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The more interactive, the more innovative? A case study of South Korean cellular phone manufacturers

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Abstract

This paper shows that there had been a gap in R&D intensity between South Korean and western cellular phone firms in past years, but this gap has closed. South Korean firm R&D efficiency has recently generally been superior to that of European and American competitors. South Korean innovative power came from three sources: interaction with operators, getting service information and applications from service providers, and internal and external competition. After successful experiences in innovating products for the domestic market, South Korean cellular phone makers used customised design with foreign mobile operators and their foreign R&D centres to localise design and make modifications to meet foreign market demand. Therefore, for 3C (computer, communication and consumer) latecomers in developing economies, due to capital, cost and risk issues, they should strengthen their R&D efficiency through these methods in place of prematurely increasing R&D intensity before the firm is large enough.

Keywords: Innovation; Cellular phone industry; R&D efficiency; Developing economy

1. Introduction

The cellular phone is becoming increasingly important in the Information Communications Technology (ICT) industries for global nations. The reason is that cellular phone and related product shipments and value have expanded rapidly. An International Data Collecting (IDC) research report indicates that the production value of cellular phones surpassed personal computers to become the leader in the technology industry (IDC, 2005). However, a common consensus about how to be successful in the cellular industry has not emerged.

How have domestic communications equipment firms in the lately industrialised economies achieved success? One of the answers may be in their innovation ability. Fan (2006) studied the innovation capability development of four domestic Chinese firms—Huawei, ZTE, Datang Telecom (DTT) and Great Dragon Telecom (GDT). Innovation capability and self-developed technologies are key areas for Chinese firms to catch up with multinational corporations. It was found that domestic firms should focus on in-house R&D development in order to build their innovation capability, supplemented by external alliances. Fan (2006) focused on telecom equipment such as base stations and switches and ignored cellular phones.

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

Aside from enhancing R&D intensity, increasing R&D efficiency is also a way to increase innovative capability. With increasing pressure to create and sustain competitive

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advantages through technological innovation, technology-based firms increasingly depend on the efficient management of their R&D activities (Bone and Saxon, 2000).

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

Most of the previous contributions to this paper's subject lack specialised analysis of South Korea's cellular phone industry. This is especially true for the product innovation subject because these studies relied on standardised products or economy of scale mass produced products such as the DRAM, Flash and LCD. The cellular phone industry is a very special technology management subject because it is a product that integrates the computer, consumer and communications (3C). Therefore, communication industries have a higher need to coordinate the communication standards related to a given local market (Rice and Galvin, 2006).

Rapid technological innovations and increasing market competition have created the pressure to develop and introduce new products. To be successful, companies must provide innovative solutions using effective marketing activities, more demand forecasting and an increase in market attractiveness due to environmental changes and government policy (Ahn et al., 2005). As the requisite capability complexity for participation in mobile telecommunications has increased, the complexity and extent of vertical and horizontal disintegration in the industry has increased. Where firms have been able to internalise all of their design, production and distribution capabilities in the past, the changing nature of products has made this business mode impossible (Rice and Galvin, 2006).

Following second-generation (2G) cellular phone technology, e.g., Global System for Mobile Communication (GSM)—the cellular phone industry has followed consumer electronics products by undergoing dramatic changes fuelled by rapid technological development, innovative applications and more integrated functions. The cellular phone is the most representative of all 3C products. South Korean cellular phone manufacturers have succeeded in catching up with and leapfrogging their previously more advanced western progenitors in global market share, export value and company brand name consumer value.

In the early stages South Korean companies were the same as most latecomers, improving on existing product designs, exploiting their cost-down ability, focusing on their process strengths and competing on the basis of high quality and low cost. Even Samsung at one time believed that as long as international markets for low-cost, high technology hardware continued to expand, they could continue to repeat the "behind the frontier cycle" and play catch up in mobile telephony innovation as they had done before for many years. In this scenario, most South Korean firms have yet to achieve international status, particularly in higher priced, more complex products and systems, capital goods and services (Hobday et al., 2004).

South Korean cellular phone firms are now able to lower the risk and cost of new market creation, R&D expenses and innovative product development. At the same time they have improved in R&D efficiency. Samsung and LG lead in new product creation, especially in higher priced, design-intensive products. Samsung and LG have now surpassed most American, Japanese and European firms in the cellular phone industry. This paper is organised as follows: To review the chronological development, industry supply chain, and innovation process of South Korea's cellular phone industry, we divide this subject into details and examine the know-how of Korean cellular firms.

