Submission to Carnegie Mellon University Software Industry Center Globalization Project[1]

The Chinese Software Industry: How Good Are State Supported Capabilities at Surviving in the Domestic Market? [2]

Ted Tschang, Singapore Management University
Xue Lan, Tsinghua University

September 17, 2003

The Chinese software industry is, much like the China of old, somewhat enigmatic. Its status and strengths are hard to determine, in part because of its somewhat nascent state. With few exceptions in the world has a domestic economy provided such a powerful impetus and opportunities for foreign and local software firms alike. Yet at the same time, the leadership of the software industry is strongly government influenced. As such, the software industry's development needs to be understood within the context of these powerful mechanisms. This provides a stark contrast in growth paths with that of the Indian software industry. Not only is where the source of growth derived from and the role of the state different, the culture in terms of language and the business organization of the industry is different. Whereas India is primarily export driven, its domestic products market is largely dominated by multinationals. In contrast China's domestic firms hold about 33% of China's domestic market, with official policy being to increase this to 60% in 10 years (Gartner, 2002).[3]

The government policies are now as have in the past generally been very supportive of science and technology. Partly as a consequence of this, many software and IT firms have originated from the state or state supported sectors. Although China's hardware manufacturing industry is better known in the world, software has become an official part of the strategy for new industrial development. The reasons behind this lie in the government's belief that the science and technology are essential to the country's independent development, and that key technologies should not be left to the control of foreign enterprises, nor should the rewards of producing those technologies be given up to those same enterprises.

In a recent major policy document – State Council Document number 18, the government targeted both software and semiconductors as the next major industries of focus. Following up on that, in the 10th Five Year Plan (the main economic plan covering the years from 2001-2005) the objectives for software included growth targets of more than 30 percent annually (outstripping the overall economy's average of 10 percent), market sales of nearly $20 billion by 2005, the building of 20 large software companies with revenues of over 1 billion RMB or $120 million USD, more than 100 famous brands, and software exports of $1.5-2 billion by 2005. Software growth in China already enjoys growth rates of about 30 percent or more a year, which puts it on target.

---

[1]. For publication in Ashish Arora and Alfanso Gambardella (eds.), *From Underdogs to Tigers: the Rise and Growth of the Software Industry in Some Emerging Economies*, Oxford University Press (in press).

[2] The authors would like to thank Professor Chen ShenBin, Dr. Cai YuLin and Professor Sun JiuLin of the Chinese Academy of Sciences for their cooperation with us on this project, particularly in procuring and interpreting new data, as well as Ms. Amritha Mani for tireless research assistance. The authors are also grateful to Dr. Masaru Yoshitomi and the Asian Development Bank Institute for funding the fieldwork for the study, and Professors Ashish Arora and Alfonso Gambardella for their valuable comments and funding assistance.

[3] Another estimate of the domestic share of products puts it at 40% (CSIA, 2000).

Our main interest in this chapter is to examine the historical roots and growth of the Chinese software industry, its current status, and the limitations and prospects of the domestic growth path, particularly as it seeks to evolve past its current capabilities. The nature of the domestic market and the manner in which it forges the domestic technological capabilities are critical features of our analysis. The Chinese software sector will have plenty of interesting implications for the kinds of alternative paths to development that may be taken in other countries.

From an economics standpoint, we can try to discern whether the factors behind China's domestic software industry are sustainable in two ways. Firstly, how does the large size, and rapid broad economic growth and informatization of the economy benefit the industry? Does the critical mass of software needs help to enlarge software firms through scale economies, specialization, and other means, as well as to deepen their capabilities? Secondly, does China have any natural comparative advantage in software production over multinationals, such as a larger software labor force, labor cost advantage or strong technological or organizational capabilities? We will bring evidence to bear on these issues in the following sections.

There is also a conventional belief in industry watchers and government alike that the Chinese industry is largely made up of smaller, weaker firms, and that there is a need to grow larger firms. Another part of this perceived weakness comes in the form of lower process capabilities, which are believed to be poorer than India's. Poor software process capabilities were cited by Huawei, a large Chinese telecoms firm, as a reason why it located a major software development facility in Bangalore, India (interview with Huawei, 2001). Rampant software piracy and high employee turnover could also be two factors that contribute to the smaller and weaker size of China's software firms.

Saxenian points to government and gaunxi – the network of dense personal relationships – as factors holding back the development of the Chinese software industry (Saxenian, 2003). Some participants interviewed by Saxenian (2003) were extremely pessimistic, noting that the Chinese products were inferior to foreign imports and were being propped up (unfairly) and inefficiently by the government, that rampant piracy is destroying the competitiveness of the industry, that the network of guanxi relationships that made it difficult to sell software, and that software enterprise capabilities were poor. These contentious views can sometimes be a matter of differing perspectives, opinions, or even time scales. Watchers of the Indian software industry or the Chinese hardware industry 20 years ago might have said the same about their capabilities.

