Sequential learning in a Chinese spin-off: the case of Lenovo Group Limited

Wei Xie[1] and Steven White[2]

[1]School of Economics and Management, Tsinghua University, Beijing 100084, China
xiew@em.tsinghua.edu.cn
[2]INSEAD, France
steven.white@insead.edu

This paper analyzes the learning process and sequential capabilities development in Lenovo, China's most successful PC manufacturer, which originated as a spin-off from a government-supported research institute. The case study reveals this firm's evolutionary, path-dependent and stage-wise progress from initial sales, distribution and service activities to manufacturing, product and process design and, finally developmental R&D. The study shows the interaction among the firm's changing environment, its competitive strategy, and its set of resources and capabilities. The case has implications for research on such organizations, as well as implications for management.

Introduction

The objective of this paper is to shed light on spin-off development and evolution in the Chinese context through an in-depth study of Lenovo Group Limited,[1] the leading computer manufacturer in China that originated as a spin-off from a government-funded research institute. The case provides a basis for conceptualising the process by which an institute spin-off evolved from distribution and service-based business activities to become a highly successful, vertically-integrated firm manufacturing products based on its proprietary technology. We are specifically interested in understanding the evolving nature of learning by which the firm's managers were able to realize such a transition, and the implications for both research and practice.

China, like other countries, has been searching for ways to generate and demonstrate economic impact from government-funded R&D organizations and university laboratories. As evidence of the efficacy of its policies, the government will point to several successful spin-offs, including Lenovo, Tsinghua Tongfang and Beida Founder, who now play a significant role in China's technology-based industries, especially information and data processing technology industries.[2]

While such spin-offs play a disproportionately large role in many of China's high-tech industries as the locus of both technology development and its commercialisation, there are few studies that elucidate the process by which these spin-offs emerged and developed. Related studies address China's R&D structures and mechanisms (Fischer, 1983), military technology transfer (Brockhoff and Guan, 1996), innovation policies (Huang *et al.*, 1999), its national innovation system (Liu and White, 2001), issues facing government labs (De Boer *et al.* 1998), and the interaction between R&D and marketing in these firms (Li and Atuahene-Gima, 2001). These do not, however, address issues specific to the context of learning and strategic capability building in spin-offs. In developed

country contexts, for example, the range of spin-off issues addressed includes factors affecting the performance of spin-offs (e.g., Dahlstrand, 1997), structures and strategies for spinning-off new companies (Roberts and Malone, 1996; Steffensen *et al.*, 1999; Davenport *et al.* 2002), and techniques for stimulating spin-off creation (O'Gorman, 2003; Meyer, 2003) and managing the spin-off process (Carayannis *et al.*, 1998).

Our focus on learning and capabilities development in Chinese spin-offs links this study to the body of work that recognizes learning and capabilities development as a critical challenge for latecomer firms in developing countries, dislocated from centres of technological development (Gassmann and von Zedtwitz, 1998; Boutellier *et al.* 2002). Over the past two decades, a significant number of studies have examined this issue at the project, firm, industry and national levels of analysis in developing country contexts (e.g., Kim and Lee, 2003; Lee *et al.*, 1988; Bell, 1984; Amsden, 1989; Bell and Pavitt, 1993; Hobday, 1995; Kim, 1997; Kim *et al.*, 1987; Kim and Dahlman, 1992; Kim and Nelson, 2000; Lall, 1987, 1992; Matthews, 1996; Matthews and Cho, 2000). A much smaller number of studies have addressed the specific issue of technological learning and the development process in manufacturing industries and electronics firms (Hobday, 1995; Kim, 1997), semiconductors (Matthews and Cho, 2000; Choung *et al.* 2000), machinery (Amsden and Kim, 1989), autos (Kim, 1997) and nuclear power (Sung and Hong, 1999).

Compared to the large number of studies focusing on firms and industries in South Korea, there is a relatively small number of studies of learning processes in Chinese organizations. Some firms that have been studied include Haier (Wang, 1999; Zhao, 2001), Shanghai Volkswagen (Mu, 1997; Xie and Wu, 1997, 2001), Huawei, Datang and Eastcom (Shen, 1999; Zhao, 2001; Gillespie, 2001; Yang, 2003), colour TV firms (Xie, 2001; Zhao, 2001; Xie and Wu, 2003), and state-owned enterprises (Shi, 1998). Studies in the context of China's electronics industry have either been focused on the government's industrial policy and its outcomes (e.g., Kraemer and Derick, 1994a, b, 2001, 2002), or changes in the institutional environment that gave rise to new technology-based firms (e.g., Lu, 2000).

Framework

To organize our analysis of the stage-wise development of Lenovo's learning and capability development, we draw on Karagozoglu and Brown's (1986) multi-level framework. Four factors – government policies, multinationals, a firm's competitive strategies, and its underlying capabilities – are regarded as critical to a firm's learning performance. First, governments in any national context, and even more so in China, influence the basic external conditions in which a firm learns through their impact on incentives, formal and informal constraints, and other institutional controls (Kraemer and Derick, 1994, 2001; Shen, 1999; Xie, 2001; White and Linden, 2002). Second, multinationals can represent threatening competition to local firms (White and Linden, 2002), but also provide positive incentives and a basis from which local firms can learn (Xie and Wu, 2003). For leading domestic firms, multinationals often serve as the benchmark for their own performance, in addition to the source of competitive strategies. Third, a firm's competitive strategies represent a firm's interpretation and response to the threats and opportunities its top managers perceive in the environment. Finally, a firm's underlying capabilities and learning activities are interdependent with its competitive strategies; on the one hand, evolving strategies can shift the focus and intensity of learning activities while, conversely, strategies are influenced by a firm's existing set of resources and capabilities.

In the context of this paper, we refer to a firm's acquisition of new capabilities broadly as organizational learning. These capabilities may be variously defined, but in this study we are particularly interested in functional capabilities such as sales, marketing, distribution, manufacturing, product and process engineering and development, and technological research. These capabilities generate resources that may have competitive value, such as patents, reseller networks, reputation, and production expertise.

Lenovo Group Limited

The Lenovo Group Limited is currently the leading PC manufacturer in China by market share, and the largest manufacturer in Asia outside Japan. It consistently ranks in as the top firm in after-sales service, above IBM and Hewlett-Packard (AsiaInfo Daily China News, 1999), and each year since 2000 has received the Intel PC Innovation Award for its innovative and home-oriented PC product designs.

Lenovo began as a spin-off from the Institute of Computing Technology, a research institute

Table 1. Milestones in Lenovo's development.

Year	Events
1984	Established in 1984 as ICT Co., a spin-off firm from the Institute for Computer Technology, a government-funded R&D institute under the Chinese Academy of Sciences.
1987	Became a distributor for AST, and later for HP and other foreign branded PCs.
1988	In October, ICT Co. was reorganized and renamed Legend Computer Group Co.
1988	Establishes Hong Kong Computer Group, a joint venture with a Hong Kong partner to produce PC motherboards and add-on cards and operate a trading business.
1989	Renamed as Legend Group Co.
1991	Began to manufacture PCs and sell them under its own brand name in mainland China
1993	Became the largest local PC manufacturer in China, behind only AST and Compaq.
1997	Overtook Compaq in terms of share of China's PC market.
1999	Became the first Chinese PC manufacturer to be the top seller (by units) in the Asia-Pacific region (excluding Japan).
2002	Changed its English name from Legend Holdings Limited to Legend Group Limited.
2003	Changed its logo from 'Legend' to 'Lenovo'.
2004	Changed its English name from 'Legend' to ''Lenovo'.