2. Research methodology

2.1. Variables and definitions

The research variables are defined as follows:

(1) Product type definition (Product Mix): The definition of cellular phones includes the standard system product in GSM, general packet radio service (GPRS), Wide-band Code-Division Multiple-Access (WCDMA) and code division multiple access (CDMA, including IS95A/B, CDMA2000 1X and CDMA2000 1X EVDO).

(2) R&D intensity and R&D efficiency: R&D expenditures and R&D expenditures as a percentage of sales are commonly used to represent a firm's R&D intensity. The number of patents is often used as an indicator of a firm's knowledge stock (DeCarolis and Deeds, 1999). Several efficiency-oriented R&D performance measures such as grant patents per R&D expenditure (Deng et al., 1999), the number of patents granted and R&D spending per patent (Bowonder et al., 2000) are commonly used in the R&D management and finance literature (Lin and Chen, 2005). Moreover, researchers find that R&D intensity has a positive impact on the degree of product diversification (Galan and Sanchez, 2006).

Therefore, this paper uses R&D intensity and R&D efficiency to measure R&D performance, whereby R&D intensity is measured as R&D expense as a percentage of sales, and R&D efficiency is measured as the number of patents that the firm receives divided by its R&D expenses (in millions of US dollars).

(3) Average Shipment Price (ASP): Due to the national policy on mobile cellular phone subsidies, if we use the Average Selling Price at the retail level to measure the price of cellular phones, there may be some mistakes

about the actual price. Therefore, we use the ASP to measure the price of cellular phones.

2.2. Data collection and testing

We collected data from the major cellular phone firms in the world from the companies' annual reports and newsletters. Our data includes Nokia, Motorola, Samsung and LG (Nokia Annual Report; Motorola Annual Report; Samsung Annual Report; LG Annual Report). Their market shares were all more than 5% in 2005. BenQ-Siemens and Sony-Ericsson, even though their market shares were also more than 5% in 2005, were not included as they had merged or been acquired.

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

3. Outlook for South Korea's cellular phone industry in past years

3.1. South Korea's mobile market led global trends

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

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

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

South Korea has been a leader over other cellular phone markets compared to other economies. In 2002, when cellular phones with colour displays, CSTN or TFT LCD only accounted for 24% of total global shipments, colour cellular phone shipments in South Korea's market accounted for more than 50%. In 2003, when cellular phones with camera modules only accounted for 15.2% of total global shipments, camera cellular phone shipments in South Korea's market accounted for more than 50%. SKT, KTF, and LGT have been very aggressive in promoting MP3 player services from 2004 to now, such as SKT MelOn and LGT musicON. As a result, MP3 player cellular phones accounted for close to 85% of total new models in Korea in 2005, while only enjoying a market share of 15% globally (see Table 1).

3.2. Development history of South Korean cellular phone firms

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

Table 1 shows development path and catch-up strategies of South Korean cellular phone firms. South Korean firms started to manufacture cellular phones in 1983; later than Nokia (1968) and Motorola (1973). At the same time, South Korea's industry was establishing a new research infrastructure in the 1980s. Since the beginning of the 1980s, many corporate research institutes have been established which have become major players in South Korea's innovation system. Many of South Korea's big enterprises are able to compete with the world's best enterprises in maintaining technological leadership (Chung, 2001). Even so, that is not enough to develop a competitive cellular phone industry. The Base-Band cellular phone solution is a key point.

South Korea's government decided to cooperate with Qualcomm (US), the biggest CDMA IC design house, to develop CDMA cellular phones in 1991. The CDMA standard, just behind GSM, is the second most widely used 2G standard in the world. This decision helped South Korean firms capture market share, such as the US and China markets. This was the same strategy used by some of

Table 1
The milestones in the South Korean cellular phone industry

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

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

the large cellular phone firms, such as Ericsson and Nokia, changing alliance formations over the industry life cycle in response to changing organisational needs and industry imperatives (Rice and Galvin, 2006).

South Korean cooperation with Qualcomm produced mobile services based on CDMA, CDMA2000, CDMA2000 1x and CDMA2000 1xEV-DO technologies, step by step from 2G to 3G after 1996. Because the design platform had been developed by Qualcomm and South Korea's cellular phone market is closed, operators always place an order with local vendors such as Samsung or LG as a first priority. As a result, South Korea's CDMA series cellular phone manufacturers developed their brand names based on how quickly the domestic market grew. On the domestic cellular phone market share side, the condition whereby South Korean firms were market leaders remained almost unchanged after 2G. There were more than 50 cellular phone manufacturers in South Korea in 2003, including Samsung Electronics, LG Electronics, Pantech & Curitel Communications (spun off from Hynix Semiconductor) and other small and medium-sized companies.

