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Technology, Innovation and Latecomer Strategies: Evidence from the Mobile Handset Manufacturing Sector in China

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The closing of the gap in competitive capacity between developing and developed economies is explored using China's telecommunications industry. Since the entry of Chinese domestic mobile handset manufacturers in 1998, Chinese domestic suppliers have successfully surpassed the market share of joint ventures while direct imports have been largely phased out. By examining China's telecommunications in general and its mobile handset manufacturing sector in particular, we found several factors that contributed to the competitiveness of China's domestic manufacturers. These are discussed in three categories: market conditions, competition, and government support.

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Lei Ding* and Kingsley E. Haynes**

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I. BACKGROUND

Without going over the history of the literature in regional dynamics (Haynes et al, 1997), we know that there has been a recent growth in studies of international and interregional convergence using aggregate economic indices. This literature often examines the relationship between new technology and economic growth (Solow, 1956; Porter, 1990; Enos, 1992; Hobday, 1995; Anderson, 1996; Rigby, 2000; Amsden and Chu, 2002). Much of that analysis indicates that chronological ‘lateness’ in the industrialization process does not relegate lagging regions permanently to their disadvantaged position. Positive changes due to increases in efficiency, rapid technological change, technological diffusion and spillovers, access to new markets and differential costs of factor inputs may all play a role in the reduction or elimination of gaps in competitive capacity, creating the possibilities for economic catch-up. Sharif (1989) recognized these ‘late-industrializers’ as latecomers in the context of technological innovation and diffusion. He noted that beneficial learning investments on the part of newcomers and the encumbrances of earlier investments on the part of mature industrializers might play compensating roles leading to different forms of convergence. Others have noted late adoption generates advantage in the incorporation of new technology and may result in accelerated diffusion among lagging regions creating newer opportunities for latecomers (Gerschenkron, 1962; Abromevitz, 1986; Perkins and Neumayer, 2005).

Other explanatory factors of empirically successful latecomer strategies include the degree of openness to international trade and investment and the level of integration into the globalization process (Storper, 1997; OECD, 1998; Rigby, 2000; Lall, 2002). Perkins and

Neumayer (2005) argue the importance of the neoclassical school's emphasis on the role of market liberalization among developing countries including the removal of institutional barriers, the positive environment for foreign investment and the internationalization of trade which both stimulate and accelerate technological diffusion and internal innovation.

Some of the literature on the emergence of the Asia economies – the so called 'little tigers' – embodies this catch-up process of latecomer economies, particularly in manufacturing where many of these economies have reduced or eliminated the gap in production related capabilities and in other cases have surpassed their advanced economy counterparts (Kim, 1980 and 1997; Ernst and O'Connor, 1992; Hobday, 1995 and 2001; Lall, 2000; Mathews and Cho, 2000; Mathews, 2002; Liu, 2005). In many cases technological innovation has played a central role in this catch up process in these latecomer regions (Ernst, 2004). Specifically, innovation in electronics manufacturing is often cited in that literature and is based on advantageous production capacity, efficiency from low cost production, rapid model changes to fit changing customer needs and tastes, available investment for technological change and refitting and skilled engineering adaptation in production processes and in final product design (Ernst, 2004; UNIDO, 2002; David, 2002).

The central idea is that international knowledge diffusion from leading regions to lagging regions can be expressed as a latecomer innovation strategy with respect to new innovations in process technologies, critical component development or in rapid changes in final product design. This is the basis of Solow's (1956) neoclassical growth school where free technological spillovers produce long-run economic convergence. Theories in the regional economic development literature, such as growth pole theory or trickle down effects, can also be seen as

expressions of these spillovers (Darwent, 1969; Hermason, 1972; Higgins and Savoie, 1995; Stimson et al, 2002). When intermediate development steps are shortened or eliminated these policies are often referred to as ‘leapfrog’ strategies – typical of some successful Asian economies (Singh, 1999).

Freeman (1987) and Nelson (1993) analyze the role of technological diffusion from a different perspective and conclude that rather than a simple flow of knowledge across country borders, technological advance and innovation relies on specific firms, networks, and economic institutions. They note the successful economic stories of the US in the 19th century, Japan in the 1960s, Korea and Singapore and other Asian economies in the 1980s, and more recently China, who all benefited from the exploitation of opportunities for technology catch-up (Liu, 2005). To some extent this view integrates the role of government into the technological innovation process, although most studies of Asian countries isolate the two processes of government and free market decision making (Amsden, 1989; World Bank, 1993).

Another perspective based on technological learning and the role of national innovation systems also is discussed (Bell and Pavitt, 1997; Kim, 1997; Lee and Lim, 2001). Lee and Lim (2001) observe that different technological regimes have different patterns of innovation and diffusion across industries and regions or even countries. However, it is important to remember that latecomer firms or sectors are not ensured of catch up performance with advanced economies even when following similar strategies because the contextual economic environment is always changing. So what worked in one environmental situation may not be effective in another.

