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A Divergent Path of Industrial Upgrading: Emergence and Evolution of the Mobile Handset Industry in China

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Abstract

Starting from almost null in the late 1990s, China's mobile phone handset industry has grown to account for more than 40 percent of the current world production. While export growth has been overwhelmingly led by multi-national corporations (MNCs), increasingly fierce competition in the domestic market ignited by the advent of local handset makers has induced unique industrial evolution: (1) outgrowth of independent design houses specialized in handset development and (2) emergence of IC fabless ventures that design core ICs for handsets. In the background of this evolutionary industrial growth there are factors such as, the scale and increasing diversity of China's domestic market that advantages local firms vis-à-vis MNCs; modularization of handset and semiconductor technologies; policy interventions that supports local startups. The emergence and evolution of China's handset industry is likely to have international implications as the growth of the global demand for low-cost and multi-function mobile phone handsets is expected to accelerate. Thus, our case suggests that the conventional view of latecomer industrialization and upgrading that emphasizes the key role of international production networks organized by MNCs needs to be modified in order to accommodate China's rise into perspective.

Keywords: industrial upgrading, China's industrial growth
JEL classification: L1, L6, O1, O3, P2

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I. Introduction

The rise of the East Asian electronics industry in the context of globalization has attracted a wide range of research interest. Regardless of variance in analytical approach, it is almost unequivocally acknowledged that multi-national corporations (MNCs) from the US, Japan, Europe, and more recently also from East Asian frontrunners such as Korea and Taiwan, have played key roles in fostering the export-led growth of the East Asian electronics industry. Aiming to achieve cost reduction with assured quality, MNCs establish affiliates, subcontract part of production to local suppliers, or outsource the whole manufacturing process of final products to competent local manufacturers (referred to as OEM, or original equipment manufacturing). These various types of cross-border transaction usually accompany varying degree of technology transfer, which facilitates, either deliberately or unintentionally, capability building of MNCs' local affiliates, subcontractors or OEM vendors. One of the central concern of the literature has been the way how Asian local economies and firms interact with MNCs that organize international production networks (IPN) so that the Asian latecomers can enhance their technological capabilities and capture better chances to get themselves involved in higher value-added activities within IPNs[1].

China has been emerging as one of the major producers of electronics products since the late 1990s[2]. Sweeping market liberalization on the eve of accession to the WTO and following upsurge of foreign direct investment drastically accelerated the trend. This naturally has led to mounting research interest in the development of the electronics industry in China. Meanwhile, studies motivated by the IPN theory are yet to fully incorporate China's emergence into their analytical framework. The shortfall is, we believe, to a great extent attributable to the paucity of case-based studies that can bridge the gap between international perspectives and China's indigenous industrialization experience that has its distinct characteristics[3].

In this context, we explore in this paper the emergence and organizational evolution of China's indigenous mobile phone handset industry since the late 1990s up to today. Through our case study we highlight a *dual-track* nature of the industry's development in China. We use the term

[1] For the IPN (also referred to as global production network or cross-border production network, of which difference we disregard here) framework and its application to the Asian electronics industry see Borrus et al.[2000], Yusuf et al.[2004], and numerous works by Ernst (1998; 2004; more) and Hobday (1995; 2000; 2001; more) . The dichotomy of East Asian "OEM-led growth" and Southeast Asian "TNC-led growth" proposed by Hobday places great emphasis on the role of local firms, but it still sees the involvement in IPNs as the prime pathway for late-comer growth..

[2] See Appendix for the share of China in the world production of electronic products and IT hardware. (**We are updating the data soon.*)

[3] Refer to Lu [2000], Steinfeld [2004], and others.

"dual-track" in the following sense: while export growth has been overwhelmingly driven by MNCs' affiliates and joint ventures, it is the robust growth and increasing diversity of the domestic market that has made it possible for local firms to brake into the business once monopolized by a few giant MNCs.

Our case study will show that increasingly heated competition in the domestic market ignited by the advent of local makers has induced organizational or technological innovations; the innovations are adaptive to China's market environment, where strong cost sensitivity and enduring quests for novelty coexist. These domestic-competition-induced innovations, as we call them, may have international implications as the global demand for low-cost and multi-function mobile phone handsets is expected to grow in coming years. Thus, our case suggests that the conventional IPN-centric view of latecomer industrialization and upgrading may need to be modified in order to fully accommodate China's rise.

The remaining sections are organized as follows. Section II sketches the emergence of China's mobile phone handset industry, focusing specifically on the rise of local handset makers from the late 1990s to 2003 and retreat that soon followed. Sections III and IV bring forth two new developments generated from mounting competition in the local handset market, i.e. outgrowth of independent design houses and core-chip fabless ventures, which we regard as variants of backward linkage effects *a la* Hirschman (1957). We will also refer to the impact of policy interventions on industrial development in these sections. In Section V we analyze dynamics of the industrial evolution described in the preceding sections, invoking again Hirschman's linkage concept. Section VI summarizes and concludes the paper with reference to international implications of China's experience.

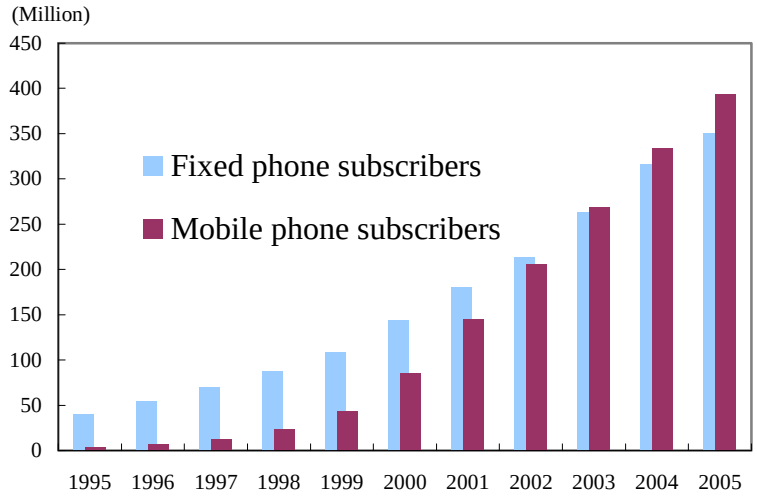
II. Local Handset Makers: From Rise to Retreat[4]

Beginning in the 1990s mobile telecommunication service started a full-fledged growth worldwide. The trend soon spread to China. The country experienced literary explosive growth in the number of mobile phone subscribers during the second half of the 1990s (Figure 1). Although the growth has slowed down recently as the urban market got saturated in terms of penetration rate, average annual growth rate during the first half of the 2000s still exceeded 30 percent. A decade of high-speed growth made China by far the largest market of mobile phone handsets in the world with more than four hundred million subscribers. The latest nationwide penetration rate is slightly more than 30

[4] For the development of China's handset makers see Enterprise Research Institute [2005] and Kimura [2006].

percent, meaning there remains huge potential to be exploited in the future in China's handset market.

Figure 1. Number of Telephone Subscribers in China



Source: MII.

Table 1. China's Mobile Phone Handset Industry: Summary Figures

(Millions of handsets, %)

	Production (A)	Exports (B)	Imports (C)	Domestic Consumption (A)-(B)+(C)	Export Ratio (B)/(A)	Share in World Production
1998	4.0	2.2	1.6	3.4	55.1%	2.3%
1999	22.6	5.7	3.0	19.9	25.2%	8.0%
2000	53.4	22.8	6.0	36.6	42.6%	12.2%
2001	87.0	39.7	7.5	54.8	45.6%	21.8%
2002	131.6	63.3	17.2	85.5	48.1%	31.2%
2003	182.3	95.3	22.1	109.0	52.3%	35.6%
2004	233.4	146.0	12.7	100.1	62.6%	34.6%
2005	303.5	228.3	12.8	88.0	75.2%	37.2%

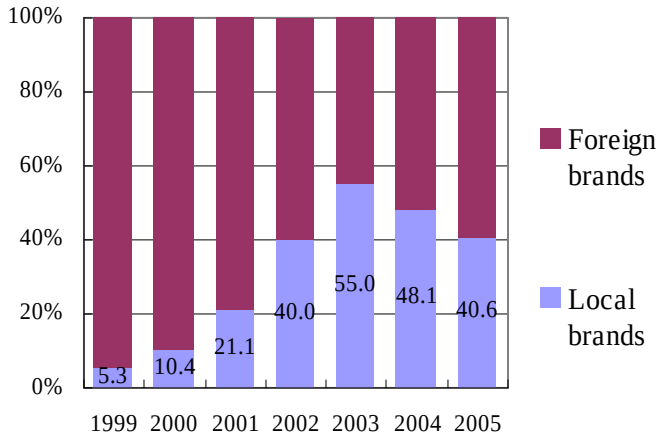
Note: The accuracy of official production figure from which series (A) is compiled is doubtful especially for 2004 to 2005 as most of other available information suggests the growth of domestic consumption remained in place in the period, though at much lower speed.

