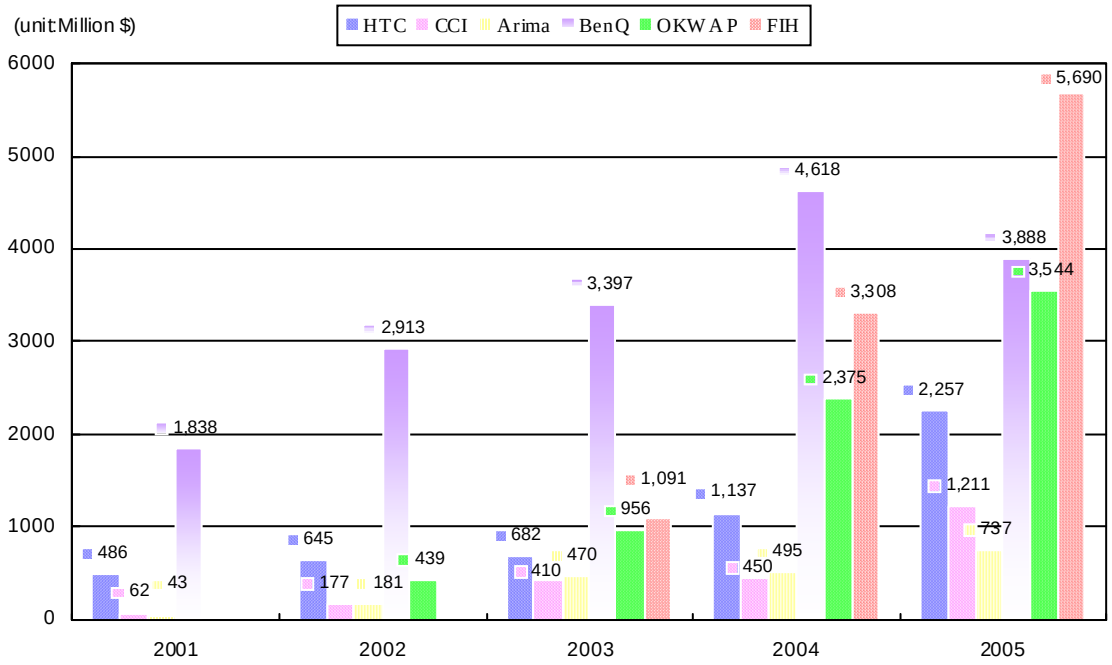


Figure 18. Taiwanese major cellular phone firms' sales in the past five years (Source: Financial statements and newsletters of Taiwanese companies

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CHAPTER 9 THE DEVELOPING MODEL OF TAIWAN'S CELLULAR PHONE INDUSTRY

9.1 ACHIEVING INNOVATIVE CAPABILITY THROUGH CUSTOMIZED R&D ACTIVITIES

How have the cellular phone firms in the lately industrialized economies achieved success? One of the answers may be in their innovation ability. Fan (2006) studies the innovation capability development of four domestic Chinese firms - Huawei, ZTE, DTT, and GDT. Innovation capability and self-developed technologies are the key areas for Chinese firms to catch up with multinational corporations. It is found that domestic firms should focus on in-house R&D development in order to build their innovation capability, supplemented by external alliances.

How does a firm enhance innovation ability or which way should it put forth effort? Resource dependency theory suggests that no organization can survive alone. It must constantly interact with its environment either to purchase resources such as labor, supplies, or equipment, or distribute its finished products (Pfeffer and Salancik 1978). According to the experience of Taiwan's cellular phone makers, they put up R&D resources to satisfy their OEM clients' demand. They have captured innovative capability through customized R&D activities

Why do cellular phone OEMs use outsourcing strategies? A company adapts to rising competition and variations in consumer preferences in different regions. Short cell phone product cycles drive cellular phone OEMs to outsource. Therefore, in the cellular phone industry, EMS/ODMs need not only have manufacturing capacity, but also hardware, mechanical, and software design ability. The above is the basic requirement if EMS/ODMs want to receive OEM orders.

A cellular phone ODM focuses on designing lower to mid-end phones, while much of the mid-to higher-end phones continue to be designed in-houses at OEMs. In the Go-Shopping approach, OEMs select products previously designed by ODMs. These products are typically ready for manufacturing and distribution under an OEM brand. OEMs can use ODMs' R&D ability to fill the gaps in their existing product portfolio.