Table 2. Market shares of top 4 PC manufacturers in China (%).

Rank	1992	1996	1997	1998	2002
1	AST (26.9)	COMPAQ (9.2)	Lenovo (10.7)	Lenovo (21.5)	Lenovo (27.3)
2	COMPAQ (18.5)	IBM (6.9)	IBM (7.5)	IBM (6.2)	IBM (9%)
3	Greatwall (11.2)	Lenovo (6.9)	COMPAQ (6.7)	Founder (5.9)	Founder (5%)
4	IBM (5.2)	Hewlett-Packard (6.7)	Hewlett-Packard (6.5)	Hewlett-Packard (5.6)	Dell (5%)

Source: Lu (2000), IDC and Kraemer & Derick (2001).

under the Chinese Academy of Sciences, in 1984 with an initial capital investment of RMB200,000 (about US$85,900 at former official exchange rate) (Table 1). It began by distributing and installing PCs produced by foreign manufacturers, before expanding into manufacturing and launching its own PC brand from 1991. Since 1994, it has been a public company, listed on the Hong Kong Stock Exchange. In 1997 it overtook both IBM and Compaq as the leading PC supplier in China, and since then has remained in first place and expanded its share to almost 30% of the Chinese market (Table 2),[3] It has diversified its product lines beyond PCs and components (motherboards, add-on cards) to include servers, digital cameras, printers, telephone handsets, set-top boxes, and network facilities. The PC division, however, remains Lenovo's most important division and is the focus of the analysis presented in this paper.

Methodology

Data on Lenovo were gathered from both archival sources and interviews. We draw on the extensive and rich descriptive data available in Chinese but which have not been significantly tapped for English-language academic analyses, nor consolidated in a coherent conceptual framework even in Chinese studies.[4] Interviews were conducted over a 3-year period, 2001–2004 with managers and engineers in Lenovo, practitioners and experts in China's PC industry. Anchored in archival data on the firm's development since its founding, semi-structured interviews focused on characteristics of the market, competitive and regulatory environment facing Lenovo, and Lenovo's product development, R&D activities, distribution arrangements and strategic response to changes in its environment.[5]

The case-study methodology is appropriate because it allows us to study the rationale and process by which a firm may evolve from being a distributor of other firms' products to a fully integrated producer of advanced technology products. A second objective is to use the case study to generate theory that is both relevant and practically useful (Glaser and Strauss, 1967; Yin, 1981; Eisenhardt, 1989; Numagami, 1998). In particular, this case study is used to suggest important theoretical constructs linking evolving external opportunities and incentives with an organization's ability to learn and develop new capabilities.

Capabilities, learning and upstream integration

Lenovo began as a spin-off of a leading R&D institute in computer science. Rather than beginning with core proprietary technology and gradually developing downstream capabilities in manufacturing, marketing, sales and distribution, it followed a reverse development process upstream from sales and distribution. This section describes this process in terms of three phases that Liu Chuanzhi, former CEO of Lenovo, uses to describe Lenovo's development.[6] We link changes in the policy and multinational competitor environment to Lenovo's competitive strategies and the learning, resources and capabilities that supported those strategies.

Phase 1, 1984–90: distribution, sales and service (Mao)

Government. In the 1980s, the Chinese government saw developing China's PC industry as a priority and part of its broader, long-term goal of achieving self-reliance vis-à-vis foreign sources of technology and goods. To achieve this, it selected and nurtured a few large firms who would, eventually it hoped, be able to compete with foreign firms. In the name of infant industry protection, it also levied high tariffs on imports of foreign-made PCs. This regime did succeed in generating locally-produced PCs, and the appointed manufacturers were able to assemble PCs from locally produced components. Furthermore, in spite of the poor quality and low reliability of these PCs, and the manufacturers' high production costs (by industry standards), the domestic firms were able to sell an increasing number of PCs to Chinese customers and earn high profits.

Multinationals. PC sales in China during the 1980s were negligible, and the market was not a priority for leading multinational PC manufacturers like IBM and HP. As a result, second-tier foreign producers, such as California-based AST Research, were the first to enter China and quickly gained the leading market shares.

Lenovo's competitive strategy. Lenovo, founded in 1984, was not one of the firms designed by the government to spearhead China's PC manufacturing industry; indeed, it did not receive a license to produce PCs until 1991. The eleven founding employees, however, were under pressure from their parent (ICT, under CAS) to take advantage of the new freedom to establish companies and engage in business activities, granted to research institutes as part of an institutional experiment by the government (Lu, 2000). Neither the parent organization nor these founders, however, had any business experience. Nor did the parent organization have extensive financial resources to invest in capital-intensive manufacturing.

Lenovo did, however, have some advantages from its parent. First, ICT's leaders supported Lenovo in tangible ways, such as allowing Lenovo to use ICT's facilities free of charge. Lenovo also benefited from the use of ICT's name under which it could do business, leveraging ICT's recognition among potential clients as a leader in IT research and major projects (satellites, rockets, large-scale computing), as well as the legitimacy conferred by its links to the Chinese government. Indeed, some interviewees for this case see ICT's main contribution to Lenovo's development as these connections and legitimacy, rather than its technological resources and support.

The result of these pressures, constraints and resources was for the founders to sell their services to other organizations and firms – primarily installing computers, testing imported PCs, and training new users. Their first major client was Lenovo's grandparent, the Chinese Academy of Sciences, who awarded them a contract for RMB700, 000 (about US$300, 000 at former official exchange rates) to install and test imported computers for CAS.

From 1987 Lenovo expanded its activities to trade and distribution, becoming a distributor first for AST (the leading foreign brand in China at that time), and later adding Hewlett-Packard and other foreign brands as they made inroads into the Chinese market. These activities soon became the primary source of revenues for Lenovo, and also generated capital that Lenovo invested in a joint venture in Hong Kong to trade and then manufacturer motherboards and add-on cards.

Learning and capability development. By distributing foreign-made PCs, Lenovo not only accumulated needed capital, but also learned how to organize sales channels and market PCs. Liu, the former CEO, even said, 'our earliest and best teacher was Hewlett-Packard' (Gold *et al*., 2001). Through these activities, Lenovo also began to build up its understanding of its Chinese customers and their PC purchasing habits.

By the end of this initial period, Lenovo had made significant progress in creating its national

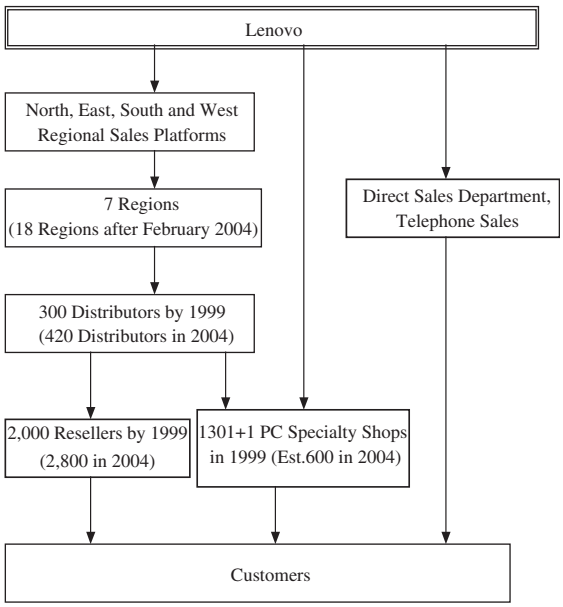

Figure 1. Lenovo's distribution network[11].

distribution network that was a scarce and competitively valuable resource, especially at this early stage of China's market transition (Figure 1). The only other organizations that had such networks at this time were the state-owned distribution organizations found in most industries – legacies of the central planning system responsible for fulfilling the State Planning Commission and relevant industrial bureau's allocation directives for manufacturing inputs, intermediary products, and final goods. In stark contrast to such distributors, Lenovo was geared towards its customers' needs, not the state's plan. Furthermore, Lenovo could only exist by matching customer demand with supply, unlike the state-owned distributors at that time who had no such performance pressure.