Source: Compiled by the author based on MII statistics (domestic production), custom statistics (trade), and estimates by Gartner (world production).

Driven by the surge demand both in the world and domestic markets, China's mobile phone handset industry has exhibited a spectacular growth since the late 1990s (Table 1). The country's share in the world production shot up from a negligible few percent to nearly 40 percent by 2005[5]. Exports and domestic consumption rose almost in parallel until 2003, after which the latter became more or less flat. In 2005 around 75 percent of handsets produced in China are exported. Although local handset makers turn increasingly outward-looking recently, MNCs altogether still contribute to close to 95 percent of the exports. Thus, just like many of other electronics industries, export growth of China's handset industry has been overwhelmingly led by MNCs to date.

When we turn our eyes to the domestic market, however, a strikingly distinct picture shows up. Figure 2 presents the trend of the aggregated share of local brands vis-à-vis foreign brands in China's domestic market based on official data released from the Ministry of Information Industry (MII). Stating from just around five percent in 1999, the local brands' share increased very steeply until 2003, when the official media triumphantly announced Chinese handset makers eventually captured more than 50 percent of the domestic market; then almost all of a sudden came the reversal. Since 2004 a majority of local handset makers slid into retreat, which has continued until early 2006. Below we highlight the process how local makers realized the initial success and experienced serious retreat subsequently; then we introduce new developments that have been induced by struggles by local handset makers to adapt themselves to China's ever-changing market environment.

Figure 2. The Aggregates Shares of Local Brands and Foreign Brands



Source: MII.

[5] It is reported that China's share in the world's handset production exceeded 40 percent in the first half of 2006.

Rise of local handset makers: 1998-2003

Up until the late 1990s China's market of mobile phone handset had been virtually monopolized by a few giant MNCs, Motorola and Nokia per excellence, two of which accounted for more than 70 percent of the market altogether. As imports of finished handsets were strictly controlled by the quota system, both of the two companies set up joint ventures with state-owned telecommunication equipment makers, Capitel and Eastcom respectively. The role assigned to the joint ventures was no more than assembling of components into finished handsets, leaving the local partners few chances to acquire technological capability from the transaction[6]. Other MNCs followed suit. The Chinese government adopted GSM (Global System for Mobile Telecommunication) as the second generation (2G) system of cellular phone in 1994. This decision turned out to be very helpful in enhancing competition in the domestic market as GSM became the most widely used 2G standard in the world[7].

At the initial phase of the industry's growth, policy interventions played an important role in supporting entries by local firms. As the market opportunity loomed large in the 1990s, the government came to recognize the importance of the mobile telecommunication industries including handset development and production. In early 1999, the State Council approved a joint policy proposal submitted by MII and then State Planning Commission titled "Some Proposition on Promoting the Development of the Mobile Information Industry" (referred to as "Decree No.5"). With a view to curbing further expansion of foreign brands and promoting the indigenous handset industry, the decree required all makers to acquire license for producing and marketing mobile handsets and permission for adding production lines from MII, and imposed regulations such as minimum export ratio and local contents requirement on foreign joint ventures (FJVs).

Virtually all the major foreign handset makers from the US, Europe, Japan and Korea successfully acquired licenses via their FJVs. The regulations targeted at FJVs were not very strictly enforced, possibly because they evidently run counter to the spirit of the WTO[8]. But the regulations still circumscribed expected rapid expansion of foreign brands in the domestic market. Owing to the

[6] A retired president who led the initial success of Eastcom's mobile handset business recalls the lack of chance of technology acquisition in the JV with Motorola (*21st Century Business Herald*, December 28, 2005).

[7] 2G is the first generation of digital wireless telecommunication technology that came into commercial use in the early 1990s. China later also adopted CDMA, a 2G standard used mainly in a limited number of countries such as the US and Korea. The share of CDMA service, however has stagnated around ten percent.

[8] Interview with a Japanese maker's affiliate in Beijing (August 24, 2004).

quota control, increase in the imports of complete handsets lagged well behind the growth of domestic consumption (Table 1 above), which in effect further lifted the profit margin of the handset business.

The most important impact of the decree was that it effectively barred further entries of foreign latecomers, mostly Korean and Taiwanese companies[9]. At that time Korea was in the aftermath of the Asian financial crises; massive downsizing by large electronics companies such as Samsung Electronics and LG Electronics had generated a number of mobile handset ventures (Abe 2006). In Taiwan, many ODMs (Own Design Manufacture) vendors in the personal computer and peripheral industries had just started to diversify into the mobile handset business and were eager to extend their customer base to the mainland (Kawakami 2006). As the chance of acquiring licenses on their own was slim, the quickest alternative for them to cash in on the alluring Chinese market was to ally with any of local makers that was given a license but lacked technological prowess.

While Decree No.5 and related policy measures rendered indirect supports to Chinese firms that wished to enter into the handset business, they needed to devise a effective strategy in order to cut into the market dominated by established foreign brands. Aside from telecom equipment makers such as Eastcom or Capitel that had joint ventures with MNCs, a majority of Chinese firms that acquired license were new comers to the industry, having little or practically no expertise in wireless telecom technology. Paradoxically enough, precisely among those new comers did emerge early successful local makers that led the initial growth of China's indigenous mobile handset industry. In contrast to established state-owned telecom equipment makers, the new comers had far greater latitude to exercise improvisational entrepreneurship, which turned out to be more than enough to make up for their lack of technological expertise[10]. The key of their success can be summed up as *a marketing-focused strategy based on borrowed technology*.

Bird is the most representative of such pioneering local makers. Starting from a tiny private venture producing pagers in 1992, the company had grown to become the second largest manufacturer of pagers next to Motorola in 1998. Prior to the event, nevertheless, company executives accurately foresaw the coming eclipse of the paging service and eventually made a decision to shift to the mobile handset business.

This was a reckless decision in view of big technological gap between developing pagers and mobile

[9] Interviews with local handset makers (2004-2005).
[10] Most of the successful new comers were either virtually private enterprises or manager-controlled state-owned enterprises (for the concept of manager-controlled state-owned enterprises see Imai 2006a).

phone handsets. Bird circumvented this problem by borrowing technologies from others. The company established a joint venture with Sagem, a French telecommunication equipment maker. Sagem provided the JV with handset design, technical assistance and procurement service. Handsets produced by the JV were sold under Bird brand in the domestic market and under Sagem brand in the European market. At the same time, Bird also sourced handset designs from second-tier Korean makers and independent design houses and finished handset products from Taiwanese ODMs.

Virtually all of other Chinese entrants to the handset business adopted similar tactics. TCL, one of the largest Chinese TV makers, sourced wireless modules from Wavecom, a French wireless venture[11], and finished handsets from Compal, a major Taiwanese ODM vender, in diversifying into the handset business. During the early days of China's mobile handset industry many Korean and Taiwanese firms thrived extravagantly by selling designs, knock-down kits, or finished handsets to Chinese makers[12].

Outsourcing most of product development and manufacturing at the initial stage allowed pioneer local handset makers to focus primarily on marketing to challenge the dominance of established foreign brands. In China, telecom operators, i.e. China Mobile and China Unicom, have involved themselves little in the marketing of handsets until quite recently[13]. Typically, handsets are sold by makers to large first-tier dealers that covers nationwide or several provinces. The first-tier dealers then distribute the products to second-tier dealers that covers much smaller areas, which in turn sell the products to retailers. It is often the case that there are even third-tier dealers that go between second-tear dealers and retailers[14].

Earning hefty profits from distributing foreign brand products, major nationwide dealers had little reason to be interested in dealing seriously with local new entrants of which brands were barely recognized by consumers in the handset market at that time. In response, Bird and other local pioneers turned their eyes to markets neglected by MNCs and their nationwide dealers: the rural area, townships, small cities, and hinterlands. In these areas, as penetration of mobile phone had just

[11] A wireless module is a pre-assembled electronic circuit board of the core of handset system.

[12] It is reported that at the point of 2003 approximately two thirds of local brand handset shipped were designed by Korean makers, independent design houses, and Taiwanese ODMs ("Both sides of straits racing for handset outsourcing," *21st Century Business Herald*, February 21, 2005 [in Chinese]).

[13] Recently the telecom operators' involvement in handset marketing has been increasing in order to promote differentiated value-added telecom services. This trend may potentially change the nature of competition in China's handset market.