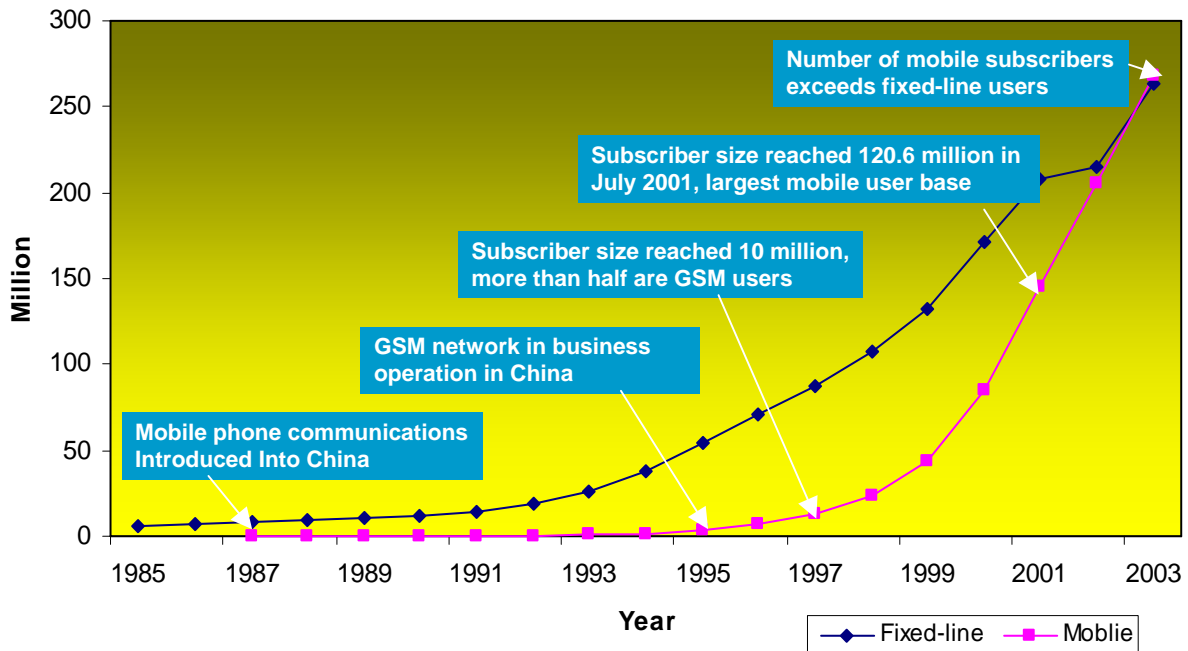
This paper explores the closing of the gap in competitive capacity by decomposing the aggregate process and looking at one sector – telecommunications – in one developing economy – China.

II. INTRODUCTION

China has the world's largest population. More than 60% live in the countryside. In 2003 approximately 20% of the population had fixed line telephone access; approximately 21% had cell phones. Less than 10% of the mobile phone subscribers live in the countryside. (MII, 2004).

Telecommunications development in China was highly rigid and a low priority for thirty years (1949-1979). A series of reforms followed during the next twelve years and mobile phone communications were introduced into China in 1987. The mid-to late 1990s saw rapid development, competition and explosive growth (Figure 1). Mobile phone communications grew at an astounding rate, reaching 10 million users by 1997. The number of mobile subscribers exceeded fixed-line users seven years later. Since 2000 there has been full competition in value added services and new technologies have been introduced (Network Weekly, 2004).

Figure 1. Telecommunications Events in China



Source: MII(2005) with notes by authors

With a population of over 1.3 billion, China has the largest handset market in the world and this market continues to grow at a rapid rate. At the end of 2003 there were an estimated 268 million mobile subscribers, and more than 5 million people signed up for cellular phones each month (MII, 2004). Before 1999 China's mobile handset market had been completely dominated by foreign brand products, such as Motorola, Nokia, and Ericsson. As China applied its "Attracting and Absorbing Foreign Direct Investment" policies towards foreign mobile communications equipment providers, almost all major handset manufacturers were encouraged to establish joint ventures in China. As a result, all mobile phones sold in China were produced by foreign-owned enterprises or imported directly from abroad before 1998. Lacking scientific

knowledge in local settings, with poorly developed or nonexistent support industries, with a history of heavily regulated telephony, with a poorly developed hard wire telephony infrastructure and with a negative view about the contribution of communications to productivity, China constrained indigenous firms from moving first in China's domestic market.