Towards the end of this period, beginning with its joint venture in Hong Kong, Lenovo made its first steps into manufacturing, primarily add-on cards. One of its most successful add-on cards, for Chinese word-processing, was originated in the laboratories of its parent, ICT. Lenovo subcontracted developmental and engineering R&D to ICT, and ICT also transferred personnel to help with implementation at the production stage. These cards became an important source of revenue, in addition to that from distributing foreign PCs.

Phase 2, 1991–2000: manufacturing PCs (Gong)

Government. From the beginning of the 1990s, China's Ministry of Electronics Industry (MEI) changed its policy for developing China's PC industry from 'nationalism to pragmatism' (Kraemer and Derick, 1994a; 1994b). First, the government stopped insisting on self-reliance, and encouraged local firms to acquire foreign technologies and become part of the international production network for PCs. Second, the government significantly reduced import tariffs on foreign-made PCs.

Multinationals. The high import tariffs on PCs in the 1980s had two direct effects on the fortunes of the multinationals once those tariffs were reduced in 1992. First, they faced few domestic competitors because the government had allowed only a few firms – 'picking winners' – to produce PCs. Second, those domestic 'winners' (such as Great Wall) had enjoyed relatively high profits from their protected local market, and had not invested in learning and capability development to move them closer to international standards. As a result, multinationals quickly came to dominate the Chinese PC market in the first half of the 1990s (Table 2). Later, once the government allowed new and aggressive domestic entrants (such as Lenovo and Founder) to manufacture PCs, the multinationals lost their absolute dominance.

Lenovo's competitive strategy. During the previous (*mao*) stage, Lenovo had begun to build up its market knowledge through its direct interaction with customers and extensive distribution network. It had also undertaken limited production and assembly of two major components: motherboards and add-on cards. Furthermore, these activities – trade, service, component manufacturing – generated profits that Lenovo could reinvest. Unlike other firms that embarked on unrelated diversification financed by a core activity, Lenovo's managers continued to focus on the PC industry. They did, however, want to capture more of the value-added activities in this industry and, after acquiring a PC manufacturing license in 1991, began to produce their own PC brand (Legend, at that time).

Lenovo adopted several important strategic approaches. First, it offered Chinese customers PCs with the latest processors, unlike the multinationals who did not place a priority on supplying its latest models to the Chinese market. For example, the multinationals were selling their newest 486-based PCs in the USA but only their older and slower 386-based PCs in China, and these older models were also selling at prices higher than the newer ones. Lenovo, in contrast,

quickly adopted the latest Intel chips and offered them on the Chinese market, simultaneously contributing to Lenovo's image as a fast and technology-intensive producer, as well as reducing the stigma of lagging technology attached to local brands by Chinese consumers (*Business Week*, 1999).

Lenovo's second strategic decision, complementing the decision to offer leading technology in its PCs, was to design its PCs to appeal specifically to Chinese customers (Gold *et al*., 2001). The PCs being sold by multinationals were not differentiated to match local customers in markets such as China, which were considered relatively minor at that time. Lenovo, in contrast, was designing products for different market segments, from banks and other large organizations to SMEs in the corporate market, and similarly diverse individual customer groups. Lenovo incorporated feedback and experience in user needs from its distribution channels and marketing department into design and innovation efforts in its business-level R&D centres. Table 3 presents examples of product features that Lenovo introduced based on its awareness of customer preferences and behaviours.

The third element of Lenovo's strategy during this period was to compete on the basis of price. For comparable products, Lenovo priced its products at about two-thirds of foreign-made PCs (*Wall Street Journal*, 1997). For example, in August 1996 Lenovo was selling its 75 MHz Pentium-based PC for US$1,520, compared to similar models by AST and IBM selling for US$2,000 or more (Upside, 1996). Lenovo was able to do this by maintaining a lower cost structure than the multinationals. First, Lenovo's management costs were lower, especially compared to those of foreign firms with expatriate managers in China. Second, more foreign component manufacturers were setting up manufacturing operations in China, such as Seagate Technology for hard drives in Shenzhen. These component manufacturers passed on some of their cost savings from their Chinese operations to PC assemblers such as Lenovo and Great Wall. Second, as a wave of Taiwanese firms entered China from the mid-1990s (Kraemer and Derick, 2001), Lenovo also gained access to supplies of components and peripherals of the same quality as those used by leading multinationals. Third, Lenovo's sales and service network reduced its distribution costs and further reduced Lenovo's cost structure.

Lenovo's distribution network continued to grow and conferred other competitive benefits to

Table 3. Innovations in Lenovo's home PCs[7].

Innovation	Main features
LEOS	LEOS is a Lenovo independently designed operating system, under Lenovo's policy on developing application-oriented PCs to penetrate into home markets. It treats the home PC as a home-entertainment center. Without booting up the Windows operating system, the time-consuming process, by pressing buttons on the remote controller, you can watch DVDs, play games and MP3, review digital photographs and even watch television on the LCD monitor.
Happy Family Software (Pre-loaded application software)	Happy Family Software has two characteristics: Chinese version and graphic-user interface. It promotes Legend PC into Chinese families
Legend Computer School (Pre-loaded application software)	Integrates five tutorial software programs on a disk to help customers learn computer skills quickly.
Three-months free account with the High School Education Information Service	The High School Education Information Service aims to provide on-line education for students by high quality teachers and students of Beijing University and Tsinghua University.
Hot keys	Lenovo added a dozen of 'hot keys' to the keyboard for such tasks as gaining access to the internet, receiving email, on-line shopping, and reading news.
One-touch recovery key	Because of the low penetration rate of PCs and user inexperience, first-time buyers often crash the operating system. This one-touch recovery key ensures the system recovery.
Front-loaded audio, microphone and USB interfaces	Recognizing that some interfaces are used frequently, Lenovo designed some interfaces into the front of the casing to make it more user-friendly.
Boot-easy technology	Lenovo's patented 'boot-easy' technology can halve system boot-up time.
Power-easy technology	Automatically sets CPU voltage.
Thermo-easy technology	Protects the CPU from overheating
Touch screen technology	Helps older people browse the internet by just touching the screen instead of using a mouse or keyboard.