[14] This is not more than a very simplified picture of a typical distribution model. In actuality there are a number of variations; ways how distribution channels are organized are changing rapidly, which we can not afford to detail here.

started, consumers' recognition of foreign brands were far less established than in mainstream markets like Beijing or Shanghai. Focusing on these potentially big left-out segments of the market, local makers directly accessed to second-tier or even third-tier dealers and offered them incentives more attractive than foreign brands did, such as compensating all the inventory loss incurred by dealers owing to reduction in retail price. They also deployed thousands of contract salespersons to retail outlets in order to promote their products directly to consumers, who were by and large ill-informed about the novel gadget called mobile phone and apt to accept salesperson's advice. Low financial cost due to lax monetary policy at that time also prompted local handset makers to adapt aggressive marketing strategies[15].

Besides, in an attempt to make up for their technological disadvantage, local handset makers also placed great emphasis on exterior design that fitted Chinese consumers' preference. This tactic helped boost the local brands' sales, as at that time MNCs were not much aware of the importance of developing handsets customized specifically to the Chinese market.

Retreat of major local makers and further development

The initial success of local handset makers peaked in 2003, when it was reported that Bird had exceeded Motorola to be the number one in China's handset market in terms of shipment (Figure 3). In the same year TCL's shipment also came quite close to Motorola and Nokia. By this time urban consumers had gradually begun to recognize local brands, though mainly in low- and mid-end segments of the market. In the meantime, major local makers had set out to acquire designing capabilities in an effort to alleviate their disadvantage vis-à-vis foreign rivals in product development.

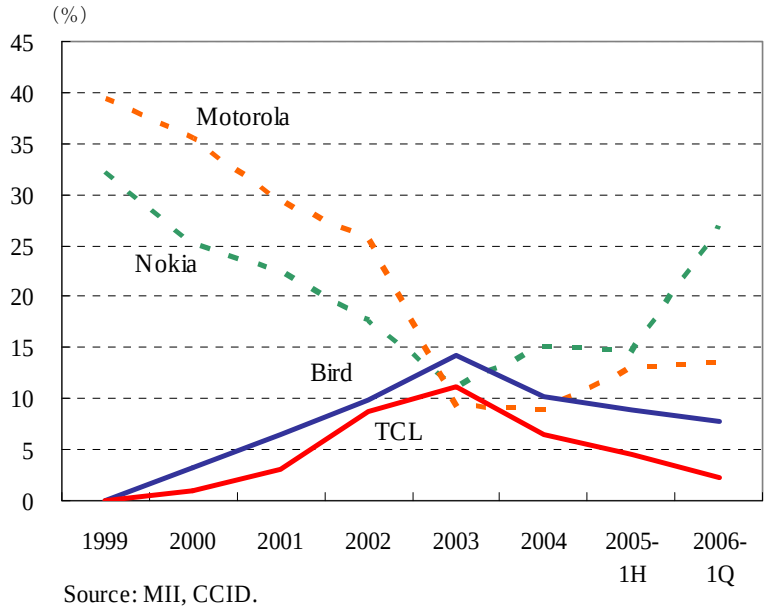
Subsequent developments proved the fragility of the success built predominantly on the marketing-focused strategy. It happened that in this year color LCD phones were introduced to the mainland's market by foreign makers, which soon caught on especially among urban consumers. Rapid transition from monochrome to color LCD brought local makers big troubles. The transition substantially increased the complexity of handset product development and widened technological gap between local and foreign makers again[16]. It took months for local makers to catch up with the new trend but the delay turned out to be costly. As a result of aggressive marketing and poor supply chain management local makers faced with huge inventory of monochrome LCD phones and

[15] Since the late 1990s to 2002 the government exercised expansive monetary policy in order to prop up economic growth. This prompted banks to extend loans to whichever business that was benefited from rampant market expansion.

[16] Quick penetration of camera phones and other multimedia features almost at the same period affected major local makers similarly.

modules that depreciated at an accelerating pace. The inventory loss compensation system for dealers, which once had helped local makers' success, affected them negatively this time.

Figure 3. Trend of Market Share:
Four Leading Foreign and Local Makers



Source: MII, CCID.

On the other hand, MNCs had already learned lessons form their lack of emphasis on marketing and commenced countermeasures. Beginning in 2003, Nokia restructured its marketing policy in China and extended its marketing efforts beyond the mainstream market and placed more emphasis on lower-end consumers, apparently imitating the tactics of local handset makers. Motorola also followed suit. At the same time, by diversifying product lineup with more emphasis on middle-end products, they put a brake on further penetration by local makers to the urban market.

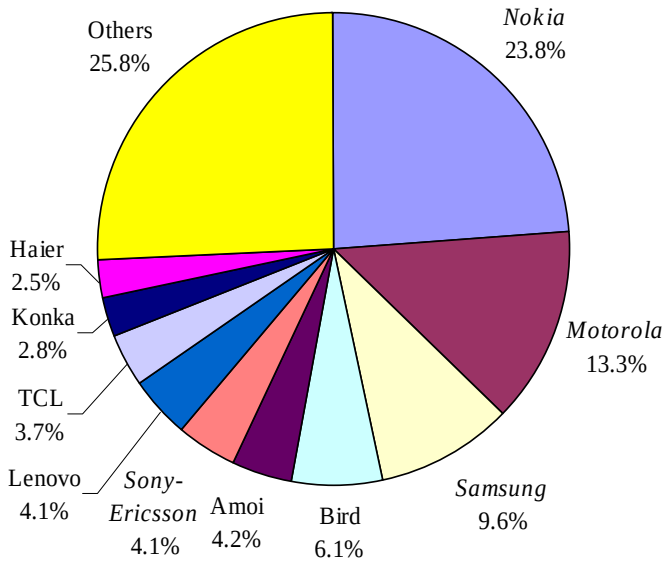
These successive events collectively led to a sharp decline of the market share of local handset makers beginning in 2004, as is shown in Figures 2 and 3. Almost all of leading local makers such as Bird, TCL, Amoi and Konka suffered huge financial loss in 2005. A number of early entrants including Eastcom and Capitel went out of own-brand business or virtually went bust during the year.

However, the drastic downfall of major local makers did not prevent proliferation of new entrants that wish to benefit from the future growth potential in the domestic market. The entry regulation stipulated by Decree No.5 had been increasingly circumvented by borrowing licenses from inactive

license-endowed makers. Eventually, in March 2005, the regulation was replaced with a much more relaxed approval system, which resulted in new entries by more than 30 mostly local companies.

At the point of 2005, handset shipments by the three global giants, i.e. Nokia, Motorola, and Samsung, accounted for virtually a half of the domestic market (Figure 4). The other half of the market was jam-packed by no less than fifty own-brand makers and illegal entrants of which number remain uncertain. In terms of the number of makers China's handset market is apparently the most competitive in the world[17].

Figure 4. Market Share of Handset Makers in China (2005/GSM+CDMA)



Note: Company names in italic denote foreign brands.

Source: Norson Telecom Consultancy. (**To be updated*)

In the following two sections we examine outgrowth of two types of new business: independent design houses and core IC fabless ventures. Both of them have emerged in response to the growth of local final product producers to provide them with physical or intangible inputs and have been thriving on the increasingly fierce competition in China's handset market. At the same time, they are kinds of adaptive innovation in the sense that, based essentially on preexisting technologies, they have been altering the way how China's mobile handset industry is organized so that it is more tailored to local market environments. In this connection we assume them as variants of backward

[17] In the Japanese market, which is a half as large as the Chinese market in terms of handset shipment, there are *only 17* makers supplying handsets, including six foreign makers of which market share is almost negligible.

linkage effects conceptualized by Hirschman (1957). We will return to the point in Section V.

III. The First Backward Linkage Effect: Independent Design Houses

An independent design house (IDH) in the context of the mobile handset industry is a firm that is specialized in the development of mobile handsets[18]. Figure 5 (see next page) summarizes the development process of mobile handsets. The process is essentially composed of four distinctive steps: (i) product definition, (ii) product design, (iii) pilot production and review, and (iv) testing and acquisition of certification. Product development is further categorized into four processes: exterior design, mechanical design, hardware design, and software design. Major IDHs are capable of undertaking the whole process of development from product definition to certification acquisition. Some of them even take on procurement of components and management of contract manufacturing on their own and ship completed handsets (or semi-assembled kits) to customers. On the other hand, there are numerous minuscule IDHs that undertake only one or two of the designing process (say, exterior design or mechanical design) for handset makers or other IDHs as subcontractors.

IDH as a mode of business was originally developed in Korea since the late 1990s. As we mentioned previously, Korean IDHs were the major providers of handset design to local handset makers during the earliest years of China's handset industry along with Taiwanese ODMs. However, as the competition in the domestic handset market became intense, local handset makers felt increasingly dissatisfied with outsourcing product development to Korean IDHs on account of high cost, insufficiency in flexibility to make quick adaptations to ever-changing market conditions, and frequent frictions caused probably by lack of mutual trust[19].