However, since the entry of Chinese domestic mobile handset manufacturers in 1998, foreign brand products gradually lost their dominance in the handset market in China. In 2002, Chinese brands captured about 30% of the market, growing to approximately 55% in 2003. Chinese domestic suppliers have successfully established their position to surpass the market share of joint ventures while direct imports largely have been phased out. Chinese brands are becoming the mainstream products in China's domestic mobile phone market.

How did China's domestic firms catch up with the early movers, overcome inherent disadvantages and succeed in dominating the world's largest handset market in less than five years? By examining the mobile communications sector as a whole and through case examples, this paper examines how China's domestic firms have surmounted their inherent disadvantages and have taken a leadership position in limited product areas. This paper concludes with a summary of factors that contributed to the success of China's domestic handset manufacturers.

III. DEVELOPMENT OF CHINA'S MOBILE HANDSET MANUFACTURING SECTOR

The mobile communications market in China relied totally on direct imports in the late 1980s. During China's transition from a planned economy to a more market oriented economy, telecommunications became a leading sector with an exponential growth rate in a dualistic economy (Jin and Haynes, 1997). Realizing the attractiveness of its potential market demand for

mobile communications equipment and the bargaining power generated from its market size, China actively approached foreign suppliers with joint venture negotiations and technology transfer opportunities. With the establishment of Shanghai Bell in 1984, joint ventures in selected areas were highly encouraged. Table 1 shows the digital cellular sector listed in the “encouraged” category in the “*Government Guideline for Foreign Investment in Telecommunications*” issued by the State Council in 1995. In contrast, analogue wireless system is listed as “restricted” while the telecommunications service sector is completely prohibited from foreign investment. Overall, foreign investment in the mobile communications equipment manufacturing sector was highly encouraged by the Chinese government in the mid-1990s.

Table 1. Regulatory Categories of FDI in the Telecom Sector (1995)

| Category | Details |
|-------------------|------------------------------------------------------------------------------------------------------------------------------------------------------|
| Encouraged | Digital cellular, SDH, ATM switching system, satellite communications system, digital microwave system |
| Restricted | Analogue wireless system, PABX, non-ATM central office switches, TV and Radio Broadcasting systems, Fax machines, low speed digital microwave system |
| Forbidden | Telecommunications basic service |

Source: Lu & Wong (2003)

When the “Attracting and Absorbing Foreign Direct Investment” policy as applied to the mobile communications equipment manufacturing sector it led to the emergence of foreign direct investment in mobile handset production in the early 1990s. In 1992, Motorola built its first manufacturing plant in the port of Tianjin. Now nearly all the world famous mobile communications equipment providers, including Motorola, Ericsson, Nokia, Siemens, and Samsung, have established joint venture companies in China. Motorola, Nokia and Ericsson are the three largest. The total foreign investment in this sector was \$1.9 billion in 1998 and over \$4

billion in 2001 (Wang, 2003). Table 2 shows Motorola alone had invested \$3.4 billion in China through 2002 (ChinaNex, 2004).

Table 2. Primary Foreign Handset Producers in China

| | <i>Motorola</i> | <i>Nokia</i> | <i>Ericsson</i> | <i>Siemens</i> | <i>Samsung</i> |
|--------------------------------------------|---------------------------------------------------------------------------------------------|----------------------------------------------------------------------------|-------------------------------------------------------|----------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------|
| Date of entry | 1987 | 1985 | 1985 | 1982 | 1992 |
| First handset manufactured in China | 1992 | Middle 1990s | 1992 | 1993 | -- |
| Subsidiaries in China | WO (1); JV (8); controlled (1); local offices (26); R&D facilities (18); employees (13,000) | JV (8); local offices (about 50); global R&D centers (2); employees (4700) | WO (4); JV (10); local offices (26); employees (4500) | JV (more than 40); local offices (28); employee (21,000) | Manufacturing facilities (11); investment company (1); local offices (3); R&D center (1); after-sale service center (1); employees (11,000) |
| Total investment | \$3.4 billion (till 2002); R&D, \$0.3 billion | More than \$2.9 billion | More than 600 million | More than \$660 million | More than \$2.6 billion |
| Revenue (2003) | \$6 billion | \$2.5 billion | \$1.8 billion | \$1 billion | \$6.4 million (sales in 2002) |
| Mobile phones production | -- | -- | -- | 12.5 million (2003) | -- |
| Mobile phones sold in China (2003) | about 12 million | about 10 million | -- | 2-3 million | -- |
| Market share (1999) | 39.4% | 32.3% | 6.44% | 5.95% | -- |
| Market share (2002) | 25.76% | 18.17% | 2.09% | 4.66% | -- |

Notes: WO: wholly owned; JV: joint venture; --: not available.