3.3. South Korean cellular phone makers' global market share and export value

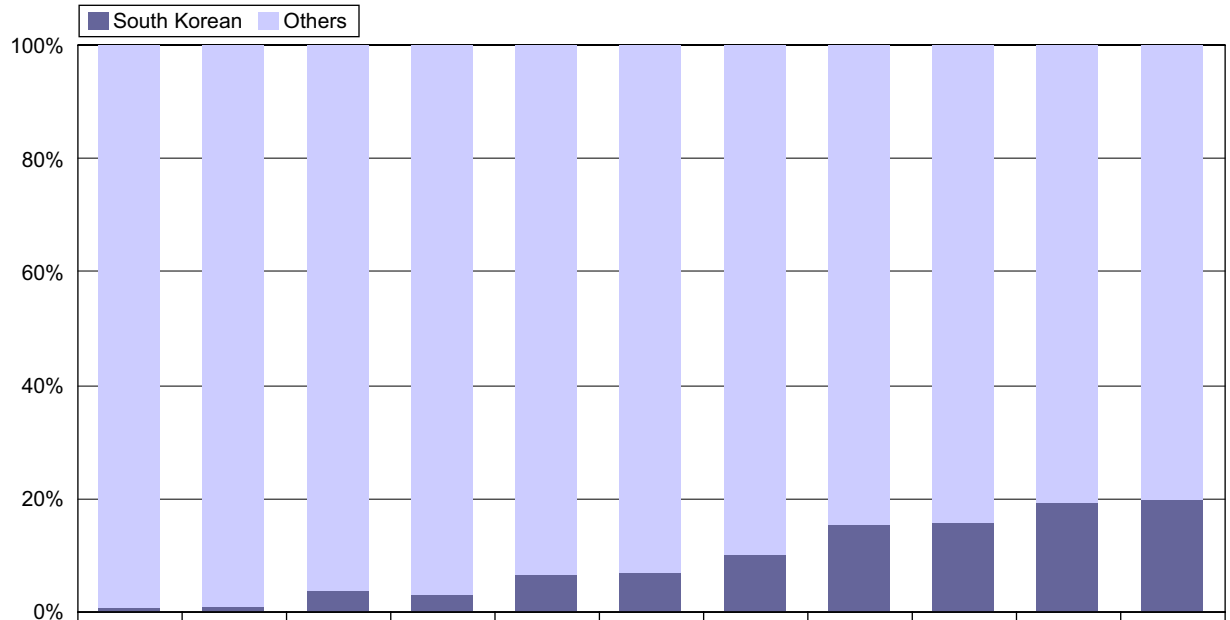
Figs. 1 and 2 show the South Korean cellular phone makers' global market share and export value. On the global market share side, from 1998 to 2005, Samsung and LG very quickly achieved remarkable global market share. They even hit a market share of over 20% of total global shipments in 2005 and were only behind Finland's Nokia. According to cellular phone maker data, Samsung, just behind Nokia and Motorola, was the third largest company by market share in 2005, with LG having the fifth largest market share.

On the cellular phone export side, before 1998 almost no cellular phones were exported from South Korea. Since the beginning of 1999, the cellular phone export value from there began to increase dramatically, especially in CDMA series cellular phones. Aside from CDMA phones, Samsung Electronics, LG Electronics and Pantech & Curitel, the first three cellular phone domestic brands, also developed GSM/GPRS/WCDMA cellular phone products at the same time. In 2005 the export value of South Korean cellular phones reached US$12.94 billion, with a 71.69% share of total production value and a growth rate of 13.61%.