Emergence of local IDHs

Chinese local IDHs emerged soon after the onset of the handset industry in China. Since around 2002, the growth of local IDHs was accelerated. Exploiting their advantage in labor cost, familiarity with the demand of customers and Chinese consumers, and keenness to make adaptations, local IDHs virtually replaced their Korean and Taiwanese rivals as the mainstream players in the design outsourcing business for Chinese handset makers by 2004 to 2005[20]. The drastic decline of

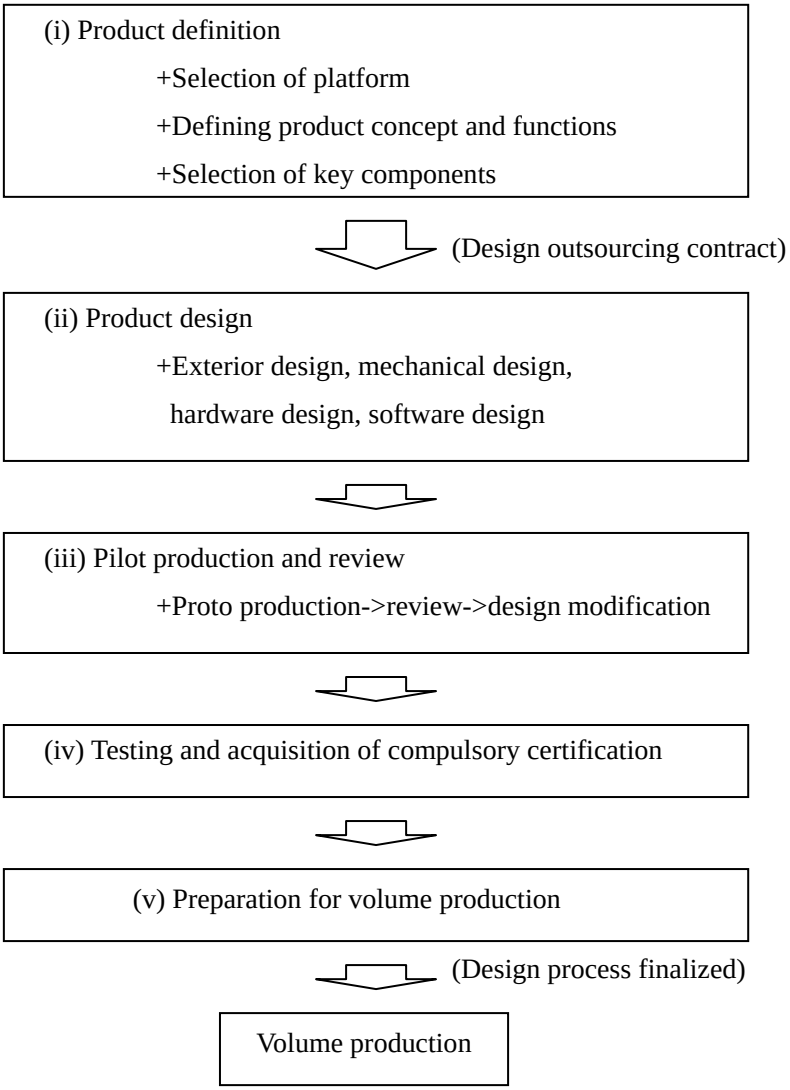
[18] Independent design houses specialized in the development of electronic devices were born in the US in the trend of design outsourcing beginning in the 1990s (See Engardio and Einhorn 2005 and Wilson 2004). Cellon, a San-Jose-based venture established in 1999 by Chinese and US engineers claims to be the first IDH specialized in mobile handset development. Cellon soon establishes a joint venture, CECW, in China and shifted its focus on the Chinese market (see Table 2 below).

[19] Interview with a major local handset maker and other sources.

[20] Taiwanese ODMs shifted their focus on transactions with MNCs rather than Chinese makers in expectation of better chance of learning by doing (Kawakami 2006, pp.78-9). However, they still account for a certain fraction of the handset outsourcing business in the mainland market.

outsourcing orders from Chinese makers forced a number of Korean IDHs to go bust after 2003 (Abe 2006, pp.44-5) [21].

Figure 5. Process of Typical 2G Handset Development



According to estimates made by US consultancy iSuppli and other sources, there are 50 to 60 IDHs that are capable of undertaking the process of product development in an integrated way[22]. Rough estimates suggest that at least 40 to 50 percent of handsets shipped by local makers are designed by

[21] Remaining IDHs are more or less subordinate to three major handset makers, i.e., Samsung, LG, and Pantech This contrasts starkly with the outstanding presence of IDHs in China.
[22] It is estimated that there are 300 to 500 small IDHs that undertake only a part of development such as exterior design or mechanical design, most of which are located in Shenzhen and Shanghai.

IDHs[23]. Thus the presence of IDHs in China's handset market is exceptionally large in contrast to the global market, where in-house development by handset makers remains dominant. Below we examine the factors in the background of the emergence of local IDHs and its implications.

The most important background factor of the emergence of Chinese IDHs is the global trend of the growing maturation and modularization of the second generation (2G) mobile handset technologies. Typically, 2G handset are developed based on so called *platforms*, which are predominantly provided by a limited number of US and European semiconductor vendors such as Texas Instrument (TI), Philips Semiconductors (now reorganized as NXP), Qualcomm in the case of CDMA and so on (later we will introduce the recent rise of Taiwanese and Chinese platform providers). Being the heart of the handset system, platform is basically composed of baseband IC chipset, i.e., a modem that is responsible for voice signal processing, and embedded protocol stack software, i.e., software that incorporates a set of procedure for signal transmission and reception.

In contrast to the product development of the third generation (3G) cutting-edge handsets in which the development process of semiconductors and handsets closely interact, the development of 2G handsets are typically based on given platforms with little customization by platform providers. Thus the most critical issue in the handset development is how to assimilate the technologies incorporated in the platform and combine them with other key functions such as RF (wireless reception and transmission), power management, and non-voice data processing so that the handset can realize functions required by the product definition. Most of modules or chipsets that realize these key functions are also provided by various semiconductor vendors including platform providers themselves. In this sense, product development of 2G handsets is typically a process of *assimilation and combination of existing technologies centered on a platform.*

At the onset of the mobile handset industry in China, the stock of local engineers who are capable of the above-mentioned assimilation and combination process were still quite limited. They were mostly concentrated on MNCs' affiliates, especially Motorola, which had (and still has) the largest R&D facility in China among MNCs, the two most competent local wireless telecom equipment vendors, i.e., ZTE and Huawei Technologies, and some public research institutions.

[23] Note that this is a very rough estimate that is apt to a substantial error margin. The chances are the share of IDHs in the indigenous handset industry may be much larger. There is wide divergence among the estimates of the annual shipment of handsets, ranging from 29 to 37 million units in 2005 (respectively from Pday research, a Chinese consultancy, and iSuppli Corporation). Whichever figure we believe, IDHs' share based on these shipment figures may exceed 50 percent of the shipment by local handset makers.

Competitive advantages

As we examined in the previous section, in entering the handset business, most of local makers relied product designing on Korean IDHs or Taiwanese ODMs for the lack of technological expertise. The almost only competency of local makers vis-à-vis MNCs were their familiarity with and adaptability to the domestic market environment. Local IDHs emerged precisely in the background of this imbalance between local handset makers' marketing capabilities and weak technological expertise.

Profiles of the five largest IDHs are summarized in Table 2. The five IDHs account for more than 80 percent of the handset design outsourcing market in China altogether[24]. It shows that most of their founders and/or core engineers came from electronics products distributors who had engineering backgrounds and close contact with the handset business, or spun-off employees from MNCs or a few competent local handset makers, typically Motorola (China) and ZTE. These people saw a great business chance in providing design outsourcing services to local handset makers in place of Korean IDHs or Taiwanese ODMs, by exploiting their familiarity with the domestic market combined with technological expertise learnt by doing in MNCs or competent local makers.

Table 2. Profiles of five major IDHs

China Techfaith Wireless Communication Technology Limited	
Establishment, founders, and the management	Established in 2002 by Dong Defu, ex-sales manager of Motorola (China). 11 executive directors out of 13 came from Motorola. Listed on NASDAQ in May 2005.
Scale	Employees: 2,010（August 2005)/Shipment: 11 million units (2005）
Major clients	Local: ZTE, Bird, Haier, Konka, Capitel, CECT, Lenovo, Panda, Soutec, Eastom, Kejian, Huawei Foregn: NEC, Kyocera, Mitsubishi Electric, UTStarcom, Sanyo Electric, Alcatel
CECW Wireless Limited	
Establishment, founders, and the management	Established in 2000 as a joint venture between CEC (a state-owned enterprise) and Cellon, a US-based IDH established by Jason Sun (electronic component distributor) and others.
Scale	Employees: 850 (including Cellon, 2005)/Shipment: 7 million units (2005)
Major clients	Local: Haier, CEC, CECT, Konka, Amoi, TTA (TCL=Alcatel) Foreign: Siemens, Philips, Grandiente (Brazilian operator)

(to be continued)

[24] Estimate by iSuppli Corporation.