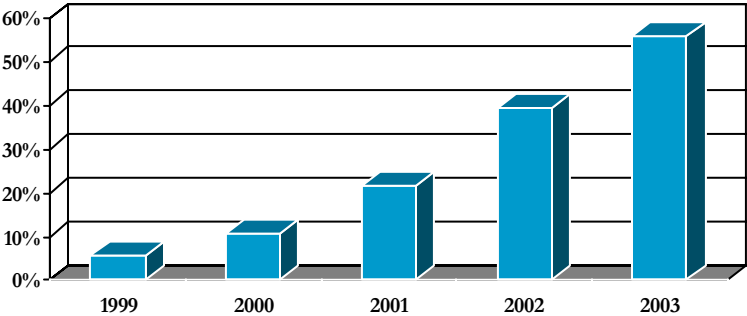
Source: Individual company's official website and ChinaNex website at: <http://www.chinanex.com/company/index.htm>

These foreign companies enjoyed a long period of success due to strong demand in China. Four primary joint venture firms, Motorola, Ericsson, Nokia, and Siemens, dominated China's mobile handset market before 2002. The aggregate market share of these four companies was over 85% in 1999. China is also the single largest market for many large multinational companies. China accounts for 30% of Motorola's handset sales, making Motorola increasingly dependent on China for growth. Ericsson has established a primary base for production for

worldwide sales in China and transferred R&D and production research to China, making it a regional presence. Nokia's largest market is China, with revenue of over \$2.5 billion and exports valued at \$2.1 billion for 2003. Siemens' early, but smaller, commitment continued to pay dividends while Samsung, although late, was investing heavily (ChinaNex, 2004).

Local producers have captured more than 50% of China's domestic market, but joint ventures in China are still their primary production bases to supply the global market. In 2001, the total number of mobile handsets exported from China was 39.63 million, increasing to 63.15 million in 2002 and 95.23 million in 2003 (Ministry of Commerce, 2004). More than 98% of these exported handsets were manufactured by those joint ventures (MII, 2004). Although these foreign companies have lost their dominating role in China's domestic market, they are producing more handsets than China's domestic firms (about 70% of total production in 2003) increasingly for export. However, as of 2004 foreign companies through joint ventures still dominate the domestic high-end handset market (with a price greater than 3000 RMB/\$400 per handset).

Figure 2. Local Brand Market Share Growth



Source: Ministry of Information Industry (various years)

Local firms started supplying China's domestic handset market in 1998 when Kejian manufactured the first GSM handset with a domestic brand. However, the development of the local manufacturers had been very slow prior to 2002. A few large international companies dominated China's internal market, especially in the urban areas. The market share of domestic brands in China's domestic market was only 5% in 1999 and 10.7% in 2000.

Chinese domestic companies lagged in all technological areas of handset manufacturing and design. The Chinese government began to support domestic producers officially after 1999. In January 1999, "Several Issues on Speeding up the Development of Chinese Mobile Communications Industry" was issued by the State Council (Tan, 2002). This document stipulated a list of measures to support local mobile communications equipment providers, including assignment of research grants for R&D, preferred interest rates, discounted tax rates, restriction of further foreign investment in the handset manufacturing sector, and other indirect measures, such as local governments' provision of free land in high-tech industrial parks for handset producers.

Table 3. China's Domestic Handset Manufacturers (2003)

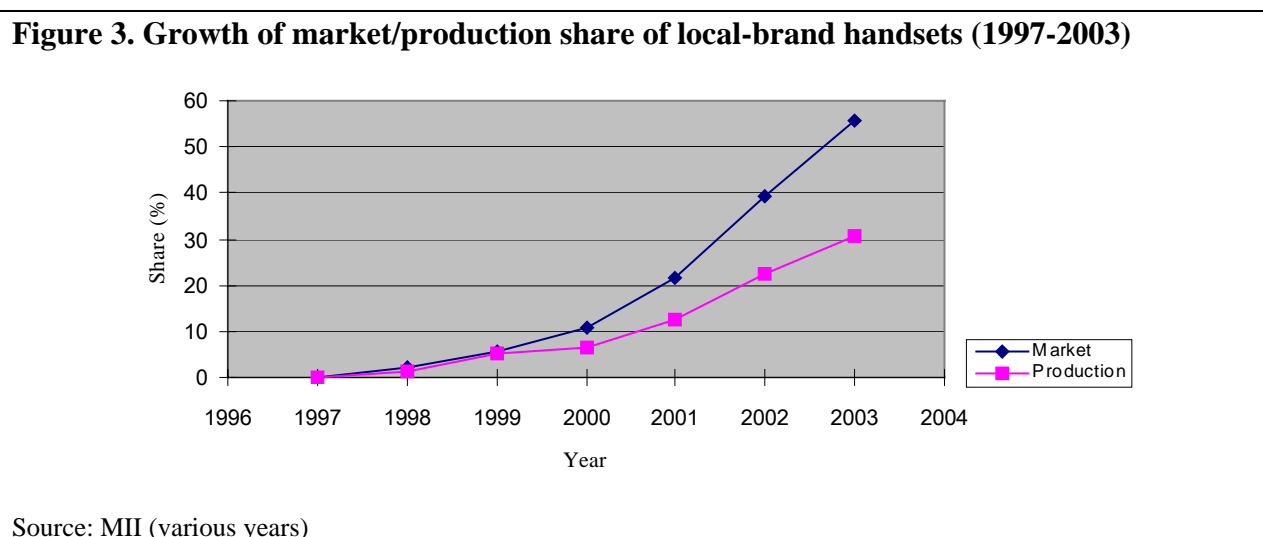
| <i>Categories</i> | <i>Firms (date of first mobile phone manufactured)</i> |
|--------------------------------------------|---------------------------------------------------------------------------------|
| Consumer electronics producers | TCL (2000), Haier (1999), Konka (2000), Xixian (1998), Hisense (2001) |
| Specialized mobile phone producers | Bird (1999), Kejian (1998), EastCom (1999), Capitel (2001), CECT (2001), Putian |
| Telecommunications equipment makers | Datang(2001), Zhongxin(2000), Panda (1998), Panda Mobile (1998) |
| PC manufacturers | Legend (2002), Tide (2001) |