Lenovo beyond an improved cost structure. First, it gave Lenovo much greater geographic coverage than either multinationals or other domestic producers. By the end of the *mao* stage, Lenovo had approximately 50 authorized distributors in each of the seven regions into which it divided the Chinese market, and each distributor had its own reseller network. Altogether, there were approximately 2,000 resellers in Lenovo's distribution system, in addition to its 130 '1 + 1' PC specialty shops in major cities. IBM, in contrast, had about ten tier-one distributors, and primarily in large cities. Second, although there was competition among distributors, Lenovo nurtured a positive relationship with its distributors, many of which had grown with Lenovo over the years. In the mid-1990s, for example, Lenovo established the rule that its own regional subunits would not sell PCs, but would only provide information and material flow service to distributors and resellers. Such policies and practices engendered greater loyalty among its distributors than those of other manufacturers, foreign or domestic. Even as Lenovo increased the depth and breadth of its distribution channels, it never had equity interests in its distributors, including its 1 + 1 PC specialty shops.[8]

Learning and capability development. During this stage, Lenovo expanded and elaborated its distribution network and sales and service activities. These also formed the basis for Lenovo's marketing activities that also informed Lenovo's product design decisions. At the same time, Lenovo had to develop a large-scale and low-cost manufacturing capability to ensure its cost-competitiveness in the face of the foreign and domestic competition that was intensifying during this period.

One source of learning was its customers, with which Lenovo had direct contact through its extensive PC distribution network. In addition to observing customer buying habits and choices, Lenovo also actively sought out customer input to help guide its product development activities. In 1998, for example, a Lenovo survey revealed that 80% of its customers bought PCs for gaining access to the Internet. Even after 6 months after purchase, however, fewer that 10% had actually used their PC for that purpose. Lenovo found that for average users, configuring the PC to connect to an Internet service provider (ISP) was too complicated and time-consuming. Lenovo responded soon after with its internet-ready PC that incorporated six 'hot keys' to the keyboard that automated such activities as gaining access to the Internet, receiving email, purchasing on-line, and accessing news. Within a year of its highly successful launch, this model had sold 900,000 units (*AsiaWeek*, 2001).

Multinationals were another source of learning for Lenovo. Even while producing its own brand, Lenovo continued to distribute foreign-made PCs for Hewlett-Packard, Toshiba and IBM. In addition to solidifying Lenovo's position as the dominant PC distributor in China, it also provided Lenovo with the opportunity to closely scrutinize foreign product designs and customer responses.

Lenovo eventually established three large-scale manufacturing bases in Beijing, Shanghai and Huiyang (Guangdong Province) during this period. Its high-volume strategy not only provided scale economies and thereby a more competitive cost structure, but it also enabled Lenovo to benefit rapidly from learning-by-doing. Lenovo acquired leading production technology from its extensive imports of manufacturing equipment, along with extensive training by its suppliers. Its shop-floor engineers thus learned and successfully implemented leading manufacturing management processes without having the burden of legacy, poorly trained workers and substandard practices that plagued many of Lenovo's state-owned competitors.

Broader and deeper internal R&D activities were the third and critical source of learning that supported Lenovo's cost-based and customer-focused strategy. Successfully implementing this strategy would require R&D activities that brought together marketing, product design and engineering, and manufacturing. Although Lenovo had a general understanding of the need for such activities to support its strategy and embarked on establishing an internal R&D capability in the late 1980s, its managers had no clear idea how to structure or manage such activities.

Its first structural approach, to establish a corporate-level R&D centre with 200 personnel in 1990, proved inappropriate. Its corporate-level scientists and engineers were not interested and too slow in reacting to what they considered mundane needs from production sites and marketing. Instead, they were interested in developing cutting-edge technologies, such as large-scale integrated circuits and digital switches. Top management quickly realized this mismatch between Lenovo's strategic business needs and the interests of its corporate R&D centre. They disbanded the centre and assigned the R&D personnel to business units, thereby establishing several

Table 4. Major foreign PC firms' activities in China.

Company	Form (joint venture or wholly-owned)	Local partner	Products, operations
IBM	JV	Great Wall	Desktop and notebook PCs, storage products, motherboards
Compaq	JV	Stone Group	Desktop PCs
	JV	Star Group	Notebook PCs
Hewlett-Packard	JV	Lenovo	Desktop PCs, inkjet printers
Dell	WO		Desktop and Notebook PCs
Acer	WO (3 separate units)		Monitors, peripherals, motherboards, software, networking equipment
Toshiba	JV	Tontru	Servers
NEC	JV	N/A	Desktop PCs
LG electronics	JV	Tontru	Monitors
Siemens	WO	N/A	Desktop PCs

Source: Kraemer & Derick (2002), p.31.

business unit-level R&D centres that answered to business unit managers. This structure proved appropriate and sufficient for Lenovo's needs up to 2001. The close interaction among R&D, manufacturing and marketing functions enabled Lenovo to implement its two-pronged strategy of low-cost manufacturing and innovative products matching the Chinese market.

Phase 3, 2000 – present: technological development (Ji)

Government. In its industrial policy for the Chinese PC industry, the Chinese government has continued on the trajectory of market liberalization that began in the early 1990s. Already it allowed new domestic entrants (such as Lenovo) to acquire licenses to manufacture PCs. It had also steadily and dramatically reduced import tariffs first in 1992, then again in 1996 and 1999 leading up to its bid for WTO membership. WTO agreements then committed China to further tariff reductions, from 13% in 2001 to zero by 2005. At the same time, the Chinese government will no longer restrict the local production of foreign firms in China to a percentage of their exports.

Multinationals. Foreign firms have fully recognized the scale and potential of the Chinese PC market, and have finally accorded it high strategic priority. The PC penetration rate is still only approximately 1.5%, but already the Chinese market is the third largest in terms of unit shipments after the USA and Japan. To serve this market, and as the government steadily reduces their strategic options, all of the major multinationals are establishing more of their operations in China, either through joint ventures or, more recently, wholly-owned subsidiaries (Table 4).

Lenovo's competitive strategy. In the face of decreasing advantages to domestic firms and increasing competition from foreign competitors such as IBM, Hewlett-Packard and Dell, Lenovo has so far not only defended, but has extended its lead as a result of its underlying strengths in product design, manufacturing and distribution. Andy Grove, former CEO and founder of Intel, had already recognized in 1998 Lenovo's manufacturing capabilities as world-class.

Lenovo's management, however, recognizes several competitive issues they will have to address to enable Lenovo to continue to compete with even more determined and focused rivals for an increasingly diverse domestic market. First, compared to the leading multinationals targeting the Chinese market, Lenovo lags behind in technological capabilities. At the same time, its domestic rivals are catching up, closing the formerly wide technological gap between themselves and Lenovo. Second, as more multinationals establish significant manufacturing bases in China, they will also have the same opportunities to reduce their cost structure, such as from labor costs comparable to those of Lenovo. Third, competition based on product innovativeness is gaining importance as firms in the industry become less able to compete on price and costs.

To respond to these developments in the competitive landscape, and based on a joint analysis by McKinsey and Company in 2000, Lenovo's management has identified technology and innovation as the basis of its new strategic development. To fund this effort, Lenovo announced in 2000 that it would invest an additional RMB 1.8 billion

(US$218 million) in the development of new technology. To further signal this change in emphasis as well as establish a brand name that could be extended overseas, in 2003 Lenovo changed its name from Legend to Lenovo, meaning 'leading innovation'. Given the dramatic increase in Lenovo's patents – invention, utility and industrial design – since 1999 (Table 5), this increased emphasis on innovation seems to be bearing fruit.