Time to market is another important factor for OEMs to increase their usage of ODMs. Due to the design and test process, the cellular phone launch time may range from six to eight months using the Design-It strategy. If the cellular phone is a fresh model, then the design

and test time will need more than one year. If a firm uses the outsourcing approach and re-uses the design platform, then the developing time will only range from three to five months. As a result, OEMs will pay more attention on developing hardware/software platforms.

Cellular phone EMS/ODMs can enhance their product roadmap and product lifecycle management to support OEMs. OEMs can effectively deploy their resources by developing new products and re-allocating design resources. Tables 31 and 32 show that Taiwanese cellular phone firms' R&D intensities are higher than that of NB/PC firms. They have to enhance their innovative ability to survive in cellular phone industries.

Table 31. R&D spending of revenue of major Taiwanese PCs and cellular phones' ODM/EMS

	2001	2002	2003	2004	2005
HTC R&D Spending of Revenue (Handset)	3.86%	3.39%	4.80%	5.48%	3.94%
CCL R&D Spending of Revenue (Handset)	11.89%	7.37%	4.33%	4.72%	2.19%
Arima R&D Spending of Revenue (Handset)	9.62%	4.14%	2.47%	2.60%	2.43%
DBTEL Spending of Revenue (Handset)	3.31%	7.99%	7.93%	8.00%	6.23%
Hon Hai R&D Spending of Revenue (PC/NB)	1.41%	0.91%	0.84%	0.96%	0.64%
Compal R&D Spending of Revenue (PC/NB)	1.33%	1.33%	1.30%	1.10%	1.10%
Quanta R&D Spending of Revenue (PC/NB)	1.19%	1.33%	0.86%	0.90%	0.83%
Inventec R&D Spending of Revenue (PC/NB)	1.42%	1.39%	1.64%	1.07%	0.98%

Source: Financial statements and newsletters of these companies.

Table 32. The P-values of the Mann-Whitney U test of Taiwanese cellular phone firms' R&D intensities higher than NB/PC firms

	Hon Hai	Compal	Quanta	Inventec
HTC	0.0090***	0.0090***	0.0090***	0.0090***
CCL	0.0090***	0.0090***	0.0090***	0.0090***
Arima	0.0090***	0.0090***	0.0090***	0.0090***
DBTEL	0.0090***	0.0090***	0.0090***	0.0090***

Note: *** represents significance at the 1% level.

Under this industrial environment, the relationship between an EMS/ODM and an OEM looks like a one-by-one infrastructure. Tables 33 and 34 show that Taiwanese cellular phone firms' customer concentration ratios are higher than that of NB/PC firms, because they need more trust and interaction with each other. CCI is Motorola's major ODM supplier after 2004, and this customer accounted for 97% of 2005 total sales, respectively. The long-run relationship is difficult to start, but is easy to maintain in the cellular phone industry.

Table 33. The customer concentration ratio of Taiwanese PCs and cellular phones' ODM/EMS

ODM/EMS	Main Clients	2001	2002	2003	2004	2005
Arima	Sony Ericsson	58%	63%	73%	66%	69%
CCI	Motorola	58%	38%	48%	71%	97%
FIH	Nokia, Motorola	64%	58%	56%	59%	52%
Quanta	Dell, HP, Apple, Sony, Acer, Toshiba	27%	29%	40%	22%	27%
Compal	HP, Apple, Dell, Acer, Fujitsu, Toshiba	23%	29%	26%	32%	35%
Inventec	HP, Toshiba, BenQ, Acer	46%	30%	46%	45%	54%

Source: Financial statements and newsletters of these companies.

Table 34. The P-values of the Mann-Whitney U test of Taiwanese cellular phone firms' customer concentration ratio higher than NB/PC firms

	Quanta	Compal	Inventec
Arima	0.0090***	0.0090***	0.0090***
CCL	0.0163**	0.0090***	0.1172
FIH	0.0090***	0.0090***	0.0163**

Note: *** represents significance at the 1% level; ** represents significance at the 5% level.