Thus, the challenge in studying China's software markets lies somewhere between understanding how its convoluted domestic markets, networks of "guangxi" (Saxenian, 2003) and efficaciousness of the government, and the diverse and complicated nature of the capabilities of the software firms and their customers, might dictate its growth. In this paper, we will focus more on the latter. Attempting to gauge the Chinese software industry's current capabilities as do some international watchers can result in a fairly negative view of the sector, while using Chinese statistics can lead to a misreading in the opposite direction. Because of this variance in views, we use both Chinese sources and international sources to arrive at a more balanced view of both the positives and negatives.[4] The use of consulting

[4] In particular, we have tried to cross-correlate four different sources of consulting data: IDC, Gartner, CSIA and CCID (where CSIA and CCID are governmental in background). We also based our analysis on a sample of 30 firms that we interviewed, which is mainly comprised of better performing small and medium sized companies.

reports and other secondary literature also corroborate the story that it is indeed an industry in transition with growing pains, but certainly not one that is a lost cause.

We will examine the industry at multiple levels, namely, its aggregate performance, its sectoral performance, and performance at the firm level. In section 2, we will analyze the performance and composition of the industry at aggregate levels. We will also examine the origins of some of the representative and leading firms, in which the role of the state is clear. This provides a stronger appreciation for how some of the capabilities were forged. In section 3, we will examine the nature of the market in detail, focusing on the types of sectors and products, focusing on individual exemplars where possible. Finally, in section 4, we will analyze the factors influencing the current growth path, particularly the near and medium term constraints.

2. China's Software Industry: Structure and Origins

2.1. Structure of the Software Industry

The strength of the Chinese software industry comes in part from the huge market of users and domestic producers, which is fueling the needs for all kinds of software, including services and products. China's software industry is benefiting from amongst others, its hardware and manufacturing industry. The need of domestic manufacturers for embedded software can provide opportunities to domestic software producers. This general point was discussed earlier by Heeks (1999) who believed that one possible strategy for growth would be to focus on software for the domestic sector. This path had been followed by Brazil starting some time ago, where a relatively stronger domestic industrial position not unlike China's existed (Schware, 1992).

In economic terms, the rapid and fairly diverse industrial growth of China has led to a large surge in domestic demand. At the same time, the purchasing power of consumers and the ensuing consumerism has risen sharply. As a result of this domestic orientation, the industry has a broad range of coverage, whether it is evaluated across types of end use sectors, types of products and services, or levels of capability (advanced or relatively rudimentary).

6282 firms were officially recognized as software enterprises in 2002, which is 110% more than that of 2001. A survey of 4500 enterprises shows that those whose sales exceed 10 million yuan comprise one fourth of the industry, and only 19 enterprises have sales exceeding 1 billion (CSIA, 2003 -- From Chen). However, it was also asserted that in 2001, there were about 3000 software development companies and about 2000 companies involved in software sales (SIIA USITO, 2002). According to the CSIA (2003), China has 300,000 software professionals in the industry, of which about half may be at the technician level.[5]

Table 1. Number of firms by Software & SI Sales (in yuan)

	> 1 Billion	> 500 Million	> 100 Million
2001	11	16	100
2002	19	35	192
Increase	8	19	92

This provided a balanced view of the industry that covered both the positive and the negative (self evaluatory) views.

[5] Note that this is quite different from Gartner's report of 150,000 software professionals in 2001 and 50,000 graduating a year (Gartner, 2002).

Source: CSIA, 2003

According to one statistical source, China's software industry is already a fairly large proportion of the overall computer industry, but is still a very small proportion of the country's GDP, being about 0.67 percent in 2000.

Table 2. Output of software, computer industry and total GDP (100 million yuan)

	Output of software industry	Output of computer industry	Software as proportion of computer industry	Total GDP	Software as proportion of GDP
1999	440.5	1720.0	25.6%	82000	0.54%
2000	593.0	2150.0	27.6%	89000	0.67%
2001	796.0	2500.0	31.8%	93368	0.85%
2002	1100.0	2900.0	37.9%	98616	1.12%

Sources: CSIA; GDP figures: World Bank

The actual size of the software industry varies substantially depending on which statistics are used. For the aggregate statistics, we use the Chinese software industry association's figures, since they have a longer time series. However, these figures are far greater than consulting firms' such as IDC. For instance, CSIA's report of US 3 billion in software products for 2000 contradicts IDC's 1.28 billion, and its reported 4 billion in services for the same period varies greatly from IDC's 0.935 billion. The variances likely have to do with the different definitions of software enterprises and software activities used, as well as estimation problems. The fact that many of the largest CSIA firms report being mainly systems integrators suggest that there is a large systems integration component in the CSIA's numbers, which IDC may not be capturing.