While targeting significant technological innovation for future growth, Lenovo is continuing its two-pronged strategy of offering differentiated products incorporating leading technology to more finely-segmented customer segments. First, drawing on its internal R&D capabilities, Lenovo is offering more customized hardware configurations and software bundles for its Chinese customers. For example, within its notebook product category, it offers five series, each targeted to the needs of specific customer groups (Table 6). In the home PC category, it offers four series, including one for children that helps children learn computer skills through games and entertainment; another for middle-aged and older users that incorporates touch-screen technology as an alternative to using a mouse or keyboard; another for high school students that have more fashionable designs and learning software; and a fourth for adults that includes Lenovo's proprietary software.[10]

Complementing its more differentiated product lines, Lenovo has elaborated its distribution system to more finely address the geographic variation in customer purchasing power, attitudes, lifestyles and consumption patterns (Cui and Liu, 2000). In 2004 Lenovo increased the number of primary market regions to 18 from 7 (Figure 1). Managers of these regions report directly to the headquarters in Beijing, while the four regional platforms (north, south, east and west) have only a logistics coordination function. It is also significantly expanding its $1+1$ PC specialty shops to 600 by the end of 2004 from 130 in 1999 in order to strengthen the linkage between Lenovo and its end users. Finally, during this same period and as a result of Dell's direct-sales success in China, Lenovo recognized a new customer segment and added a telephone-based and direct sales unit to serve them.

Learning and capability development. Although Lenovo continues to learn via its distribution, marketing and manufacturing activities, the nature of innovation implied by its current strategy places an even greater emphasis on R&D at both

Table 5. Lenovo's patents.

Patent classification	1997	1998	1999	2000	2001	2002	2003
Invention patent	1		2	2	3	10	101
Utility model			6	18	15	90	102
Industrial design patents	4	11	28	31	53	125	104
Total	5	11	36	51	71	225	307

Source: Author's calculation based on patent database of China's Intellectual Property Bureau.

Table 6. Lenovo's 5 notebook series[9].

Series	Special features	Customer segment
A-Series (''Advanced'')	Technology performance-oriented product with high quality.	Enterprise users, with required knowledge and skills in computers, especially high-level managers and IT professionals.
E-Series (''Efficient'')	Economic model with trade-offs between performance and price.	Users in the education sector, government and SMEs.
Y-Series (''You'')	Personalized design, with emphasis on multimedia functions and entertainment.	Users in small studios, students, fans of multimedia, and users with first PC in home.
S-Series (''Super-mobile'')	Wireless application, fashion focus, low-weight and small-sized design with reasonable performance.	Users emphasizing wireless applications and low-weight characteristics, especially business people such as marketing and sales people, and women.
X-Series (Expert Users)	High computation capacity and qualified for instead of desktop PCs and mobile working station).	Mainly users who require high-power computation capacity, or work in the field of multimedia design, development of large-scale information systems, or multi-operating systems.

Table 7. Stages and features of Lenovo's learning process and capabilities development.

Distribution, sales and service (*Mao*) 1984–1990	Manufacturing (*Gong*) 1991–2000	Technological development (*Ji*) 2001–present
Key activities		
Became a distributor for AST in 1987, later for HP and other foreign brand PCs.	Began to produce own-branded PCs through its own manufacturing bases.	Emphasizes adaptation of product designs and building internal leading-edge R&D capabilities.
Substance of learning and capability building		
Marketing and distribution capabilities	High-volume and low-cost manufacturing capabilities.	Product and process technologies for reducing production costs and meeting local customers' preferences. Build-to-order manufacturing capability
Sources of learning		
Trade-related activities; Learning from multinationals.	Learning from multinationals. Learning from customers through distributors and retailers Own business unit level R&D.	Internal two-tier R&D system. Learning through strategic alliances. R&D for cutting-edge technology.

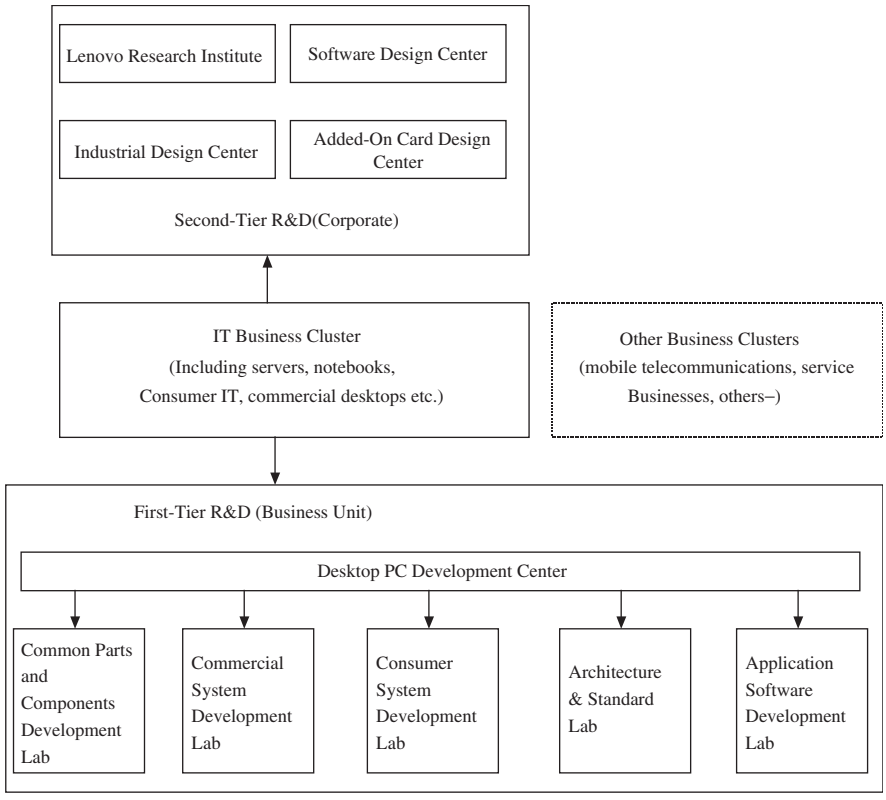

Figure 2. Lenovo's two-tier R&D organization structure (for PCs)[13].

the applied and more fundamental levels. Finally, after several restructurings of its R&D activities,[12] Lenovo's management has settled on a two-tier structure (Figure 2) corresponding to what they term 'technology for today' and 'for tomorrow and the day after tomorrow'.

The first tier, charged with developing 'today's' technology for PCs, is located with the IT Business Cluster, which includes the server, notebook, consumer IT, commercial desktop and several other business units. These are served by more specific labs; for example, the Desktop PC Development

Center includes five supporting labs that are responsible for parts and components, commercial systems, consumer systems, architecture and standards, and application software. These labs are responsible for engineering systems and components based on needs identified in current operations, although in some cases they may subcontract research work to second-level R&D centres. In any case, these labs must cooperate with the production engineering departments within Lenovo's three manufacturing plants to ensure that their solutions are easy and cost-effective to implement in manufacturing.[14]

Second tier R&D is corporate-level under a deputy director and includes four centres. The Lenovo Research Institute is at the heart of Lenovo's development of future key technologies. The current focus is on coordinating applications, to develop the technologies and protocols that will make it possible to exploit opportunities for coordinating different information devices, including home appliances, telecommunications and computers. The other three centres are charged with developing technology and platforms for all business units within Lenovo. The Software Design Center develops application software;[15] the Industrial Design Center innovates in product appearance and attractiveness; and the Add-on Card Design Center develops motherboards and other parts and components to optimize the performance of Lenovo's products. These centres are supposed to support the first-level research units, and relationships between the first- and second-tier centres are governed by internal contracting agreements.