Table 2. (continued)

SIM Technology Group Limited）	
Establishment, founders, and the management	Established in 2001 by Wang Zutong and his wife Yang Wening, electronic component distributors. General manager of handset division was ex-executive director of ZTE's handset division. Listed on Hong Kong Mainboard in May 2005.
Scale	Employees: 497（June 2005, R&D staff only)/Shipment: 6 millon units (2005)
Major clients	Local: Bird, Lenovo, Panda, Daxian, other small brand makers Foreign: Telecom Italia Mobile (Italian operator), VK Mobile
Longcheer Holdings Limited	
Establishment, founders, and the management	Established in 2000 by Tao Qiang, mobile handset dealer, and several engineers from ZTE. Four out of nine executive directors are engineers from ZTE. Listed on Singapor Exchange in June 2005.
Scale	Employee: 330 (2004)/Shipment: 5 million (2005)
Major clients	Local: ZTE, Konka, Daxian, Soutec, Gionee, GT Mobile, Phonetech, Tianyu and other small brand makers
Ginwave Technologies Limited	
Establishment, founders, and the management	Established in 2000 by Li Hailin, ex-chief engineer of Konka's handset division and the keyperson of the first national project of GSM handset development. Most of key engineers came from Konka
Scale	Employees: Around 300/Shipment: 3 million unit (2005)
Major clients	Local: Konka, CECT, Gionee, Eastcom, Teslda and other small brand makers Foreign: European operators

Source: Compiled by the authors based on interviews (2005-2006), company disclosure materials, company websites, and various articles. Shipment figure based on iSuppli estimates.

Another advantage of Chinese IDHs against Korean and Taiwanese rivals is lower labor cost. This is a very important factor because of a "*knowledge-labor-intensive*" nature of typical 2G handset development; the development process is predominantly realized by labor inputs by a small number of hi-skilled engineers and many more relatively-unskilled young engineers.

In addition to hi-skilled engineers responsible for the core system development, project managers who are responsible for managing the whole process of a development project also play a key role, as their capabilities in integrating various designing processes affect the quality and speed of the project. However, aside from these limited number of key persons, a great majority of workers in IDHs are usually very young engineers with undergraduate or graduate degrees in engineering but with limited experience in the industry. Average salaries of those young engineers are much lower

than their counterparts in Korea and Taiwan, let alone advanced industrialized countries[25]. Table 3 represents the human resource structure of a representative large IDH. It indicates that the share of "core engineers" who have a relatively long experience in the handset industry in each type of designing process is substantially small. Software development, of which importance has been increasing as handsets become more multi-functional, is the most "knowledge-labor-intensive" part of the handset development.

Table 3. Staff Structure of a Major IDH by Job Type

Job Type	Number of employees in each job type			
		Core employees		
		Number	Share in each job type	Average length of career in the handset industry (years)
Software design	920	25	2.7%	5.2
Hardware design	240	26	10.8%	7.5
Mechanical and exterior	320	21	6.6%	4.7
Procurement	90	5	5.6%	6.0
Sales	50	3	6.0%	8.7
Manufacturing Support	160	5	3.1%	8.0
Project Managers	60	5	8.3%	5.8
Quality Control	120	6	5.0%	7.8
Others	50	n.a.	n.a.	n.a.

Source: Interview with the company (September 2005).

Needless to say, most of the characteristics of 2G handset product development summarized above apply not only to IDHs but also to in-house development by local handset makers. As we mentioned previously, in response to the growing competitive pressure, major makers come to place more emphasis on enhancing their in-house development capabilities. On the other hand, however, it should be noted that many of those major makers still opt to outsource substantial part of product development to IDHs, as is illustrated by the fact that the list of customers of the largest five IDHs in

[25] According to a survey of electronic engineers conducted by *Electronic Engineering Times* (China) in May 2005 (n=2,682), average annual income of the respondents was 76,100 RMB (about 9,200 Us dollars), around one eighth of the level in advanced industrial countries ("China's electronic engineers' salaries up 11 %," *emsnow*, December 27, 2005 [http://www.emsnow.com/npps/story.cfm?ID=16369: accessed on September 29, 2006]).

Table 2 above includes virtually *all* of major local makers, including technologically-advanced firms such as Huawei, ZTE, and Lenovo. Then the question is, what is the essential advantage of IDHs in comparison with in-house design by makers?

Rapid growth and ever-increasing diversity of the domestic market is the most fundamental factor that facilitates the emergence of IDHs. The number of handset models released has been increasing year by year. According to the official figure announces by MII, there were 876 new handset models acquired certification in 2005, which is ten times as many as new handset models released in Japan in the same year[26].

If a handset maker tries to cover all (or at least most) of product lineups corresponding to greatly differentiated market segments on its own, it will incur substantial overhead investment that most of local makers are difficult to afford. In contrast, IDHs are able to dilute their development expense by converging a proto-type model to a number of various derivative models that share the common platform or mainboard and selling the models to several customers[27]. Major IDHs also enjoy the economy of scale in comparison with the second or third tier local handset makers, as the annual shipment of handsets designed by each of them exceeds several million units or more. These advantage of IDHs have effectively lowered break-even volume of one handset model typically to a hundred thousand or less, which in turn facilitates further diversification of the Chinese handset market.

Another important factor is the organizational efficiency of IDHs compared with handset makers. By focusing exclusively on the handset development business, engineers are endowed with much stronger incentive to be efficient and innovative in contrast to the case of makers' in-house development. They are also exposed directly to competition with other IDHs in terms of efficiency and innovativeness in product development. On account of the strong incentive and competitive pressure engineers face, IDHs have succeeded in substantially shortening the development cycle; a full-fresh product development typically requires six month or less[28].

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[26] "Last year 132 million domestic legal handset shipped, model competition heat up," www.sina.com, June 29, 2006 [accessed on July 4, 2006: in Chinese]. It should be noted, however, the concept of "model" may differ substantially between the two countries. In China a minor modification to the original model often makes a "new model," whereas in Japan it is not usually the case.

[27] The most typical example is SIM Technologies. The IDH developed 152 models based on twelve prototype mainboard in 2005 (*2005 Annual Report*).

[28] In Japan, it typically takes one to 1.5 year to launch a full-fresh product.

Further evolution

Since a great majority of clients of IDHs are local handset makers, their retreat beginning in 2004 has affected IDHs adversely too. However, the consequence turned out to be much less serious as was the case with their clients. Although the average profit margin of IDHs experienced substantial decline in 2004 to 2005, it still remains much higher than that of handset makers[29].

There are some reasons that may possibly explain this paradoxically good performance of IDHs. Firstly, as competition in the handset market has become more intense, handset makers rely more on IDHs to realize quick launching of new products. Secondly, as Table 2 above illustrates, some of major IDHs successfully extended their customer base to MNCs and overseas telecom operators. We will return to this point in the concluding section.

Thirdly, and probably most importantly, since around 2004, there have been an increasing number of illegal handset makers that sell unlicensed and uncertified handsets and semi-illegal makers that sell handsets under leased license. They mostly target at the rural area, townships, small cities and hinterlands, where lead local makers had once realized their initial success (see the previous section). The new entrants' difference from predecessors is that they promote multi-functional handsets (e.g. phones with multimedia player) at substantially lower prices than the similar (but usually much higher quality) products from authorized (either foreign or local) makers[30]. They realized remarkable growth by exploiting their marketing competency in niche markets that has not been fully penetrated by authentic makers. Some estimates put the annual shipment of such illegal handsets at 10 to 30 million units. It suggests that the official figure substantially underestimates the scale and the share of local makers in China's domestic market.

Virtually all of those unauthorized handset makers outsource product development to IDHs. It is often the case that minuscule IDHs purchase ready-made mainboards from major IDHs, assemble them into finished handsets by adding exterior, mechanical design, and other components, then sell them under unauthorized or leased brand names.

This proliferation of unauthorized handset makers and IDHs that serve their design outsourcing demand has been to a great extent facilitated by further evolution of the industry that has lowered the technological entry bar of the handset development. In the following section we examine the new evolution: the outgrowth of local IC fables ventures that design core ICs for handsets.