Source: summarized by the authors

Encouraged by government's support and lured by the rapidly growing handset market in China, many domestic firms entered this market after 1999. There are over twenty domestic GSM or CDMA handset manufacturers now, which grew out of existing manufacturers in the four categories as listed in Table 3: consumer electronics producers, specialized mobile phone producers, telecommunications equipment manufacturers, and PC manufactures. Mastering manufacturing skills and occupying the domestic market was a first priority for these domestic producers. In fact, most domestic firms chose a "brand-pasting" (*Tie Pai*) strategy, that is, they imported mobile phones directly from South Korea or Taiwan and then pasted their own brands on the phones. In this sense, most of the first generation handsets of these firms are not "real" domestic brand products since they were not designed and manufactured domestically. But at the same time, they invested heavily in manufacturing facilities and process technologies to achieve economies of scale and learning curve effects. Later, most of these firms chose joint cooperation with foreign companies (not joint ventures) or developed R&D independently. Some of the domestic manufacturers are still using the "brand-pasting" method for at least a portion of their products and enjoy the benefits of the government's preferential policies. For example, as late as in 2003, a senior official of Ministry of Information Industry (MII) condemned publicly the "brand-pasting" strategy and threatened to ban the import of mobile phones completely in 2004 (Wang, 2004). Some analysts are skeptical about the technical competency of China's domestic firms (Ministry of Commerce, 2003), but clearly the capacity gap is closing.

China's local producers gradually dominated the domestic mobile phone market. Figure 3 shows that the domestic market share of Chinese local manufacturers increased gradually from 5.46% in 1999 to 10.7% in 2000, and 21.8% in 2001. In 2002 the market share increased sharply

to 39.4%. In 2003, China's domestic firms produced 34.3 million and sold 34.1 million mobile handsets, taking a majority of China's mobile handset market with a share of 55.8% (MII, 2004). In contrast, the share of the four leading foreign-brands, Motorola, Nokia, Siemens, and Ericsson, declined from more than 85% in 1999 to 46% in 2002, and 24% in 2003 (MII, 2004). Bird has been a leading producer with the largest market share of all domestic firms since 2000. According to MII (2004), Bird held 15% of handset market in 2003, and is a major contributor to lifting the share of Chinese brands to 55.8% in 2003. Overall, ten domestic firms produced more than one million handsets in 2003.



Chinese handset makers have successfully narrowed the technology gap with industry leaders by aggressive investment in manufacturing facilities. After 2002, Chinese handset manufacturers also significantly increased investment in R&D, focusing on upgrading their technological capabilities. Bird spent 6% of its revenue on R&D in 2003 (Network Weekly, 2004). But Chinese makers had not yet reached the stage of mastering the core technologies of handset products. In fact, by the close of 2004 no domestic firm in China has grasped the core

technology of GSM and CDMA mobile phones. This is true also for many Japanese and South Korean companies (as of 2004) since core technologies of chip design were controlled by Texas Instruments (TI), Qualcomm and a few other companies.

Overall, there is a dynamic balance between Chinese domestic firms and foreign owned enterprises in the handset market. China's policy has successfully empowered local firms to dominate the low-end and some medium-end Chinese markets with the help of foreign-owned and joint venture enterprises. On the other hand, foreign owned enterprises have continued to successfully dominate the high-end and some medium-end markets in China through joint ventures and intermediate goods export. China's domestic firms have occupied a large market share but have a long way to go to achieve technological leadership.