Because of the breadth of technologies and capabilities relevant for PCs, however, Lenovo recognizes that it must supplement internal R&D activities, especially those targeting the future, with cooperative activities with other firms. To this end, it has formed alliances with China Telecom, IBM, National Semiconductor and D-Link, among others. In August 2003, for example, it co-founded with Intel the Lenovo-Intel Future Technology Advancement Center. This centre is charged with building reliable computation environments and key technologies for the next-generation Internet, and designing leading-edge products that fuse computers and telecommunications.

Discussion

Lenovo's development experience suggests several hypotheses regarding the relationship among a new firm's competitive strategy, learning and capabilities on one hand, and its performance in a particular competitive and institutional environment on the other. First, the case clearly illustrates the evolutionary and path-dependent nature of capability development. Rather than being a constraint, however, Lenovo's case shows that an initial set of resources and capabilities can support the development of additional complementary ones. In Lenovo's case, the founders benefited in the early days from the spin-off's external legitimacy based on its parent's reputation. In addition, its personnel had technical expertise that could generate revenues from downstream activities – distribution, sales and service; these did not require scarce capital requirements. Changes in the institutional environment also allowed the founders to undertake such activities, although it also created constraints on its efforts for undertaking others (i.e., manufacturing). Given Lenovo's initial resources and capabilities, however, it is doubtful whether it could have become a competitive PC manufacturer any earlier than it did.

The case also suggests that the motivation to learn and develop new capabilities may be related to the background, expertise and values of the founding members. While Lenovo's founders initially established a sales and service firm, they themselves were researchers and engineers and always had the ultimate objective of moving upstream into manufacturing and R&D. Such motivation may be just as critical a factor for a firm to develop new capabilities as having the opportunity and resources (financial and technical) to do so.

Lenovo's case also illustrates how the nature and direction of learning evolves in relationship to changing environmental features and the firm's accumulation of relevant resources and capabilities. Hence, Lenovo began in the initial *Mao* phase by directing its resources to the sales and service opportunities that generated revenues that not only financed its entrance into manufacturing during the following *Gong* phase, but also provided an enduring competitive advantage vis-à-vis its foreign and even domestic competitor – namely, its understanding of its customers and unique distribution network. Similarly, its experience in manufacturing not only generated revenues, but also provided the basis for identifying competitively important areas in which to focus R&D efforts during the current *Ji* phase. The movement into each phase was associated with business opportunities and enabled Lenovo to compete more and more directly with leading firms in the industry.

The case shows changes in the capabilities and domains in which a firm competes and also illustrates how the means to acquire new resources and capabilities much change. Initially, Lenovo could compete in sales by relying on other firms' products or technology developed by its parent. In order to grow, however, it had to internalise first manufacturing capabilities and then R&D capabilities. This is pushed further as rivals begin to see the newcomer as an emerging threat and restrict access to resources or capabilities that they had earlier proved when the newcomer was seen as a partner.

Lenovo also represents the way in which a new entrant may challenge incumbents, especially foreign competitors, by developing resources and capabilities that are especially adapted to the local market. Lenovo accumulated customer knowledge and created a distribution network that has proven nearly impossible for foreign and even most domestic competitors to replicate. It has continued with this strategy as it has extended its capabilities into manufacturing and R&D; namely, a major objective of Lenovo's ongoing activities is to develop products that are even more finely attuned to increasingly more specific customer segments. This consistent focus and deepening capability in this regard has also emerged as a significant competitive advantage for Lenovo in the Chinese market.

Such extreme adaptation to a particular market, however, may be a liability if the firm wants to expand to new markets, especially those outside its home market. Lenovo, although financially and competitively quite successful in the Chinese market, has only token sales outside of China (approximately 10%). It is not clear at this time whether such dominance of domestic over international sales is simply a matter of managerial focus, or an inherent limitation in the competitiveness of Lenovo's products in other markets. Although the Chinese market alone promises to be a major growing PC market for the foreseeable future, the possibility that Lenovo's products may not match other markets would have to be addressed if or when Lenovo chooses to consider increasing its presence in foreign markets.

Finally, the Lenovo case illustrates an alternative path for a new entrant – whether a spin-off or firm that is diversifying into a new business – to become an integrated firm. This path begins with downstream activities in marketing, sales and service, and then expands upstream into manufacturing, product development and engineering, and finally research. This is in contrast to the path followed by most of the other firms that were newly established in response to new opportunities created by China's transitioning institutional and market environment. These firms began with manufacturing and moved into marketing and sales (Xie and Wu, 2003). For example, firms such as Changhong, a leading television manufacturer, began by importing production lines and then building their sales and marketing capabilities and, much later if at all, varying degrees of R&D capabilities. Other firms were spin-offs with truly proprietary technology that expanded their capabilities downstream into manufacturing, marketing and sales. The Founder Group Company is one such example of downstream capability building (Lu, 2000). Around the same that Lenovo was founded, this company exploited the pictographic-language electronic publishing systems technology developed by Beijing University researchers and thereby produced China's first high-resolution colour electronic publishing systems.

Managerial implications

Some of the conceptual elements of the Lenovo case have clear implications for management. Two elements – path dependence and capability building – should suggest to managers that they clearly link their existing set of resources and capabilities to desired changes in those features that they see as necessary to compete. Finally, after almost 15 years, Lenovo put together an integrated set of functional capabilities, from R&D to manufacturing to sales and service. Furthermore, because it started with sales and service, its current success can arguably be attributed to it first mastering and understanding manufacturing activities before investing significantly in R&D. Furthermore, each step of its expansion into new activities and capabilities was supported by its success in preceding stages.

The case also shows how each stage in a firm's development of new capabilities requires different strategies and structures for learning. The firm will acquire different capabilities through different means; for example, through acting as a subcontractor to leading firms, collaborating with a partner, acquisitions, licensing or other means. Furthermore, as the firm develops capabilities in new functional areas, or broadens the range of capabilities in a particular function, the organization must be restructured to support

effective and efficient coordination of increasingly diverse activities.

The case has lessons that are also particularly relevant for latecomer firms, especially but not only those in developing countries like China. Although investments in R&D may be considered vital to compete at the leading edge of an industry, and governments may even reward investments in R&D, it is necessary to realistically assess the opportunity costs and probably outcomes from such investments by a firm with limited resources compared to those of large multinationals. Firms with limited resources should allocate them to activities and learning efforts that will enable it to compete successfully with its rivals. Developing resources and capabilities that set them apart from otherwise much better funded and endowed rivals represent a better strategic option that attempting to compete on the same basis with such firms. Lenovo's investments in distribution and product development attuned to Chinese customers, for example, have so far more than offset the reality that its investments in R&D are very small compared to the R&D expenditures of its multinational rivals. However, in the long term, Lenovo needs more R&D or move to a more R&D-focused model. Firms invest in R&D not only to generate innovations, but also to learn from rivals and external knowledge sources[16] (Cohen and Levinthal, 1989, 1990).