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[29] Pday Research estimated the average profit margin of IDHs in 2003 to 2005 to be 70 percent, 35 percent, and 23 percent respectively.

[30] Many of handsets from those unauthorized makers imitate exterior designs and/or functional features of popular foreign brand makers.

IV. The Second Backward Linkage Effect: Local Core IC Fabless Ventures

Local IC fabless ventures that design core ICs for handsets have just emerged since around 2004 to 2005. While they still have remained to be marginal players even in the Chinese market, their shipment has been recording rapid growth. Their emergence seems to symbolize China's industrial challenge towards further upgrading, which is the reason why we focus on them here.

As we examined in the preceding section, the development of 2G mobile handset is based on platforms that have been traditionally provided by US or European semiconductor vendors. The assimilation of platform technologies and combination with other key functions has been the most critical part of the 2G handset development.

The capabilities of this assimilation and combination of key technologies has been the bottleneck in handset development in China, which was also the main reason why major IDHs with such scarce capabilities had realized initial success. However, as multi-functionality became the prime driver in the Chinese handset market since around 2003, the necessity for alleviating the bottleneck owing to the complexity of platform technologies has been strongly felt by local handset makers and IDHs. On the other hand, dominant platform vendors like TI were less interested in adjusting their platforms so as to lower the technological bar of the handset development for their Chinese customers, as their principal focus has been serving the needs of global giants such as Nokia, which carry out most of their product development outside China[31].

Pathbreaking by MediaTek

The first great breakthrough was made by MediaTek, a Taiwanese semiconductor fabless that had grown by its success in the DVD-controller IC market to be the largest semiconductor fabless in Asia. In the early 2000s, in an effort to diversify its business, MediaTek focused on the growing popularity of multimedia functions in the mainland's handset market and developed a so-called "turn-key solution" type of platforms. The key characteristic of MediaTek's platforms are that they revolutionarily simplify the development of multi-functionality handsets. By exploiting their expertise in multimedia data processing, they integrate the baseband IC and the multimedia application processor into a single chip. In this way, while they can lower the cost by reducing the size of the chip, they free their clients from a demanding task of combining platforms and application processors. At the same time, they package their chipset software for multimedia functions such as MP3 of MPEG4 players so that their clients can develop multi-functionality

[31] A number of Chinese customers of TI platforms we interviewed pointed out (or even complained about) the technological complexity of TI's products and the company's insufficient adaptation to the Chinese market (Interviews with IDHs and handset makers in August 2006).

handsets in a “turn-key” fashion within greatly reduced lead time.

MediaTek’s platforms caught on first among IDHs in 2004, as they were generally dare to try newly-born but novel and cheap components. It is estimated that more than a great majority of unauthorized handsets utilized MediaTek chipsets for its superior cost performance; then, with the growing popularity of multimedia phones in the low- and middle-end markets, MediaTek chipsets soon adapted by major makers including Bird, TCL, and Lenovo at a remarkable speed and has replaced TI as the dominant platform provider in China by the next year, capturing nearly 40 percent of the domestic market of handset baseband platform[32]. Aside from the suitability of its products to China’s market environment, MediaTek’s customer service oriented to Chinese customers (IDHs or makers) with relatively weak technological backgrounds and smoother communication owing to the common language also bolstered the company’s quick penetration to the mainland market.

Birth of China-based core IC fabless

The spectacular success of MediaTek has opened a way for a competent local follower, Spreadtrum Communications[33]. Established in 2001 by a bunch of Chinese returnee engineers from Silicon Valley with funding by local and overseas venture capitals, the company’s initial target was the development of baseband IC for TD-SCDMA, the Chinese-government-endorsed standard of 3G[34]. Although Spreadtrum succeeded in developing baseband IC for the first time as a China-based fabless in 2003, the unexpectedly long delay in commercialization of TD-SCDMA in China forced the company to refocus on GSM baseband ICs. Almost at the same time as MediaTek’s platform caught on, Spreadtrum developed its first GSM baseband IC in early 2004[35]. In the next year the company launched SC6600, its first multimedia-focused baseband platform for low-end handsets.

Either intentionally or not, Spreadtrum has been following the footsteps of MediaTek very closely. The key feature of the company’s platforms is also turn-key solutions that integrate baseband IC, multimedia processor, and power management module and package various software, so that even

[32] Estimated by Merrill Lynch (2006). However, those leading handset makers usually continue to source platforms from several providers.

[33] The description of Spreadtrum’s business is based on interviews with the company, local IDHs and makers (August 2006), and various articles.

[34] TD-SCDMA was first advocated by Siemens. Later the Chinese government decided to adapt the technology as the country’s national standard and develop it in cooperation with Siemens. It was eventually accepted by International Telecommunication Union (ITU) as one of the international 3G standard along with W-CDMA and CDMA 2000. However, there is no country except China as yet that expressed intention to introduce the standard.

[35] There are at least five fabless ventures other than Spreadtrum (mostly state-supported joint ventures) that have developed baseband chipsets, but they have been exclusively focused on TD-SCDMA. Thus, at the point of late 2006 Spreadtrum is the only China-based fabless that succeeded in commercialization of its products.

customers that lacks enough development resource can development multi-functional phones within substantially reduced time at a lower price[36].

The company's outstanding difference with MediaTek is its more emphasis on user customization. In order to compete with MediaTek, the company realizes more flexible customization in response to the needs of smaller customers by relying on its in-house and third-party software development resources. Beginning from relatively minor IDHs and makers (probably including unauthorized brands, as is the case with MediaTek), in 2006 several lead makers and IDHs such as Lenovo, Amoi and CECW started to adopt Spreadtrum's platform[37]. Although Spreadtrum accounts for only around five percent of the baseband chipset market in China in 2005, local makers tend to welcome home-made platforms for the potential of closer partnership, on condition that their functionality, reliability, and future roadmap is secured, suggesting there is substantial market potential to be explored by the company.[38]

Just like the case of local IDHs, it is the recent trend of modularization of semiconductor designing technologies par excellence that has enabled quick rise of local IC fabless such as Spreadtrum. Both baseband ICs and application processors are based on two core technologies: DSP, or Digital Signal Processor, and CPU, or Central Processing Unit. Spreadtrum sources these two core technologies, or so-called core IPs, from CEVA and ARM, American and British mainstream core IP providers respectively, as many other rivals do[39]. Vendors of development tools (EDA, or electronic design automation) such as Cadence or Mentor Graphics also provide IC fabless with various IPs[40]. In this sense, while IC designing requires much higher skills than is the case with the handset development, *assimilation and combination of existing key technologies in a way that is adoptive to China's market environment* is also the key of the IC designing for local IC fabless ventures.

While Spreadtrum is the only China-based fabless that has realized commercialization of baseband IC, in other IC products there are a number of fabless emerging into the scene as the demand for localization increases. Among them, we focus on application processors, i.e., chips responsible for

[36] Major platform vendors usually charge customers (makers or IDHs) two to three million US dollars as licensing fee. In contrast, the licensing fee of emerging platform vendors such as MediaTek and Spreadtrum amounts to only two to five hundred thousand dollars.
[37] However, whether these lead companies have adopted Spreadtrum's GSM platform for commercial use or the company's TD-SCDMA platforms for testing use remains unclear.
[38] Interviews with local makers and IDHs (August 2006). However, many of them are prudent about adopting home-made platforms due to uncertainty concerning product reliability and future roadmaps.
[39] IPs in the context of IC designing are functional modules that compose part of an IC. CEVA and ARM are the by far the largest providers of embedded DSP and CPU respectively.
[40] IPs related to IC manufacturing are provided by foundries such as TSMC or UMC.

non-voice data processing, for this is one of the most technologically complex product next to baseband IC.

Stand-alone type application processors compete with one-chip solutions provided by MediaTek and Spreadtrum, in which baseband IC and application processors are integrated in a single chip. Generally speaking, they are more costly than one-chip solution but can realize higher processing capacity.

Vimicro is probably the most successful China-based provider of application processors for mobile handsets. The venture was established in 1999 also by Silicon Valley returnees and realized initial success in image-processors for Web cameras. By 2004 the company claimed that it captured 60 percent of the global market of the product. Knowing the growth potential in the web camera market will be exhausted soon, the company set out to develop multi-media application processor, to which they can apply their competency in image-processing technologies. The company announced that their processors have been adopted by 150 models, including those of leading maker such as Lenovo, ZTE, and Samsung. The merits of Vimicro's processors are quite similar to the case of Spreadtrum: product lineup tailored to various demands for multimedia functions in the Chinese market; meticulous services for local customers; low cost. There are several processor providers following suit.