Figure 19 shows the development trend of the cellular phone manufacturing industry. More and more OEMs are cooperating with IC designers and EMS/ODMs to develop their full product lines. For instance, in CDMA and Clam Shell cellular phones, especially for the China market, Nokia needs FIH's resources to capture market share. Due to its superior R&D capability and high manufacturing capacity, CCI has become an important partner of Motorola, especially in low-end phones' development.

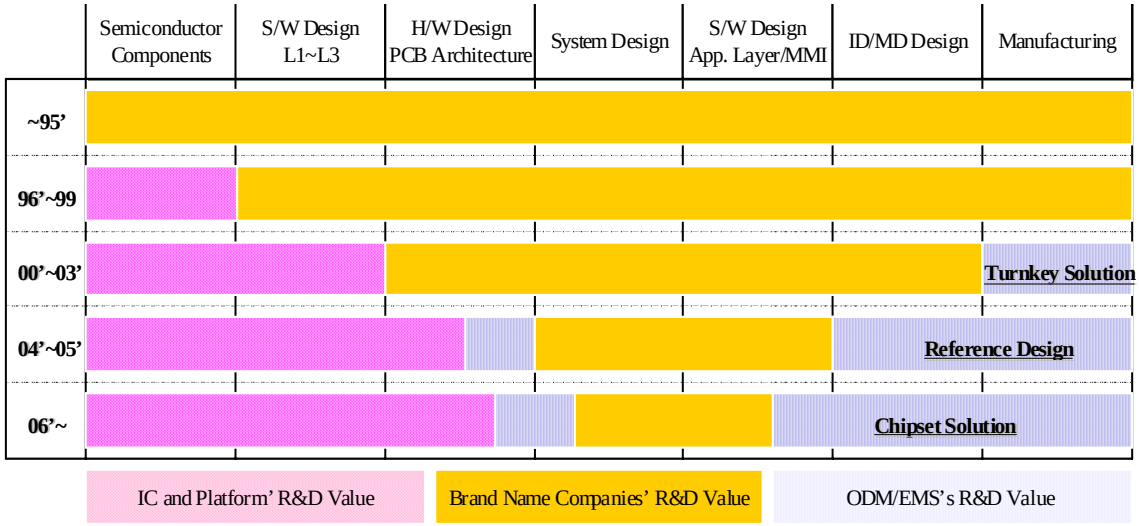


Figure 19. The development trend of the cellular phone manufacturing industry

9.2 CATCHING UP AND DEVELOPING THROUGH A MARKET AND CUSTOMIZED-ORIENTED STRATEGY

China is the most populous nation in the world at 1.3 billion people. Its cellular phone users numbered over 350 million at the end of 2005, making China the biggest cellular phone market in the world. In order to satisfy OEM client demand, aside from the cost issue, many Taiwanese EMS/ODMs aimed their first target market at China. Most EMS/ODMs started to move their production lines and after-market services to China.

In order to touch new emerging markets, such as Latin America, India, and Eastern Europe, OEMs are requesting Taiwan's EMS/ODMs to build up production factories in the target market. Due to human and capital resource limits, only less Taiwan's EMS/ODMs can have the global logistic management ability. Taiwan's EMS/ODMs also have other strengths: document management ability. It means that Taiwan's EMS/ODMs can control all product develop processes step by step. Some global OEMs already depend on Taiwan's EMS/ODMs to maintain world-class logistic capabilities. Taiwan's EMS/ODMs have more bargaining power to control component suppliers and negotiate with them for high-value components and other materials, such as connecters, ICs, and TFT-LCDs, which totally can make up to 95% of the bill-of-materials cost.

Figures 20 and 21 show the development steps of Taiwan's cellular phone makers by process and geography. We can see Taiwan's cellular phone makers have different strategies to develop their R&D paths. For example, FIH started its cellular phone business by components, such as connectors, PCBs (Printed Circuit Boards) and cases. In order to better serve Nokia, in 2003 FIH merged with Eimo Oyj which was a Finnish company making covers and antennae and had a supply chain partnership with Nokia. FIH then started to produce covers and simply surface mount assembly for Nokia. After 2004, FIH began to ship full system phones to Nokia, including surface mounted PCBs, assembling the mechanism components, and final assembly and testing. Right now FIH is designing CDMA cellular phones for Nokia in order to capture China's market share. However, other Taiwanese makers have different growth paths. After holding basic manufacturing and testing ability, HTC started its customized Smartphone for mobile operators directly by using Microsoft's open OS.