4. Innovation matters—particularly in mature consumer goods

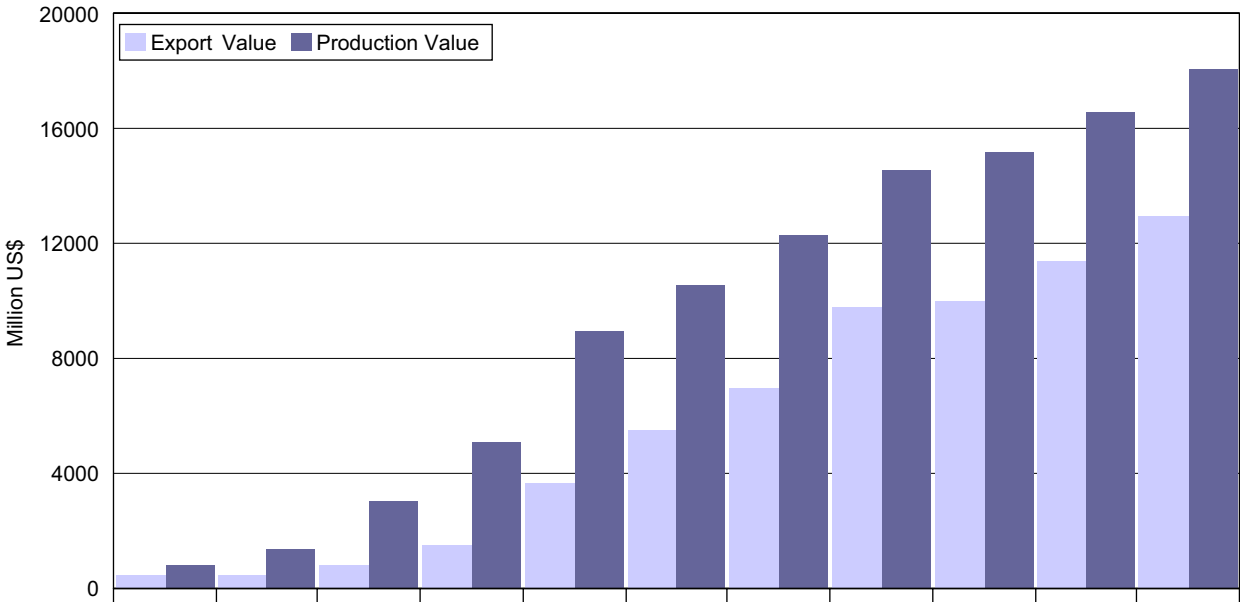
4.1. R&D employees, R&D, intensity and product ASP

In the ICT industry R&D expense as a part of revenue is an important index to evaluate how a company emphasises



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

Fig. 1. South Korean cellular phones' worldwide market share by shipments. *Source*: Dataquest.



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

Fig. 2. South Korean cellular phones' export value and total value. *Source*: KISDI.

innovation. Another index that usually has a high correlation with R&D expense is R&D engineers as a part of the total employees. In order to catch up to foreign world market leaders, Samsung Electronics expanded from 12,000 R&D engineers in 1997, to more than 20,000 in 2003 and 27,000 in 2005. There were 7000 cellular phone R&D

engineers in 2005 among its total R&D team. The ratio of R&D engineers to total employees was 22% in 1997, moving to 36% in 2005.

Fig. 3 shows the cellular phone ASP of the major vendors in the world. We find that Korea's cellular phone makers, such as Samsung and LG, do not use the low cost oriented strategy to gain market share. On the contrary, they focus their attention on the global mid-to-high end cellular phone market. Samsung's ASP, for the most part, is above US$180 and the highest in the industry. In contrast with Samsung, the industry's average ASP is under US$160 from 2002 to 2005.

Table 2 shows the *P*-values of the Mann–Whitney test of the cellular phone ASP between South Korean and other foreign firms. The result shows a significant ASP between South Korean and other foreign firms. Compared with Samsung's high-end focus, LG mainly aims at the mid-to-high end market as well while Nokia, Motorola, BenQ-Siemens and Alcatel have a relatively wider range of product lines.

As low-end products are the major part of sales growth, and price wars have erupted in this market, the ASP and operating margins of cellular phone firms have decreased. Major global brand cellular phone companies are divided into two categories in terms of their profit capacity. The first category group is Samsung and Nokia, whose profitability maintained around 20–25% before 2004. The other group includes Motorola, Siemens (its cellular phone division was acquired by BenQ in 2005), and other small and medium-sized companies with profitability below 10% (Table 3).

Researchers suggest that companies put more R&D resources to raise the quality of products (Galan and Sanchez, 2006). However, in spite of Samsung's high-end focus, there is no evidence that Samsung's R&D expenses and intensity are superior to Nokia or Motorola. Table 2 shows a comparison of R&D expenses, R&D intensity, and revenue of major cellular phone vendors in the world. Samsung increased its R&D expense from 5.86% in 2000 to 10.08% in 2005. Tables 4 and 5 show the *P*-values of the Mann–Whitney tests for R&D intensity and R&D expenses between South Korean and other foreign firms. The *P*-values represents a significant gap between South Korean and other foreign firms. The R&D intensity and R&D expenses of South Korean firms were significantly lower than other foreign firms in the past. However, South Korean firms are beginning to catch up and even to leapfrog.

Therefore, we explained how South Korean firms achieve competitiveness by comparing R&D efficiencies. Table 6 shows the comparison with R&D efficiency of major cellular phone vendors in the world. Table 7 shows the *P*-values of Mann–Whitney test of R&D efficiencies between South Korean and other foreign firms. We find that the R&D efficiencies of South Korean firms were higher than that of other foreign firms. South Korean firms are able to gain more patents under the same R&D resources.