It should be noted that policy measures have played an important role in fostering the rapid emergence of local IC fabless since around 2000. In the year the State Council issued a decree to rebate six percent of value-added tax out of 17 percent to semiconductor and software companies registered in China[41]. MII also provides subsidies to Chinese firms engaged in cutting-edge IT development projects. Both Spreadtrum and Vimicro have been beneficiaries of subsidies from MII. However, at the early stage of their business they were not necessary the most important targets of semiconductor industrial policy. There are a number of projects that had received much more funding from the government but ended up with nothing or remained commercially unviable. Thus, entrepreneurship, rather than policy supports, is the major factor that led the success of Spreadtrum and Vimicro.

[41] The decree was abolished in 2004 as a result of strong pressure from the US government. However, helped partly by the hefty incentives provided by the decree, the number of IC fabless in China grew almost fivefold since 2000 to 2004.

V. Dynamics of Indigenous Industrial Upgrading

As we examined in the preceding three sections, the rise and retreat of local makers and subsequent competition in China's mobile handset market has induced unique evolution that leads to the country's indigenous industrial upgrading: outgrowth of IDHs specialized in handset development and IC fabless ventures that design core ICs for handsets.

Hirschman described in his seminal work (1957) the process of unbalanced growth, advocating the concepts of backward and forward linkage effects. He pointed out that the growth of lower-stream industries in the first place creates tension (i.e., imbalance) that at some point induces the consequent growth of upper-stream industries. As we already discussed in section II, we assume the outgrowth of the two new business in China's handset industry as a variant of backward linkage effects. We call it a "variant" because the configuration of the industry emerging out of the process is substantially different from its precedents in advanced countries, as the large presence of IDHs and the growing prevalence of "turn-key" solution illustrate. Figure 6 summarized the way how the backward linkage effects have worked in China's handset industry[42] (see next page).

Meanwhile, we need to note that, as was stressed by Hirschman, backward linkage effects work only under certain conditions. Firstly, in the case of the mobile handset industry we surveyed, the "strategic depth" of the Chinese market is the most important factor that has been facilitating the work of linkage effects. The geographic scale of the territory and the great diversity in income and consumer preference makes it possible for technologically-disadvantaged local makers to survive amid rivalry with giant MNCs[43]. At the same time, this segmentations and their elusiveness in the domestic market advantages agile organizations such as local IDHs and IC fabless ventures.

Secondly, policy interventions play a supportive role especially at the onset of the industrial growth. However, after the initial phase their significance tends to decrease, as the fate of the entry-restriction into the handset business designated by Decree No.5 illustrates.

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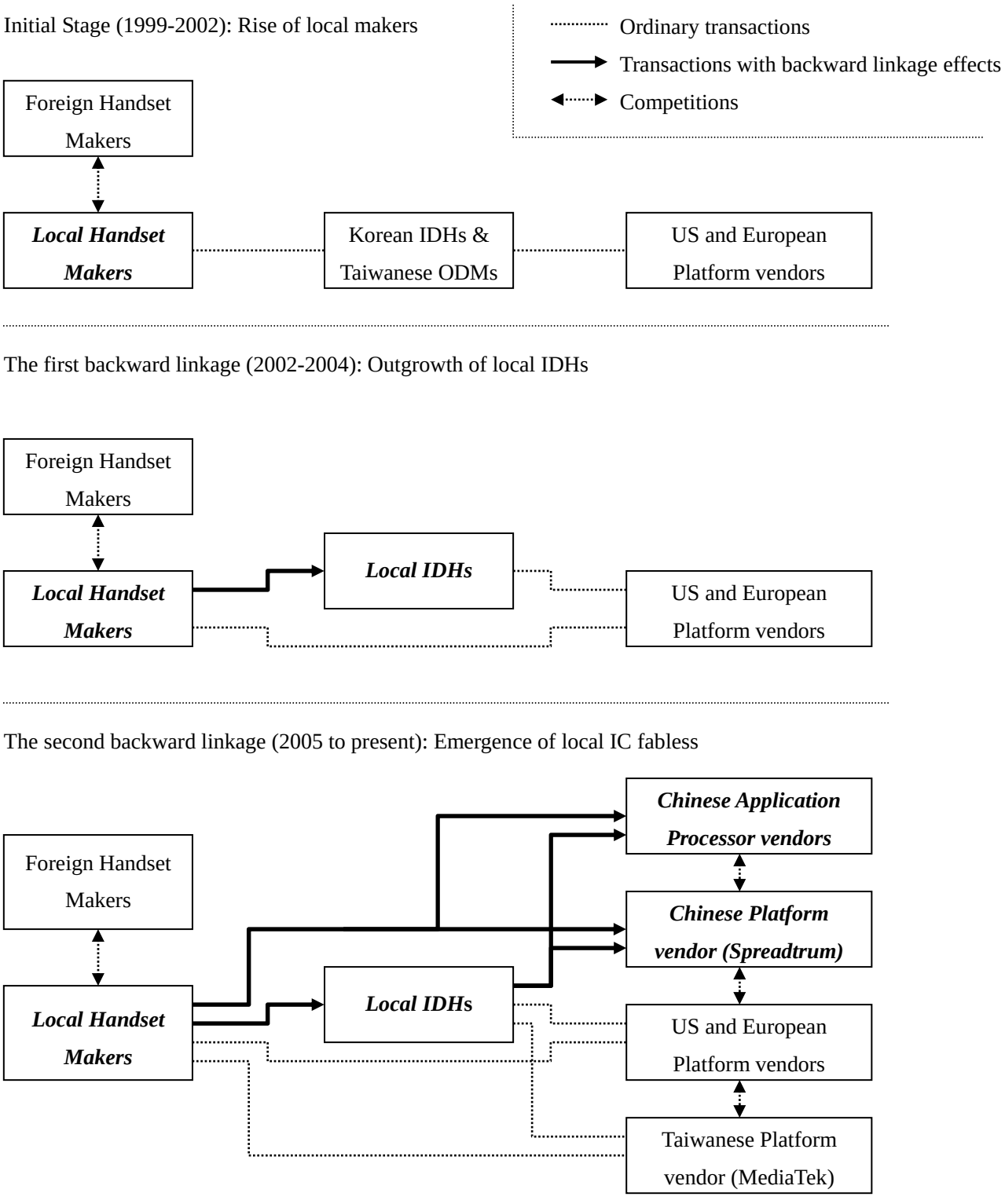
[42] Note that aside from the competitive relationships described in the figure, there are potential competitions between neighboring "low-stream" firms and "up-stream" firms, such as between handset makers and IDHs (handset makers may opt to enhance in-house development; IDHs may opt to become brand makers), or as between IDHs and platform providers (turn-key solutions provided by platform vendors may eclipse value-added of IDHs). These potential competitions between "lower-stream" and "upper stream" are also the important drivers of the industrial evolution.

[43] If MNCs try to penetrate into the domestic market further by, say, extending their marketing networks, it would incur cost that may not necessarily pay.

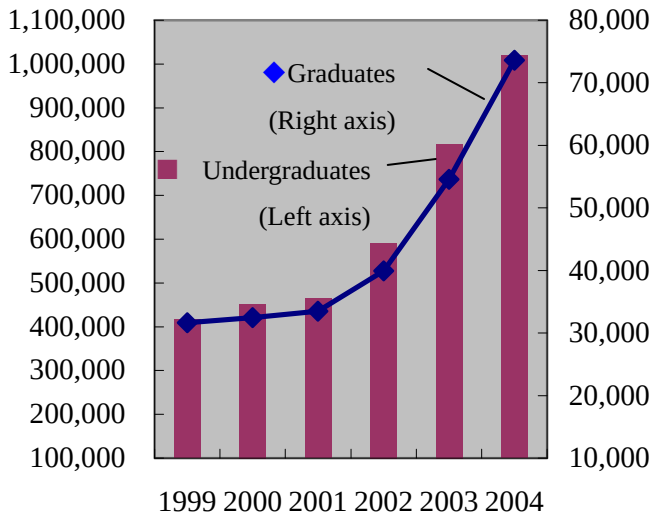
Figure 6. The backward linkage effects in China's mobile phone handset industry



Source: Compiled by the authors.

Thirdly, the ample supply of human resource is also one of the key factors that has fostered the realization of the linkage effects in China. At the initial stage of the industrial development, *sufficient* endowment of human resource is not necessarily required. What is essential is the certain amount of supply of key entrepreneurs and engineers that play the role of "seeds." In China, where the supply of human resource has been highly elastic, as industrial growth initiated by the "seeds" gets on the track, the resultant shortage of human resource is likely to call forth the more-than sufficient increase in supply. In recent years, the number of undergraduates and graduates majoring science and technology has been rising rapidly as the demand for engineers goes up (Figure 7).

Figure 7. Number of Undergraduates and Graduates in Science and Technology



Source: Ministry of Education.