Conclusions

This study has sought to characterize the process of learning and capability building in a technology-based firm that started from a set of downstream rather than upstream resources and capabilities. Specifically, we find that learning was a stage-wise process (Lee *et al*., 1988) that benefited from clear strategic objectives that focused learning efforts (Lall, 1987, 1992; Bell and Pavitt, 1993). The locus of learning also evolved over time (Hobday, 1995), and the sources and channels for learning also changed across different stages (Kim, 1997; Hobday, 1995).

The study also shows how the nature of a firm's initial set of resources and capabilities may have an impact on subsequent decisions regarding that nature and direction of learning. For example, we may expect capabilities developed by domestic firms in an emerging market such as China to continue to be extremely market-oriented even when the firm is fully integrated if the firm's initial set of resources and capabilities emerged in response to market opportunities (demand-based) rather than proprietary technology (supply-based). Furthermore, when a firm has developed and competes successfully based on its ability to meet the demands of a particular market, it may result in the firm being either ill equipped or uninterested to enter foreign markets.

More generally, this study has provided an alternative development model for spin-offs in which the parent's key contributions may not be technology, even if the spin-off eventually emerges as a leading technology-based enterprise. In the case we studied, the spin-off started as a sales and service firm, and then vertically integrated into manufacturing and then R&D. The parent's critical contribution was not proprietary technology or significant start-up funding, but seconded technical personnel, freedom for them to undertake commercial activities, and their first commercial contract that became their revenue stream.[17] An additional critical contribution was legitimacy via connections to a government organization.

Finally, the study raises the issue of appropriate allocation of resources for learning in latecomer firms, especially those facing established competitors with greater financial, technological or other resources and capabilities. We have suggested that such underdog firms should focus their learning activities and resources in areas that build on their existing resources and capabilities and that could help them survive and compete in the face of otherwise stronger, better endowed rivals. However, considering the exploratory nature of this case study about single company, one needs to be cautious in generalizing the research findings of this article to specific cases about China. The conclusions need to be validated further with a more rigorous research method.

Acknowledgements

The research, on which this paper is based, was financially supported by the NSF of China (NSF Research Project Number: 70173008 and 70373005) and the Basic Research Fund of Tsinghua University (Project Number: JC2002049). The authors would like to thank three anonymous referees for their thoughtful and extensive comments on the draft, and interviewees' time and patience for answering our questions.

References

Amsden, A.H. (1989) *Asia's Next Giant: South Korea and Late Industrialization*. New York: Oxford University Press.

Amsden, A. and Kim, L. (1989) A comparative analysis of local and transnational corporations in the Korean automobile industry. In Kim, D.K. and Kim, L. (eds), *Management behind Industrialization*. Reading in Korean Business, Seoul: Korea University Press, pp. 579–596.

Asiainfo Daily China News (1999) Dallas, 16 June.

Asiaweek (2001) The stuff of Lenovo, 25 May.

Bell, M. (1984) Learning and the accumulation of industrial technological capacity in developing countries. In: Fransman, M. and King, K. (eds), *Technological Capability in the Third World*. London: Macmillan.

Bell, M. and Pavitt, K. (1993) Technological accumulation and industrial growth: contrasts between developed and developing countries. *Industrial and Corporate Change*, **2**, 2, 157–210.

Brockhoff, K. and Guan, J. (1996) Innovation via new ventures as a conversion strategy for the Chinese defense industry. *R&D Management*, **26**, 1, 49–56.

Boutellier, R., Gassmann, O. and von Zedtwitz, M. (2002) 'Future competitiveness: research and analysis of cases on global R& D management (in Chinese), Guangzhou: Guangdong Economics Publisher.

Business Week (1999) How Lenovo lives up to its name. 5 February.

Carayannis, E.G., Rogers, E.M., Kurihara, K. and Allbritton, M.M. (1998) High-technology spin-offs from government R&D laboratories and research universities. *Technovation*, **18**, 1, 1–11.

Choung, J.Y., Hwang, H.R. and Choi, M.H. (2000) Transition of latecomer firms from technology users to technology generators: Korean semiconductor firms. *World Development*, **28**, 9, 969–982.

Cui, G. and Liu, Q. (2000) Regional market segments of China: opportunities and barriers in a big emerging market. *Journal of Consumer Marketing*, **17**, 1, 55–70.

Cohen, W. and Levinthal, D. (1990) Absorptive capacity: a new perspective on learning and innovation. *Administrative Science Quarterly*, **35**, 128–152.

Cohen, W. and Levinthal, D. (1989) Innovation and learning: the two faces of R&D. *Economic Journal*, **99**, 569–596.

Dahlstrand, A.L. (1997) Growth and inventiveness in technology-based spin-off firms. *Research Policy*, **26**, 331–344.

Davenport, S., Carr, A. and Bibby, D. (2002) Leveraging talent: spin-off strategy at industrial research. *R&D Management*, **32**, 241–254.

De Boer, S.J., Gan, W. and Shan, G. (1998) Critical issues facing R&D managers in China. *R&D Management*, **28**, 3, 187–197.

Eisenhardt, K. (1989) Building theories from case study research. *Academy of Management Review*, **14**, 532–550.

Fischer, W. (1983) The structure and organization of Chinese industrial R&D activities. *R&D Management*, **13**, 2, 63–81.

Gassmann, O. and von Zedtwitz, M. (1998) Organization of industrial R&D on a global scale. *R&D Management*, **28**, 3, 147–161.

Glaser, B. and Strauss, A. (1967) *The Discovery of Grounded Theory: Strategies for Qualitative Research*. New York: Aldine de Gruyter.

Gillespie, A. (2001) Building China's high–tech telecom equipment industry: a study of strategies in technology acquisition for competitive advantage. Master Thesis, Program of Technology Policy, MIT.

Gold, A.R., Leibowitz, G. and Perkins, A. (2001) A computer Lenovo in the making. *McKinsey Quarterly*, **3**, 73–83.

Hobday, M. (1995) *Innovation in East Asia: the Challenge to Japan*, Edward Elgar. Aldershot.

Huang, X., Schroder, B. and Steffens, B. (1999) The Chinese steel industry in transition: industry perspective on innovation policy. *R&D Management*, **29**, 1, 17–25.

Karagozoglu, N. and Brown, W.B. (1986) A multilevel, multiphase framework for viewing technological innovation. *Journal of Technology Transfer*, **10**, 2, 15–32.

Kim, L. and Dahlman, C.J. (1992) Technology policy and industrialization: an integrative framework and Korea's experience. *Research Policy*, **21**, 5, 437–452.

Kim, L. and Nelson, R.R. (eds) (2000) *Technology, Learning and Innovation: Experiences of Newly Industrializing Economies*. Cambridge: Cambridge University Press.

Kim, L. (1997) *Imitation to Innovation: the Dynamics of Korea's Technological Learning*. Boston: Harvard Business School Press.

Kim, L., Lee, J.W. and Lee, J.J. (1987) Korea's entry into the computer industry and its acquisition of technological capability. *Technovation*, **7**, 6, 277–293.

Kim, Y. and Lee, K. (2003) Technological collaboration in the Korean electronic parts industry: patterns and key success factors. *R&D Management*, **33**, 1, 59–77.

Kraemer, K.L. and Derick, J. (1994a) National computer policy and development in China. Working Paper PAC-060A. Center for Research on Information Technology and Organization, University of California.

Kraemer, K.L. and Derick, J. (1994b) From nationalism to pragmatism: IT policy in China. Working Paper PAC-060B. Center for Research on Information Technology and Organization. University of California, Irvine.