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

Table 2
The *P*-values of Mann–Whitney test of the cellular phone ASP between South Korean and other foreign firms

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

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

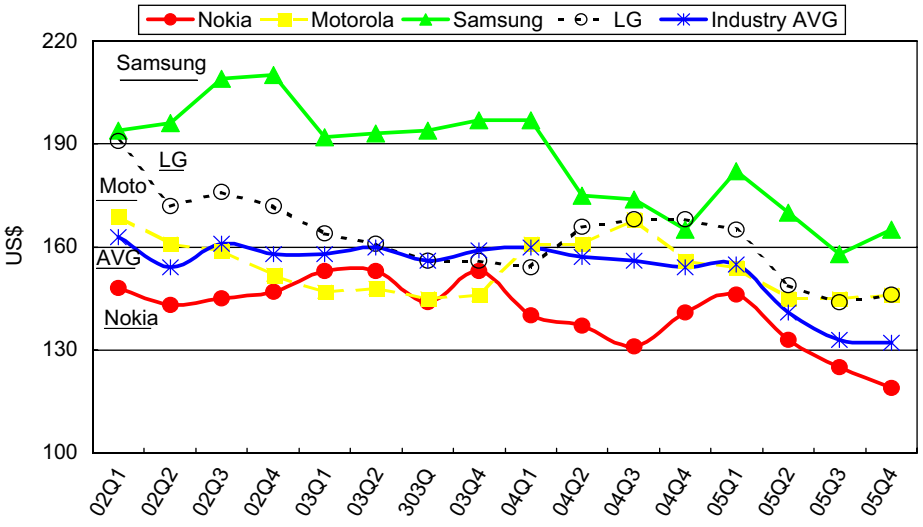


Fig. 3. Product ASP of major cellular phone vendors in the world. *Source*: Financial statements and newsletters of these companies.

Table 3
R&D expenses and revenue of major cellular phone vendors in the world

(Million US$)	2000	2001	2002	2003	2004	2005
Samsung cellular phone revenue	5168	6769	10,202	11,920	17,085	16,849
Samsung cellular phone R&D expenses	302	399	595	710	1430	1700
R&D spending of revenue (%)	5.86	5.88	5.83	6.00	8.37	10.08
Operating margin (%)	12.00	17.00	26.80	20.50	15.00	12.00
LG cellular phone revenue	1248	2191	2814	4355	7265	7421
LG cellular phone R&D expenses	59	98	113	170	366	447
R&D spending of revenue (%)	4.76	4.47	4.03	3.91	5.04	6.02
Operating margin (%)	–	10.00	9.75	4.80	6.30	6.90
Nokia cellular phone revenue	24,076	25,532	27,789	29,342	27,595	33,184
Nokia cellular phone R&D expenses	1437	1759	2261	2477	2342	3113
R&D spending of revenue (%)	5.97	6.89	8.14	8.44	8.49	9.38
Cellular phone operating margin (%)	22.30	20.10	22.80	23.60	17.80	13.60
Motorola cellular phone revenue	13,267	10,448	10,847	10,978	16,823	17,800
Motorola cellular phone R&D expenses	1098	1012	1006	1112	1602	1853
R&D spending of revenue (%)	8.28	9.69	9.27	10.13	9.52	10.41
Operating margin (%)	4.00	−3.10	7.30	4.80	10.40	11.50

Source: Financial statements and newsletters of these companies.

Table 4
The *P*-values of Mann–Whitney test of R&D intensity between South Korean and other foreign firms

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

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

Table 5
The Mann–Whitney test *P*-values of R&D expenses between South Korean and other foreign firms

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

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

4.2. Innovation of new product models have led global trends

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

Table 1 shows that Korean makers catch up through alliances with foreign firms. Although these foreign firms have advanced technology, they are not the first-tier players in market share (IDC, 2005). The resource-based and transaction cost theories predict that small companies or latecomers tend to catch up the industrial leaders via alliances (Prahalad and Hamel, 1990; Anderson et al., 1994). As a result, South Korean innovative cellular phones have let the global trend. As with Japanese cellular phones, Korean cellular phones have integrated many extra functions, such as GPS, TV tuner, fingerprint identification, smart card, and so on. South Korean cellular phones are the top two with the highest proportion of products equipped with colour screens, camera functions, and MP3 players in the global market.