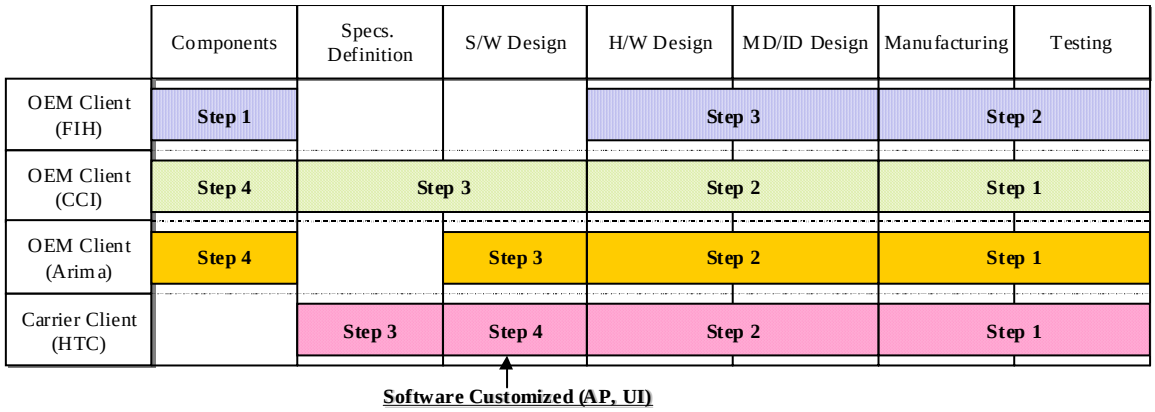


Figure 20. The development step of Taiwanese cellular phone makers by production processes

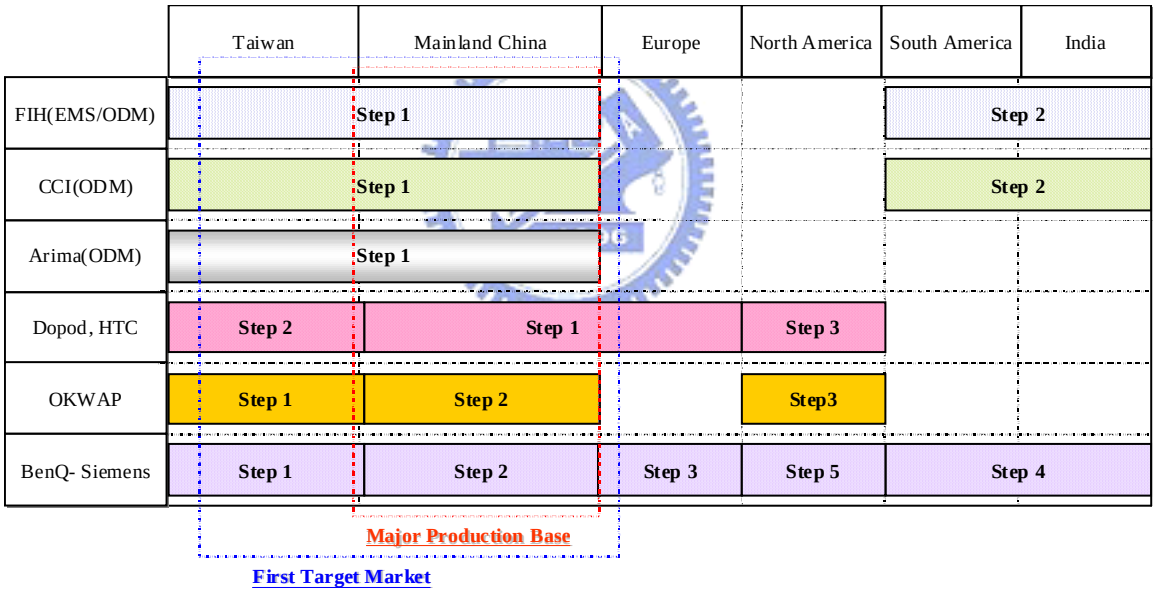


Figure 21. The development step of Taiwanese cellular phone makers by geography

Most of Taiwanese makers are using enormous China's market to accumulate their competition in manufacturing and innovation. No matter for EMS/ODMs or brand name firms, Taiwan's cellular phone makers target China as the first step. After having economies of scale, they then expand their business to other areas.