IV. BEHIND THE HYPER GROWTH

Chinese domestic mobile phone manufacturers are "latecomers" since they entered the handset market about ten years later than the foreign producers. In this sense, the mobile phone manufacturing industry in China provides a good test case of the catch-up process by firms who are "latecomers". The word "latecomer" has been used extensively in previous economic and organizational studies. For example, the Korean semiconductor industry has been widely cited as an example of the successful latecomers (Cho, et al, 1998; Mathews and Cho, 1999; Hobday, 1995; Choung et al, 2000). Cho et al (1998) classified the sources of early mover advantages, as well as latecomer advantages, into three areas: market, competition, and the characteristics of the early moving firm (see Table 4).

Many factors contributed to the rapid development of China’s mobile phone manufacturing. Following a similar framework as summarized by Cho et al (1998), we classified success factors and examined the mobile communications sector as a whole. Here we combine those factors listed as “competition” and “firm” in Table 4 into a broad *competition* category while emphasizing another important factor – government policies.

Table 4. Summary of early-movers/latecomers’ advantages

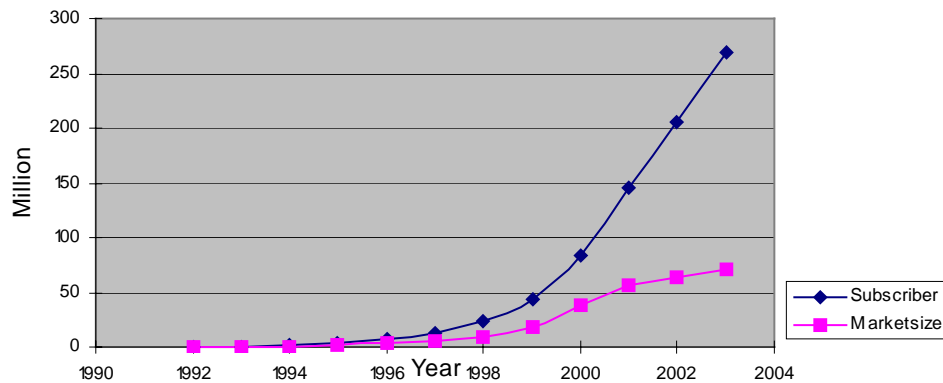
| | <i>Advantages of early movers</i> | <i>Opportunities for latecomers</i> |
|--------------------|-------------------------------------|--------------------------------------------------------------------------|
| Market | Brand loyalty; switching costs; | Dynamic market; customer taste adjustments; new technological changes; |
| Competition | Preemption | Incumbent inertia |
| Firm itself | Advantage through learning by doing | More concrete info and less uncertainty; often resource-rich environment |

Source: Based on Cho et al (1998)

Market

Local market conditions in China supported an immediate demand for mobile phones when local producers entered the market in late 1998. Before the late 1990s, owning a mobile phone was a rare luxury reserved only for leading bureaucrats or wealthy businessmen. But since 1998, ordinary persons have gradually accepted mobile phones because of the sharp decline in the mobile connection fees and mobile phone prices. In 1999, the total number of mobile phone users reached 43.3 million and nearly doubled in one year, reaching 84.5 million at the end of 2000. The number of China’s mobile phone users increases at least 50 million every year. The increase of the user base creates a large handset market in China (Figure 4). Since 2002 China has had the largest telecommunications network in terms of both fixed and mobile communications capacities. There were over 268 million mobile phone subscribers and 264 million fixed-line telephone users in China by the end of 2003. Even a small share of this large market would support the growth of a large producer.

Figure 4. Growth of mobile phone subscribers and handset market size



Source: China Statistical Yearbook (various years); MII website, <http://www.mii.gov.cn/mii/hyzw/tjxx.html>

More important, the inherent nature of the mobile phone business was such that it created opportunities for latecomers to technologically leapfrog over early starters and assume industry leadership in certain fields. China's 2G (second generation) mobile phone domestic producers could compete with foreign rivals at the chip-designing level because of technological patents. But many companies without chip technology, such as Samsung and LG, also established their position by succeeding in developing new application software and exterior designs. China's domestic producers also mastered design capability quickly. Now, China's domestic firms provide more new GSM handset models than their foreign competitors. Bird claims two-thirds of its handsets are designed in-house. It launched 35 new models in 2003 and another 50 were scheduled for 2004. In contrast, Nokia launched only 14 GSM models in China in 2003. Nokia's market share has declined steadily in China from 30% in 2000 to 13% in 2003, due partly to insipid flat design and lack of innovation (Sun, 2003).