For the sectoral breakdowns we do later, we use data from private and government consulting firms, which tend to maintain consistency of treatment across their sectoral analyses.

Major Software Activities

By characterizing the industry in terms of products, services and exports, we get a picture of how the industry is shifting its relative emphases.[6] The proportion that is products is steadily increasing, to the point where it has just exceeded the proportion of services. The proportion of output that is export-based has more than doubled to 11.27% by 2002, which is still low when compared to the 76% (based on exports of 7.65 billion out of 9.96 billion USD) for India in FY 2001-02[7].

Table 3. The Software industry breakdown by major sectors: sales in 100 million yuan

Year	Software products	Products as % of SW	Services	Services as % of SW	Exports	Exports as % of SW	Software Total
1999	182.0	41.22%	238.5	54.02%	21.0	4.76%	441.5
2000	238.0	40.13%	322.0	54.30%	33.0	5.56%	593.0
2001	330.0	41.46%	406.0	51.01%	60.0	7.54%	796.0
2002	507.4	46.13%	468.6	42.60%	124.0	11.27%	1100.0

[6] All three consulting firms have different bottom line output numbers. We show the official Chinese Software International Association numbers, which are the largest numbers. Classification and estimation issues may be at work, for instance, CSIA includes systems integration which is a very large proportion.

[7] http://www.nasscom.org/resourcecentre.asp

Source: CSIA, 2003

A further breakdown of the product category shows rapid growth in all three categories.[8]

Comment [SMU1]: We checked and found (by process of elimination) that support s/w consists of middleware, databases, and systems management This corroborates Chen and Cai.

Table 4. Growth in sales of types of products for selected years (100,000 yuan)

	1992	1996	1998	2000	2001	2002
System software	1.6	8.5	17.4	33.2	50.0	68.0
Supporting software	5.4	20.0	35.9	49.6	81.9	110.6
Application software	12.8	63.5	84.7	155	198.1	328.8
Total	19.8	92.0	138.0	238	330.0	507.4
Growth per year	330%	35%	23%	31%	38.7%	53.8%

Sources: CSIA, 2003 & CSIA, 2000

The rate of growth of total software product sales has been increasing over the last few years. Other estimates by consulting groups put recent growth at over 30 percent, so the most recent year shown in the table may be at odds with the other estimates. All this contrasts with the Indian software industry's higher compounded annual growth rate of 59% between 1998-1999. The lower Chinese figures may not be so surprising, given that China's software demand is coupled to its domestic demand, which is growing fast, but not as fast as the outsourcing market that India faced in the 1990s. Furthermore, a large part of China's industrial demand for products is probably focused for now on low value added or low cost products.

Location of Industry

Most of the industry is concentrated in the largest cities, particularly Beijing, which has a large proportion of the firms and output, followed by cities such as Shanghai, Shenzhen, Jinan, and Xian. Many of the cities are in the prosperous eastern part of the country, where much of the high tech industry reside and where the bulk of foreign investments are made, but increasingly, other industrial cities such as Xian in the West and Shenyang in the Northeast are known for strong software firms and industries.

Generally speaking, the presence of universities with strong IT programs, government support, and vibrant industrial or commercial activity are often present in these areas. In some cases such as Neusoft (also known as Tongfang) in Shenyang, or TOP in Chengdu, a single large firm dominates the city rather than a concentration of firms, but these large firms play such a significant factor in the region's software activity that just identifying large numbers of firms would not be the best indicator of strong software activity.

Classifying Domestic Software Firms

China's software firms can be loosely categorized into two groups. One type is the large firms doing systems integration (SI) work, which handle large custom projects for governments and industries, ranging from service industries such as banking to infrastructure industries such as telecommunications. Systems integration is necessary because many users are not that capable of absorbing software, and are at rudimentary stages of computerization.

[8] One of the difficulty in dealing with Chinese statistics is that different organizations use completely different ways of categorizing various types of products and services. One of the more important issues is the defining of what services and products mean in the industry statistics. In the CSIA category illustrated above, products consist of systems software, which includes operating systems and systems management software, while supporting software consists of middleware, database management software and software tools. The application software area is more straightforward, consisting of management software (such as financial, ERP, and so on), and consumer applications.

This means that software firms have to heavily customize their work to individual customers, as well as to provide a combination of hardware and software and services.