Figure 22 shows Taiwan's cellular phone industrial innovation model by a catch-up

through OEM client-oriented R&D activities. Taiwan's makers put forth their limited resources and pay attention on different areas that depend on their OEM clients' demand. In fact, Taiwan's industrial policy also encourages Taiwan's makers to use this strategy. If Taiwan's cellular phone makers want to apply for an R&D subsidy from the Technology Development Program of Taiwan's Ministry of Economic Affairs, the relationship with global OEM clients and the benefit of the R&D result are the major criteria to evaluate Taiwan's makers' R&D projects.

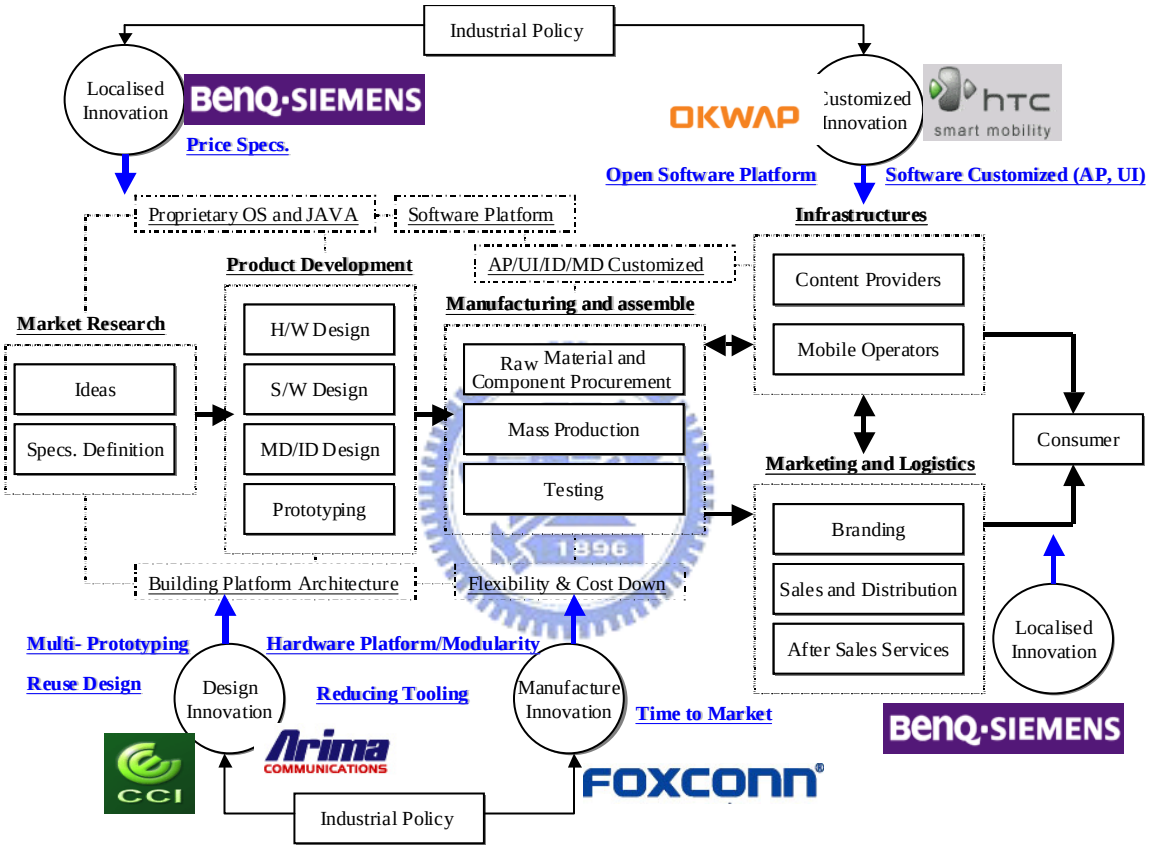


Figure 22. Taiwan's cellular phone industrial innovation model

CHAPTER 10 COMPARISON OF DIFFERENT DEVELOPING MODELS OF EAST ASIAN ECONOMIES

10.1 CHINA: PROMOTING THE DOMETIC MANUFACTURER THROUGH THE DOMESTIC MARKET

According to our data, the three industrial policy targets were achieved roughly. On the demand side, from 1998 to 2004, China has emerged as the largest mobile subscriber market in the world. According to an In-Stat report (Gartner Dataquest 2004), mobile subscribers in China have grown to more than 300 million in 2004, representing a hefty CAGR of over 50% for the period. The burgeoning growth of China's mobile subscribers has resulted in a rapid rise in mobile phone shipments. Therefore, on the supply side, China became the largest cellular phone making country in the world from 1999 to 2004. Both foreign and local vendors' shipments in China have grown rapidly in recent years. The total shipments have grown to 210 million in 2004.

This paper analyses the influence of China's communications industrial policy on its domestic cellular phone manufacturing industry. Generally speaking, the influence is still positive, including that own brand shipments and export ability have grown rapidly in recent years. During the same time, several large firms such as TCL and Ningbo Bird have been established. They are already well-known brand names in the world.

In order to develop its domestic cellular phone industry, China's government handed down No. 5 Document in 1999, restricting foreign vendors from establishing factories and also restricting cellular phone production and sales. Domestic brand vendors emerged this protected environment. Many domestic vendors used outsourcing, controlled sales channels and price wars in order to gain market share more quickly, but neglected research, technology and manufacturing ability.

Domestic vendors, such as TCL, Ningbo Bird, and Konka, have cooperated with South Korean and Taiwanese ODMs to create new handset models. After China joined the WTO in December 2001, its cellular phone industrial policy turned its eye toward the domestic market share of domestic brand names. During the time, the overall market share of foreign handset makers dropped down starting in 2002. By limiting the proportion of import/export freight and number of licenses, and by controlling the purchases of domestic components, purchased, Chinese domestic cellular phone vendors have taken over 50% of China's cellular phone market.