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

Based on Qualcomm's reference design solution, South Korean firms now offer added functions or applications to a cellular phone's capabilities. The abilities of integrating new components, creating interesting applications and realising innovative idea are key factors to design fancy models (Galan and Sanchez, 2006). Table 8 shows the number of major cellular phone vendors' new models in 2003. Samsung presented 133 models in 2003, which is around 3 times that of Nokia and around 2 times that of Motorola. According to the company newsletter, Samsung presented 164 models in 2005 and kept its position as having the most models in the industry. To a

Table 6
R&D efficiency of major cellular phone vendors in the world

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

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

Table 7
The Mann–Whitney test *P*-values of R&D efficiencies between South Korean and other foreign firms

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

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

Table 8
The number of major cellular phone vendors' new models in 2003

	Samsung	LG	Nokia	Motorola
2003	133	112	46	65

Source: Financial statements and newsletters from these companies.

certain extent, offering models means increasing marketing power and reducing leading time. On the other hand, firms that design more models have more time-to-market ability.

5. South Korea's cellular phone industrial innovation mode2l

5.1. Achieving innovative capability through an integrated industry chain

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

Fig. 4 shows South Korea's cellular phone industrial supply chain. The industry chain includes display components, electronic components, peripherals, multimedia function components and so on. Except for base band and radio frequency chips, most of the key parts can be supplied by domestic vendors, even including camera modules, GPS modules, TV tuners, and MP3 player modules.

Table 9 shows a comparison of vendors' cost control ability. Samsung purchases most of its cellular phone components from its own business group. Nokia and Motorola have a different strategy of using large-scale outsourcing except for core components such as base band chips. Due to the highly integrated industry chain, Samsung has more Bill of Material (BOM) competitive cost advantages and lacks material shortages. Moreover, competition among component vendors and the complete interaction between upstream and downstream can help South Korean cellular phone firms have a better chance to use the newest components first and apply resources more flexibly.

The highly vertically integrated structure helps Samsung create internal resource interaction, allowing more innovative chances (Fig. 6). For example, the idea of a cellular phone with camera modules came from combining cellular phones and digital cameras in 2000. Conversely to Samsung, Nokia and Motorola do not have this kind of technology and product line. Their cellular phone camera modules are instead outsourced.