Lastly, with regard to the case of the handset industry, IDHs and local IC fabless would not have appeared if it were not for the global trend of modularization of both mobile handset and semiconductor technologies. In China the growth of IDHs and IC fabless in turn has further accelerated the *local* trend of modularization (e.g. development of derivative models based on the same mainboard; turn-key solution that can be adopted across many models).

However, this local trend of modularization naturally has its drawbacks. While modularization facilitates product development based on a "new" combination of existing technologies, it is also apt to invite sheer imitation, as is often the case with China's handset industry. In this case there is a risk

that originally innovative steps towards industrial upgrading such as the outgrowth of IDHs and core IC fabless may rather hinder further upgrading of the indigenous industry[44].

VI. Conclusion

In this paper we examined the emergence and evolution of the mobile phone handset industry in China. Our case illustrates that, while export growth has been overwhelmingly led by MNCs, increasingly fierce competition in the domestic market ignited by the advent of local handset makers has induced unique organizational evolution that has led to capability building of the indigenous industry. This "dual-track" nature of industrial growth and evolution suggests that the conventional IPN-centric view of latecomer industrialization and upgrading may need to be modified in order to fully accommodate China's rise in recent years[45].

The evolution of China's mobile handset industry seems to have international implications. As competition in the domestic market has been heated up, Chinese handset makers and IDHs have become increasingly outward-oriented. While exports of handset by local makers recorded more than 100 percent growth in 2005, it still accounted for only 5.8 percent of the total exports, However, as the demand for low-cost and multi-functional phones is expected to grow in the emerging markets in the future, it is quite probable that organizational capabilities of China's mobile handset industry tailored to the similar demand for price effectiveness and multi-functionality turn out to be advantageous to further outward-development of the industry.

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[44] **This issue needs to be explored much more.*

[45] Our case also supports Amsden's view (2006) that in markets that perfect competition does not prevail local firms rather than MNCs' affiliates promote innovations.

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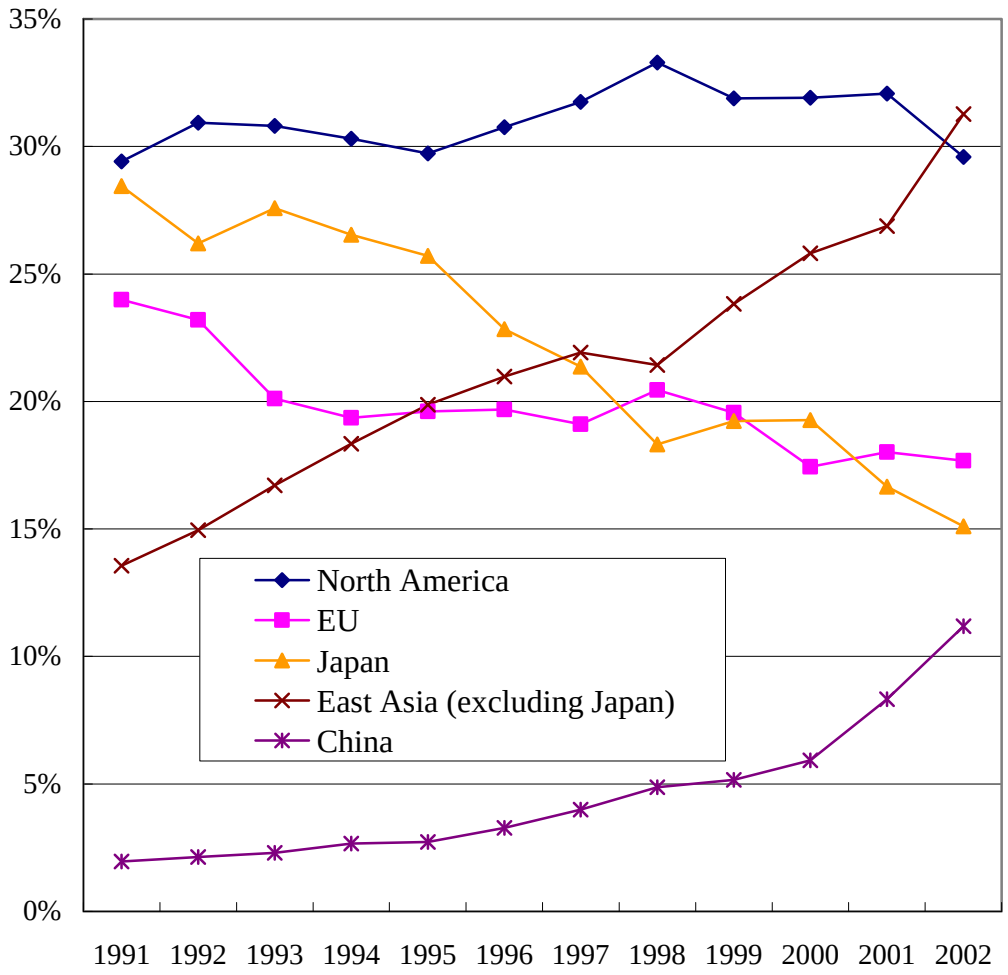
Appendix 1: World Production of Electronics Industry by Region (1991-2004)

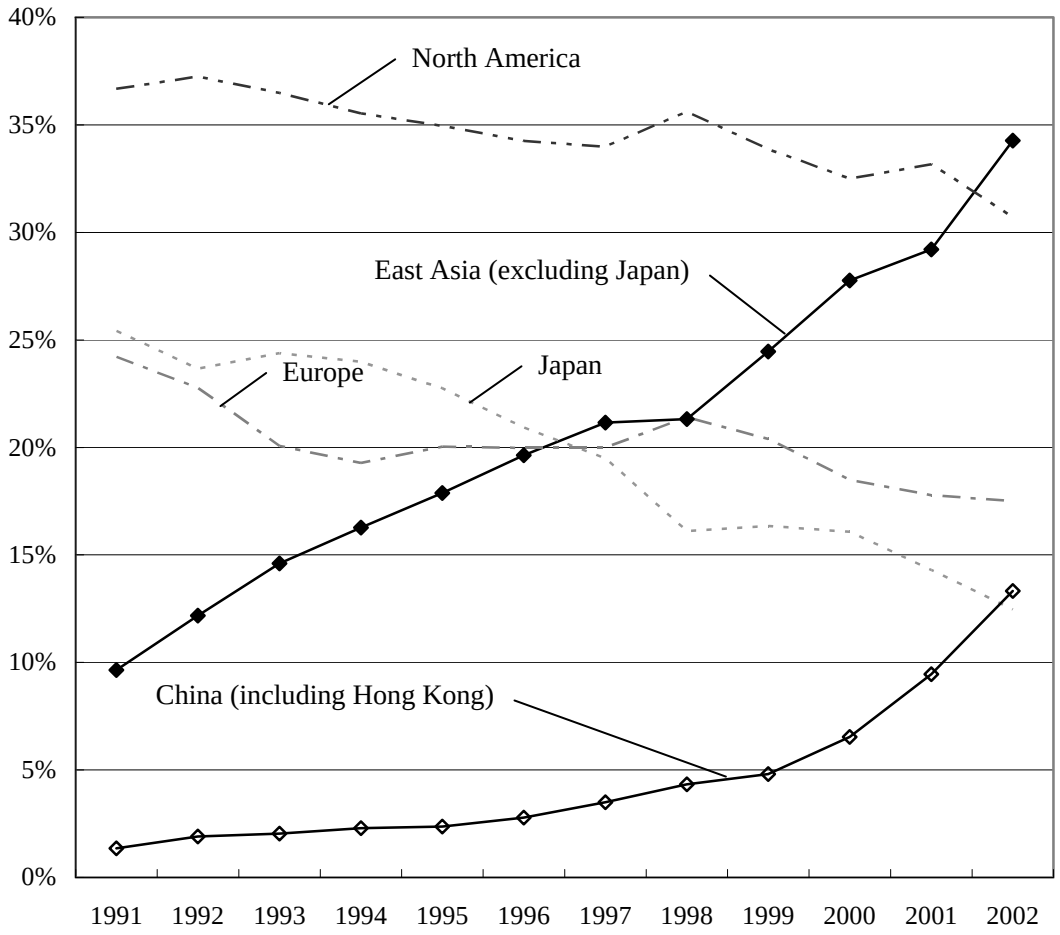


Note: East Asia includes China (including Hong Kong), Korea, Taiwan, Singapore, Malaysia, Indonesia, the Philippines, Thailand, and Vietnam.

Source: Reed Economics Research, *Yearbook of World Electronics Data*, Various years

**To be updated.*

Appendix 2: World Production of IT Hardware by Region (1991-2004)



Note:: IT hardware includes electronic data processing machinery (including peripherals) radio communication equipment, and their components.

**To be updated.*