However, after successful experiences in innovative products for the domestic market, China's cellular phone makers had to build up their long-term competitions in innovative ability. This empirical result proves that China's government encouraged domestic companies to grab market share from brand names, but domestic companies usually selected and adopted outsourcing strategies to entrust foreign companies to design and manufacture their products. China's communications industrial policy has significantly helped to capture market share, but has not significantly promoted domestic vendors' R&D ability.

China's mobile industrial policy effects the development of its mobile industry as a whole including service providers, telecom equipment vendors, IC vendors, and cellular phone firms. First, China's mobile industrial policy would like to have the most mobile subscribers in the world by encouraging competition. Therefore, the mobile service industry was restructured and China Unicom was carried by Chinese government. With an enormous population and a more competitive environment, the amount of China's cellular phone users has been growing quickly and has become the largest market in the world. Moreover, China Unicom and China Mobile are the largest CDMA and GSM operators in the world. Having an enormous market base and powerful operators, MII could establish its own standard and promote its domestic manufacturing industry.

Because of JV encouragement and promoting domestic suppliers, China's telecom equipment vendors such as Huawei and ZTE have become the major players in the world. Aside from the growth of sales and equipment exports, they also pay attention to R&D ability. By contrast, although several of China's large cellular phone companies such as TCL and Ningbo Bird have been established as well-known brand names in the world, local makers' technology and manufacturing ability are relatively low due to local vendors heavily depending on strategies of design outsourcing or ODM.

We find that there has been a gap in R&D intensity between China's cellular phone firms and telecom equipment firms in the past years, because of different effects of industrial policy. Comparing with Huawei and ZTE, which are also Chinese firms, latecomers to the telecom equipment industry, but have a strong innovative ability to catch up to the leaders of the industry, because of the telecom bidding market.

It is a successful development strategy in China in first building up a domestic industry via using its huge domestic market size, promoting competition, forming joint ventures, and encouraging domestic suppliers. For latecomers in a developing economy, paying more attention on R&D activity is also a key point for catching up to the leaders and continuing to develop.