Kraemer, K.L. and Derick, J. (2001) Creating a computer industry giant: China's industrial policies and outcomes in the 1990s. Working Paper, Center for Research on Information Technology and Organization. University of California, Irvine.

Kraemer, K.L. and Derick, J. (2002) Enter the dragon: China's computer industry. *Computer*, February, 28–36.

Lall, S. (1987) *Learning to Industrialize: the Acquisition of Technological Capability by India*. Macmillan: Basingstoke.

Lall, S. (1992) Technological capabilities and industrialization. *World Development*, **20**, 2, 165–186.

Lee, J., Bae, Z. and Choi, D. (1988) Technology development processes: a model for a developing country with a global perspective. *R&D Management*, **18**, 3, 235–250.

Li, H. and Atuahene-Gima, K. (2001) The impact of interaction between R&D and marketing on new product performance: an empirical analysis of Chinese high technology firms. *International Journal of Technology Management*, **21**, 1/2, 61–75.

Liu, X. and White, S. (2001) Comparing innovation systems: a framework and application to China's transitional context. *Research Policy*, **30**, 7, 1091–1114.

Lu, Q. (2000) *China's Leap into the Information Age: Innovation and Organization in the Computer Industry*. Oxford: Oxford University Press.

Mathews, J.A. (1996) High technology industrialization in East Asia. *Journal of Industry Studies*, **3**, 2, 1–77.

Mathews, J.A. and Cho, D.S. (2000) *Tiger Technology-the Creation of the Semiconductor Industry in East Asia*. Cambridge: Cambridge University Press.

Meyer, M. (2003) Academic entrepreneurs or entrepreneurial academics? Research-based ventures and public support mechanisms. *R&D Management*, **33**, 2, 107–115.

Mu, R. (1997) Technology transfer from Germany to China – a case of Shanghai Volkswagen Auto Company (in Chinese). *Science Research Management*, **18**, 6, 71–78.

Numagami, T. (1998) The infeasibility of invariant laws in management studies: a reflective dialogue of defense of case studies. *Organization Science*, **9**, 2–15.

O'Gorman, C. (2003) Stimulating high-tech venture creation. *R&D Management*, **33**, 2, 177–187.

Roberts, E.B. and Malone, D.E. (1996) Policies and structures for spinning off new companies from research and development organizations. *R&D Management*, **26**, 1, 17–48.

Shen, X. (1999) *The Chinese Road to High Technology: a Study of Telecommunications Switching Technology in the Economic Transition*. Basingstoke: Macmillan.

Shi, Y. (1998) *Chinese Firms and Technology in the Reform Era*. London: Routledge.

Steffensen, M., Rogers, E. and Speakman, K. (1999) Spin-offs from research centers at a research university. *Journal of Business Venturing*, **15**, 93–111.

Sung, C.S. and Hong, S.K. (1999) Development process of nuclear power industry in a developing country: Korean experience and implications. *Technovation*, **19**, 5, 305–316.

Upside (1996) China enters the computer age, Upside. August.

Wall Street Journal (1997) China's personal-computer industry is starting to beat out U.S. companies, 19 November.

Wang, D. (1999) Continuous innovation and firms' growth (in Chinese). *Science Research Management*, **20**, 1, 36–42.

White, S. and Linden, G. (2002) Organizational and industrial response to market liberalization: the interaction of pace, incentive and capacity to change. *Organization Studies*, **23**, 917–948.

Xie, W. and Wu, G. (1997) Localization as a learning process: a case study on Shanghai Santana' (in Chinese). *Science Research Management*, **18**, 1, 34–40.

Xie, W. and Wu, G. (2001) The strategic analysis on Chinese capabilities in new car model development (in Chinese). *Auto Industry Studies*, **15**, 1, 7–11.

Xie, W. and Wu, G. (2003) Differences between learning processes in small tigers and large dragons. *Research Policy*, **32**, 1463–1479.

Xie, W. (2001) *Catching-up and Price Wars* (in Chinese). Beijing: Economics and Management Publisher.

Yin, R. (1981) The case study crisis: some answers. *Administrative Science Quarterly*, **26**, 58–65.

Yang, Z.G. (2003) Complex technological learning and catching-up: a case study of China's telecom equipment manufacturing (in Chinese), unpublished PhD dissertation, Tsinghua University.

Zhao, X. (2001) Learning models of firms and processes of capability accumulation (in Chinese), unpublished PhD dissertation, Zhejiang University.

Notes

1. During the study, on 25 March 2004, the company changed its name from Legend Group Limited to Lenovo Group Limited.
2. An interview with Mr. Kaichun Bi of Ministry of Information in July 1999.
3. Latecomers can find it hard to gain market share in product areas where the life cycles is shortening. Interview with Mr. Wanmeng Jiang of Wanyan TV Technology Research Institute on 27 January 2003.
4. The conceptual framework developed in this article, has benefited from discussions with interviewees, and comments from three anonymous referees.
5. Materials drawn from second sources are mainly used to clarify findings from interviews and support the points made in the paper.
6. The process of Mao (Trade)-Gong (Manufacturing)-Ji (Technology) has been regarded, not only by Liu Chuanzhi, but also by many scholars and public Chinese media, as an important model of China's technology development processes in technology-intensive industries. One anonymous referee's comments on the earlier draft also helped us to identify this point.
7. Company archives, 'Dialogue about 1 + 1', Legend, October 1999 and interviews with Mr. Yuhai Ou of Lenovo on 27 March 2004, Mr. Qinwen Zhang of Lenovo in November of 2001.

8. Company archives, 'the application is the key', Legend, February–March, 1999 and interviews with Mr. Hongliang Yang of Legend on 30 March 2004, Mr. Zhen Wu of Beijing Tianma Science and Trade Company on 27 October 2002, Mr. Qinwen Zhang of Lenovo in November of 2001.
9. Company sales brochures and interviews with Mr. Yuhai Ou of Lenovo on 27 March 2004, and Mr. Hongyu Li of Beijing Tianqing Keji Company on 24 March 2004.
10. Interviews with Mr. Tianya Hu of Lenovo on 23 April 2003 and Mr. Zhen Wu of Beijing Tianma Science and Trade Company on 27 October 2002.
11. Interviews with Mr. Hongliang Yang of Legend on 30 March 2004, Mr. Zhen Wu of Beijing Tianma Science and Trade Company on 27 October 2002, Mr. Qinwen Zhang of Lenovo in November of 2001, and Mr. Zhizhong Xin in December of 2002.
12. Telephone discussions with Mr. Zhiyuan Ge on 22 March 2004. He is the former employee of Lenovo.
13. Interviews with Mr. Honglian Yang on 30 March 2004, Mr. Yuhai Ou of Lenovo on 27 March 2004, Mr. Zhifei Qiu of Beijing Fengzhijie Technology Company on 23 March 2004.
14. An interview with Mr. Yuhai Ou of Lenovo on 27 March 2004.
15. One of interviewee told me that the Software Design Center had spun out as an independent company, servicing Lenovo business units based on the marketing mechanism.
16. To a large extent, now Lenovo faces a dilemma of development. On the one hand, Lenovo needs more R&D to develop leading-edge technology, on another hand, it is hard for Lenovo to move up value chains in the PC industry which is dominated by giant players such as Intel and Microsoft.
17. Three anonymous referees' comments on the earlier draft helped us to identify this point.