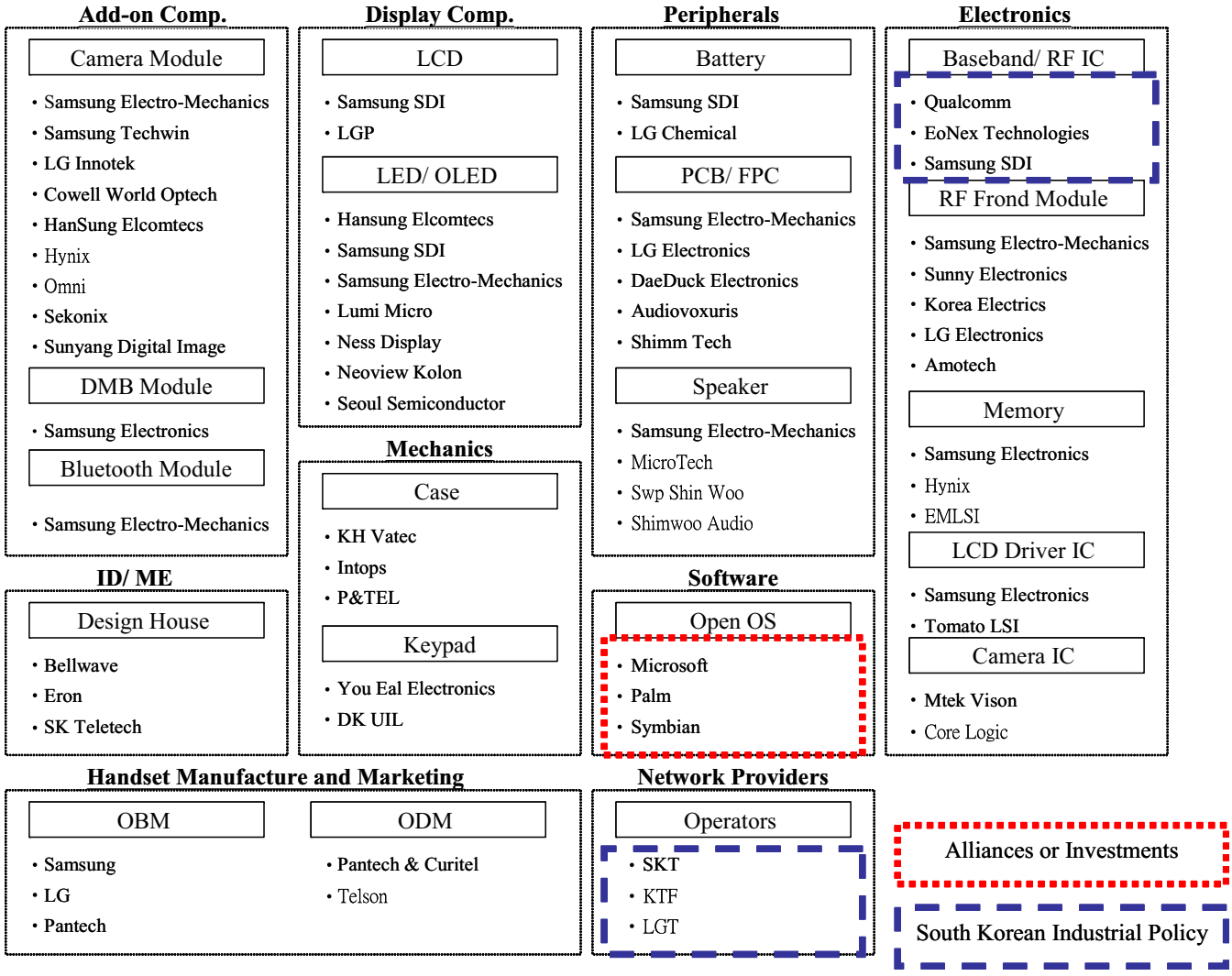


Fig. 4. South Korea's cellular phone industry supply chain.

5.2. *Catching up through a more interactive and competitive ecosystem*

South Korea's cellular phone industrial ecosystem has also created a better innovative environment. Fig. 5 shows the cellular phone distribution channels in South Korea. These manufacturers supply cellular phones to the mobile communications carriers as well as selling them via their own electronics retail shops. There are more than 9500 dealers that sell as retail stores tied to mobile communications carriers in Korea (Choi et al., 2001).

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

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

South Korea's cellular phone ecosystem is quite eclectic. South Korean mobile carriers combine Japanese advantages with Europe and US strengths. In South Korea's market, because CDMA cellular phones do not have SIM

Table 9
Comparison of vendors' cost control ability

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

Notes: ◎ cellular phone makers can buy this kind of components in house.
Source: MIC, financial statements and newsletters of these companies.

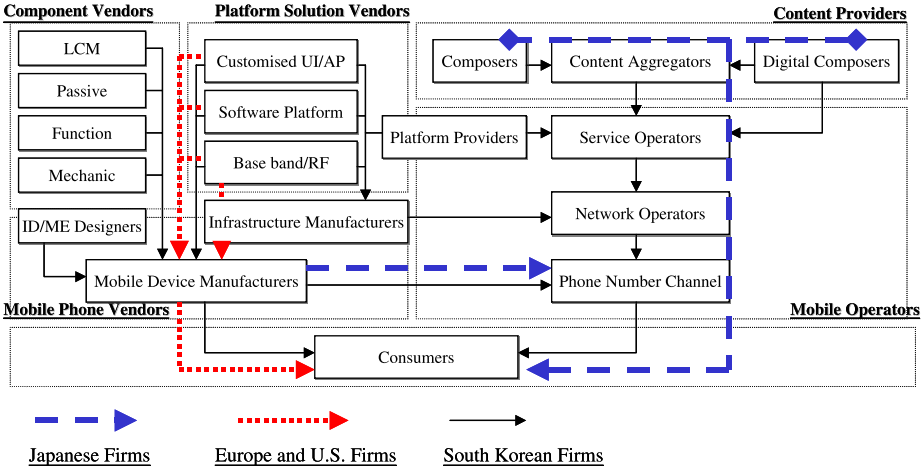


Fig. 5. Distribution channels of mobile cellular phones in South Korea.

cards, when end users want to change mobile phone carriers, they usually have to change cellular phones. Hence, cellular phone vendors have to maintain cooperation with operators. For example, SKT has vertical integration capability and can control and influence its product distribution channels. The relationship is through guidance and management instead of control. Both sides are like cooperating partners. Therefore, although cellular phone makers have to gain support from operators, brand cellular phone companies still have the most power, such as product development, decision making, channel management, pricing, and promotion (Kim et al., 2004; Berra, 2003; Song and Kim, 2001).

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

South Korea's cellular phone ecosystem is also full of internal and external competition. Through spin-offs, alliances and investments, business groups have similar

products or functions even at different subsidiaries, such as cellular phone design houses, camera modules, and displays. Together with ambient small companies, cellular phone firms like Samsung or LG can purchase competitive and creative components due to internal and external competition. Domestic R&D engineers and Industrial Design (ID) designers in South Korean cellular phone firms also face competitive projects that come from similar internal and external units.