10.2 SOUTH KOREA: CATCHING UP THROUGH R&D EFFICIENCY AND COOPERATION WITH DOMESTIC OPERATERS

By acquiring IP licenses from Qualcomm and referring to Qualcomm's design solutions, South Korean firms have added more functions and applications to cellular phones' capabilities. South Korean cellular phone manufacturers as latecomers in this market have already caught up and even leapfrogged past others in global market share, export value, and company image. Related examples are Samsung and LG, which are major CDMA2000 and GSM/WCDMA cellular phone vendors worldwide and are able to compete with Nokia and Motorola. The strategic position of Samsung's cellular phones is on the high-end market, while LG is also a leader in 3G gaming due to its high R&D capacity.

If firms want to take advantage of their domestic innovative experiences for the global market, then domestic 3C makers should be use customised designs and foreign R&D centres to localise their design and modifications to meet foreign market demand. By enhancing vertical integration from key components to design and assembly, cooperating with local carriers, and receiving market feedback, 3C firms will find it easier to create innovative ideas and new applications.

10.3 TAIWAN: CUSTOMIZED R&D ACTIVITIES TO ATTRACT THEIR OEM CLIENTS

The first key driver for global OEMs using an outsourcing strategy is the cost factor, as EMS/ODMs have transferred manufacturing facilities to low-cost areas like China to reduce manufacturing costs and maintain high quality at the same time. In the PC industry, Taiwanese ODMs dominate the industry, while Taiwan's NB/PC make up shipments over 80% of global shipments. However, for cellular phones, Taiwanese companies were latecomers while South Korean ODMs were first. Most of Taiwan's cellular phone makers have only matured in the recent years. Therefore, many Taiwanese manufacturing firms have high market shares in many ICT products except for cellular phones.

Because the cellular phone is a consumer product without a common standard, Taiwan's cellular phone makers have to use different approaches to attract OEM outsourcing aside from cost down. For instance, more and more OEMs will cooperate with IC designers and EMS/ODMs to develop full product lines. Therefore, in the cellular phone industry, EMS/ODMs not only have manufacturing capacity, but also build up hardware, mechanical, and software design abilities.

Taiwan's EMS/ODMs can use their R&D ability to help OEMs adapt to rising competition

and variations in consumer preferences in different regions, such as CCI and Motorola, and Arima and Sony Ericsson. Moreover, in order to target new emerging markets, Taiwan's EMS/ODM can help OEMs to build up production factories in the target market. Due to the limitation of the manpower and capital resources, only less Taiwan's EMS/ODMs can have the global logistic management ability, such as FIH and Nokia. In addition, some of Taiwan's makers focus on mobile operators' markets. They enhance their design ability of the customized software to fix different mobile operators' demand.

Although Taiwan's cellular phone companies were latecomers and most foreign firms are leading ahead, they allocate their limited resources well and pay attention to different places that depend on their OEM clients' demand. Taiwan's cellular phone makers pay more attention on R&D activities to attract their OEM clients by developing relatively complete product lines. The experience of Taiwan's cellular phone makers as latecomers shows how to use R&D resources more effectively in addition to cost down and time to market in an industry of non-standardized products. Taiwan's cellular phone makers provide OEMs with an enhanced product roadmap support and product lifecycle management. At the same time, global OEMs can better manage overhead costs and leverage internal resources more effectively.

10.4 COMPARISON OF DIFFERENT DEVELOPING MODELS

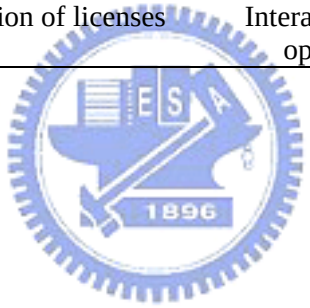
In the ICT industry, due to globalisation and the trend in world trade, cellular phones have become the popular product sold around the world. In order to compete with foreign leading companies, domestic firms of developing economies catch up with leades through different ways such economy of scale or market niche expect policy protection.

Table 35 shows the comparison of developing strategies of the cellular phone industry in East Asian developing economies. Based on the ODM/EMS business model, Taiwan's cellular phone makers maintaine their cost advantage through economy of scale. They also have used different approaches to attract global OEM outsourcing orders in addition to cost down. China's cellular phone makers advance to utilize the advantage of ODM/EMS partners to reduce their BOM cost. By combining the industry policy and sales channel, domestic brand names of the cellular phone industry captured the market share quickly. By contrast, South Korean firms use their R&D efficiency to build up comparative advantage. Furthermore, in order to break the market similarity, they use customised design with foreign mobile operators and their foreign R&D centres to localise design and modifications. By creating the market niche, South Korean firms met foreign market demand and became well-known brand names in the world.