Due to technological change China's firms are at the same starting point with foreign competitors for 3G mobile phone technologies. It is not impossible for China's domestic firms to become involved and then control core technologies in some areas for 3G. In fact, China had

paid special attention to the TD-SCDMA standard and has jointly developed it with the China Academy of Telecommunications Technology (CATT) and Siemens. TD-SCDMA is one of the only three international standards recognized by the International Telecommunications Union (ITU) for 3G and is the first ITU standard proposed by China. On Oct 30, 2002, the alliance of TD-SCDMA industry, consisting of eight domestic enterprises including Datang , Huawei, Soutec, Huali, Legend, ZTE,CEC and Putian, was established in Beijing. Financially supported by the Chinese government, a meeting on TD-SCDMA prototype standards was provided by members of the Alliance in 2004 (RTX Telecom, 2003). Although Motorola, Nokia, and Ericsson already have their own mature 3G products, these products cannot easily be introduced into China because of different standards. China's domestic firms have the potential of building technological competency in this area.

Competition

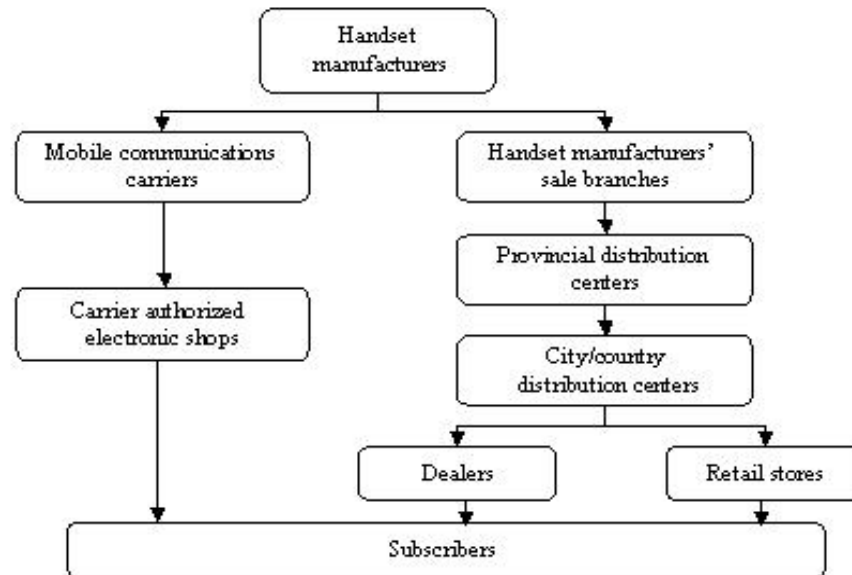
In the intensely competitive handset market, domestic manufacturers compete directly with foreign owned or joint venture rivals. China's diverse domestic mobile phone manufacturers have adopted a series of strategies to compete with their leading foreign competitors. This competition has contributed to China's success. As in many other Chinese industries, domestic competition among China's mobile handset manufacturers has been regarded as more important and threatening than competition overseas.

First, China's domestic firms focused on the low or middle-end market and initiated severe price competition based on their advantages in low costs and local market characteristics. The leading domestic firm, Bird, engages in competition by keeping prices lower than comparable products (ChinaNex, 2004). Network Weekly (2004) estimates the average price of the mobile phones sold by Bird to be about RMB 919.21 (about \$110) with an average profit of

RMB 20.84 (less than \$3) per handset, indicating that most mobile phones sold by Bird were low-end products. Joint ventures eventually lost the low-end market because of their relatively higher costs in labor and distribution. Even in the midrange segments, joint ventures are facing strong competition – mainly from Chinese companies.

Second, local manufacturers usually have more extensive distribution channels which assist the capture and maintenance of their market throughout the country, especially in small cities and in the countryside. More than twenty handset manufacturers in China (including Bird, Kejian, TCL Mobile, and other small and medium-sized companies) primarily sell handsets through their own retail stores or dealers throughout the country. In recent years, some manufacturers also began to supply handsets to the mobile communications carriers. Figure 5 shows the distribution channels of a typical mobile handset manufacturer in China. Many specialized handset producers built their distribution channels on their own while electronic goods producers or PC manufacturers used their existing distribution networks. Manufacturers usually give the dealers a commission for each handset sold by the dealers. The commission rates vary in accordance with the number of handsets sold in a certain period of time. Some dealers offer incentives, reducing their commissions in an attempt to attract more customers and to obtain higher rates of commission later. Joint ventures usually do not have their own sales networks, but depend on a complicated three-level hierarchical agency system, which increases their distribution costs. As a result, domestic firms usually have more distribution channels than their foreign competitors. Nokia sells its handsets through a reseller network with 900 outlets in China and has begun to work with regional distributors such as electronics store chains. In contrast, Bird sells its products through 40 distributors, 400 sales offices, 15,000 resellers and 50,000 retail outlets (ChinaNex, 2004).