South Korean cellular phone firms, through external alliances and a global layout, have more chances for innovation. We note the important business cooperation in South Korea's cellular phone industry in Table 1. It has concentrated its attention on building up partnerships with chip vendors, operation system software vendors and base station makers. All of these fields are where South Korean firms are weak and lack a supply chain. Of course, South Korean firms took support from their government to negotiate with these technology sources.

The partnership targets of South Korean mobile manufacturers also include foreign operators, such as Verizon Wireless (CDMA2000 1x EV-DO), China Union (CDMA2000 1x), and Vodafone (WCDMA), especially as 3G has started to develop in the US and Europe. We also see the global layout of Samsung and LG in Table 10. The localisation of design and R&D is an important strategy of Samsung and LG. Exports of EV-DO and WCDMA phones serve to improve their margins and constant strong sales growth can be attributed to a significant increase in sales to China, the US, and Europe from new models launched after 2003.

Table 10
The worldwide layout of Samsung and LG

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

Source: Samsung Electronics and LG Electronics.

5.3. South Korea's cellular phone industrial innovation model

Innovative ability is the key success factor for South Korean cellular phone firms. Fig. 6 shows South Korean cellular phone models with innovation processes. South Korean firms' innovative power comes from three sources. First, cellular phone subsidies deployed new technologies such as mobile internet and colour LCD cellular phone, as well as the early diffusion of the upcoming IMT-2000 service (Kim et al., 2004). South Korean cellular phone makers have experiences of interaction with operators and receive information of services and applications from the service providers. For instance, South Korean operators have already rolled out 3G services with CDMA20001x

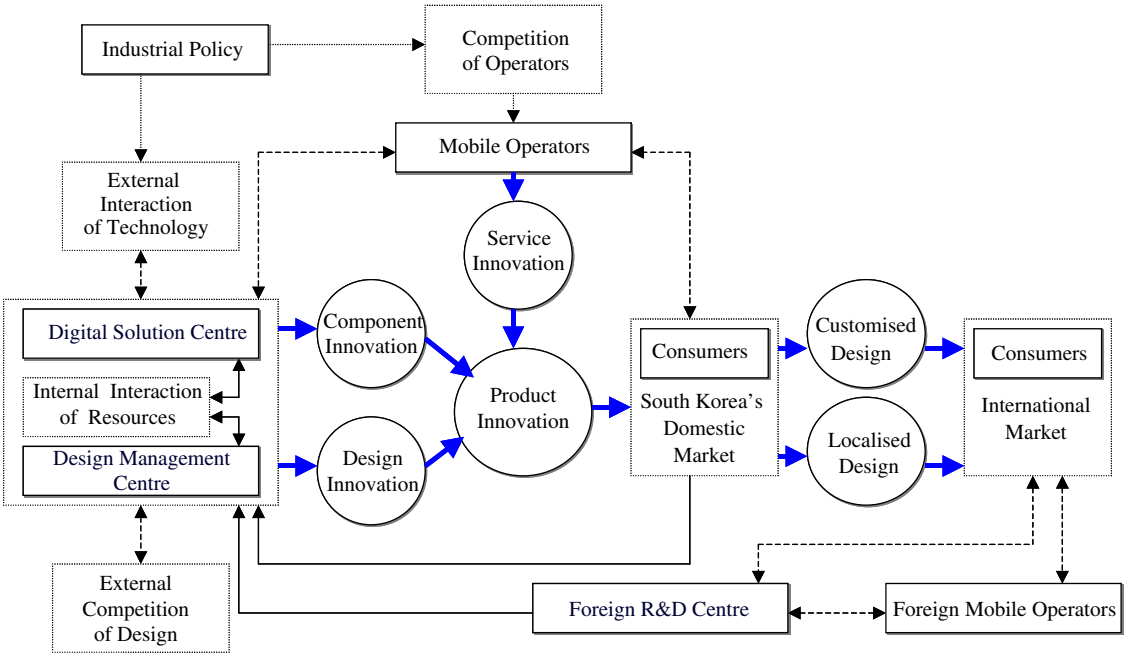


Fig. 6. South Korea's cellular phone innovation process model.

EV-DO and WCDMA, and this has helped Samsung and LG to promote their 3G mobile phones around the world.

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

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

6. Concluding remarks

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

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

For 3C latecomers in developing economies, due to capital, cost, and risk issues, we suggest that 3C firms could strengthen their R&D efficiency in place of prematurely increasing their R&D intensity before they are large enough. Latecomers should use external resources more efficiently, including alliances, investments, licenses and so on. Strengthening R&D efficiency also means that firms may announce more innovative products and reduce time to market at the same time.

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

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