Moreover, based oon the trend of absence of regulatory restraints, China still uses limitation of licenses to protect its domestic industry In the interim of joining in WTO. However, South Korean cellular phone vendors have to maintain cooperation with operators, and creats the similar result as regulatory restraints in the domestic market. Finally, this paper finds that the developing and innovation strategies of firms related to the domestic market background and industry ecosystem. Firms of China, Korea, and Taiwan chooce their strategies in terms of the enormous market base, vertically integrational structure, and outsourced experience, respectively.

Table 35. Developing models of the cellular phone industry in East Asian developing economies

Characteristics of the international industry	China (Enormous market base)	Korea (Vertical integration)	Taiwan (Outsourced experience)
Economy of scale	Corporate with ODM/EMS	-	Extend the ODM/EMS business model
Market similarity	-	Customised and localised design	-
Comparative advantage	Distribution channel and price	R&D efficiency	Cost and customised ODM/EMS service
Absence of regulatory restraints	Limitation of licenses	Interaction with operators	-



CHAPTER 11 CONCLUDING REMARKS

This empirical result first supports that China's government encouraged domestic companies to grab market share from brand names, but domestic companies usually selected and adopted outsourcing strategies to entrust foreign companies to design and manufacture their products. China's communications industrial policy has significantly helped to capture market share, but has not significantly promoted domestic vendors' R&D ability.

Because of the industrial policy protection, gaining market share was a top priority for China's cellular phone manufacturers. China's cellular phone industrial policy made domestic vendors to ignore enhancing their innovative capacities. We can find most China's cellular phone manufacturers using an outsourcing strategy instead of R&D in house. We also find that China's domestic vendors' total shipments and the proportion of SMT and technology are still low. Since local vendors depend on outsourcing or post the brand strategy, the ratio of local makers' SMT-Line self-assemble shipments to total local makers' shipments significantly declines. Similarly, because local vendors heavily depend on strategies of outsourcing or posting the brand, the ratio of local makers' own technology shipments to total local makers' shipments not significantly decreases.

According to China's experience and compared with South Korea's communications industry experience, China's government should pay more attention to encouraging domestic vendors to make efforts in R&D and manufacturing ability. For example, South Korea's government combined Qualcomm's technology and policy to successfully support developing/extending its cellular phone manufacturers, including Samsung, LG, and Pantech, etc. By acquiring IP licenses from Qualcomm, Samsung and LG are now major CDMA2000 handset vendors worldwide and have enough ability to compete with Nokia and Motorola. The positions of Samsung's handsets are at the high-end market and LG is also a leader in 3G gaming due to its hold on high R&D ability.

Taiwan is another story: Taiwan's government has a reserve fund for domestic vendors. If a native company engages in R&D activities, it will receive expenses and tax deductions. China's government can also adjust its cellular phone policy to emphasize R&D and manufacturing ability, such as homemade rate. On the other hand, upstream component supplies are a key indicator to measure R&D ability. Therefore, China's government should pay more attention to building up a communications IC industry in China which is an essential element to improve its core competition.

For 3C latecomers in developing economies, due to capital, cost, and risk issues, we

suggest that 3C firms could strengthen their R&D efficiency in place of prematurely increasing their R&D intensity before they are large enough. Latecomers should use external resources more efficiently, including alliances, investments, licenses, and so on. Strengthening R&D efficiency also means that firms may announce more innovative products and reduce time to market at the same time. Finally, governments of lately developing economies could promote domestic vendors by filling the upstream component supply chain, especially key parts and technology like IC and software.

Generalisation is one of the limitations in this paper. Due to industry ecosystems being very different in lately industrialised economies, we should study more cases, including success and failure samples, to find out how to strengthen innovation. We also should further investigate to judge if South Korea's vertical integrated model can achieve continual success in the future. Quantification is another limitation in this paper. We may use more quantification methodologies in the future to find evidence of how innovation activities affect latecomers.

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