Figure 5. Distribution channels of domestic firms



Source: summarized by the authors

Chinese producers also often provide better quality after-sale services. Since many of these mobile phone manufacturers are also consumer-electric producers, they have experience and expertise in after-sale service. Bird built nearly 2,000 customers support centers, many in second and third-tier cities.

Government Support

Last and most important is the Chinese government's carefully planned intervention and support for the handset manufacturing sector. In the early stages, the Chinese government maintained policies promoting foreign investment in this industry. Diverse forms were adopted, including foreign wholly owned enterprises, joint venture enterprises, joint cooperation enterprises and so on. The presence of many joint venture handset manufacturers in China fostered the diffusion of technology expertise across the country. This was a broad-ranging

knowledge diffusion and exchange which involved R&D, production, sub-contracting, marketing, after-sales services, and local human resource training. China's domestic entrepreneurs, designers, workers, and engineers quickly grasped the opportunity to develop competitive local products. Since a local company, Kejian, produced the first GSM handset in 1998, local manufacturers' production of handsets gained rapid growth built on the diffusion of technologies into China through various foreign investment and technology transfers and augmented them by local R&D efforts.

China's ultimate goal is to enable its local firms to compete with multinational companies, both in the Chinese market and in the global market. The Chinese government shifted its role from *supporter* of joint ventures in the mobile communications manufacturing industry, including the handset sector, to a role of *protector* when domestic firms began to compete with those foreign investment controlled firms. The State Council adopted policies designed to allow Chinese firms to increase technological capacity and occupy the domestic market, to attract more investment and to collect special program funds to improve the technological competency of domestic mobile communications equipment producers (Network Weekly, 2004). The State Council financially supported R&D for mobile technologies by (1) transferring 5% of fixed-line telephone installation fees as a special grant from 1999 to 2003 and (2) the MII invested 1.4 billion Yuan (\$169.7 million) from mobile connection fees. In addition, it stopped issuing licenses for joint ventures in mobile handset manufacturing after 1999.

Further, when GSM handset technology was becoming obsolete and CDMA technologies were maturing, the government established preferential policies toward domestic CDMA manufacturers. These policies limited domestic licenses for foreign competitors, restricted the

sales of CDMA handsets produced by joint venture firms and required domestic branding and R&D development. In 2001 licenses for CDMA mobile phone production were issued to 18 domestic firms and Motorola; Nokia received a license in 2003; no more licenses will be issued. The government restricts importation of CDMA handsets with quotas and charges an extra 2.5 to 5% of total sale volume if joint venture firms sell CDMA handsets in China. The government required domestic CDMA mobile handset manufacturers to own their own brands, have independent R&D capability and/or possess appropriate patents.

In summary, tariff reduction, preferred interest rates, subsidies for R&D, regulations of market entry, and many other measures were implemented in China to support its mobile handset manufacturing sector. Telecommunications service providers also are encouraged by the government to purchase products of domestic vendors. An extreme example is that the Chinese government organized supply-demand coordination conferences to promote the adoption of domestic products (Lu and Wong, 2003). In addition, numerical targets for export, production and R&D have been suggested by the government (MII, 2004). The government has been an important factor in the development of China's handset manufacturing sector and closing the technology capacity gap.

V. CONCLUSION

China is the largest handset market in the world and this market continues to grow at an extremely rapid rate. Before 1999 China's mobile handset market was completely dominated by foreign brands products. However, since the entry of Chinese domestic mobile handset manufacturers in 1998, the domestic suppliers have gradually established their position to surpass the market share of joint ventures while direct imports have been largely phased out.

While products of joint ventures still control the high-end market, Chinese domestic brands are becoming the mainstream products in China's mobile handset market.

By examining China's mobile handset manufacturing sector as a whole and through case examples, we found several factors that contributed to the success of China's domestic handset manufacturers. Following a framework summarized by Cho et al (1998), we classify these factors into three categories. First, China's large handset market supported an immediate demand for mobile phones. The inherent nature of the mobile phone business was such that it created opportunities for latecomers to technologically leapfrog. Second, in the intense competition with joint ventures, China's domestic producers occupied the domestic market with the advantages of low prices, extensive distribution channels, high performance-price ratios, better after-sale service, as well as a better understanding of the local market and tastes. Last, China growth of the industry has been carefully planned with intervention through government policies. By playing various roles in a timely manner, the Chinese government has provided crucial support for development of the mobile handset industry.

The case of China's mobile handset market suggests China has localized the production of low-to-medium-end handset products, which gradually destroyed the direct import of these products and occupied the market which had been dominated by joint ventures. New and high-end handset products are primarily developed and manufactured by joint ventures or imported directly from overseas. These high-end products would downgrade to medium-end or low-end ones over a short period of time. However, by actively investing in R&D and participating in the establishment of new technology standards, it is possible that China's local producers will build their technological competencies and become technological leaders in certain areas.

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