Many of the largest Chinese software firms are in this systems integration line of work. Of the 69 largest firms with over 10 billion yuan in sales in 2000 (CSIA, 2000), 32 were mainly doing systems integration, while another 19 were doing a mixture of systems integration and product work. Systems integration in the Chinese context typically refers to hardware sales and implementation costs, but increasingly, SI firms were moving into software development, services and solutions development. In 2000, the top 69 companies (in revenue terms) had about 46.03% of the market for products and service, while the top 20 companies had about 31.45% of the market.[9]

Many systems integrators do a wide range of services, including product development, solutions, and so on. For example, Tsinghua Tongfang develops and applies an array of core technologies in various areas, including information systems, computer systems, information security, broadband telecommunications, information processing, and artificial intelligence. The company has grown vertically, such that it can provide a "one stop" solution consisting of equipment, products and IT solutions. It has also developed horizontally, such that it covers the e-government, e-commerce, urban, and e-learning sectors. Surprisingly, but not unusually for the Chinese market, it has gone outside of the high tech industries, and also carries activities in the energy and environment industry, architectural engineering and urban environmental engineering.

The second type of firm focuses on product development. This part of the industry is made up of small and medium sized enterprises (SMEs). Some are growing reasonably well, while many, especially the small firms (the majority of the industry), are just only surviving. Many SMEs develop products, but most of these still have to use a combination of products and systems integration and/or services. This is not to say that there are no large or medium sized firms that are doing poorly, but just that there are so many smaller firms. Some of the smaller firms do not even do any software development, but may be doing distribution, hardware installation or some other types of work.

The structure of these domestic software firms does not bode too well for competing with larger and better endowed foreign multinationals. For instance, the smaller product firms will have several disadvantages ranging from product sophistication to financing. The larger systems integrators are stuck doing a different kind of work, and will find it harder to transition their capabilities, and the smaller, weaker firms are not in the same game.

Foreign Competition in China and the Major Software Vendors

Of the ten largest packaged software vendors in China, shown in the table below, the largest are the multinationals, and only two are Chinese – UFSoft and Kingdee. These two are the largest accounting vendors in China, but like many other financial/accounting software firms, they have moved into other types of management software, and especially the higher value end involving enterprise resource planning (ERP) software. Saxenian notes that both these benefit from the preferential purchasing policies of the government (Saxenian, 2003).

[9] These numbers are obtained by summing up the largest firms' revenue as reported in the CSIA list, then dividing by the total number of products and services given separately in the CSIA 2000 report.

Most foreign multinationals compete at the higher end of the packaged software sector, so these sectors are where they exhibit their greatest strength in China. Most of the largest vendors either carry financial or enterprise software (e.g. SAP), middleware and enterprise solutions (e.g. IBM), or packaged software for desktops (e.g. Microsoft). However, since the multinationals are still exploring the Chinese market, they have not created strong local operations dedicated to localizing and customizing their software.

Table 5. Largest Packaged Software Vendors By Revenue and Market Share

	mill US	**%**
IBM	77.99	6.08
Microsoft	65.07	5.07
Oracle	58.28	4.55
Sybase	30.93	2.41
Informix	26.33	2.05
Computer Associates	25.74	2.01
UF Soft	23.30	1.82
Novell	21.49	1.68
Lotus	17.53	1.37
Kingdee	16.25	1.27

Source: IDC, 2001a

The complexity of the Chinese market also makes it difficult for foreign multinationals to penetrate the entire market. These conditions include its being highly fragmented across provincial bodies, levels of government and society, and capability. Even more complicated human relationships unique to China make marketing complicated (Saxenian, 2003). In terms of capability, the lower end consists of users who are unable to absorb packaged software and sophisticated solutions – the very forte of the multinationals. Their unwillingness to move heavier amounts of software development activity to China limits their ability to customize software. As a result, they are limited to select sectors (discussed in section 3), including the mass market for packaged software, and high end software. They have also adopted various techniques, including partnering with local distributors and systems integrators to distribute their products.

2.2. Government Support of Research and Development

One important factor in the development of the Chinese software industry and its capabilities is that a significant part of the industry has its origins in a variety of state or state supported institutions. Specifically, as much as 30 percent of enterprises are government in ownership. (CSIA, 2000) When spinoffs from universities and research institutes (i.e. state supported origins) are counted, an even larger proportion may result. This appears to be true both of the large systems integrators as well as some of the small and medium sized product development firms. Some enterprises that originated with government research actually have better research capabilities, or make products based on earlier research. This in turn has given this part of the industry a step-up in their efforts to survive and grow, especially since the state continues to support these firms through procurement and other policy actions.

The General Role of the Government in Forming Technological Capabilities

The Chinese government has always played a major role in the formation of technological capabilities. The fact that a large fraction of the Chinese economy was actually comprised of government enterprises illustrates how much the economy resembles a developmental state. Through its long standing programs on high technology fostering and incubation, China set

the conditions for some of its more important hardware enterprises to take shape. However, the role of the government has been characterized as evolving away from a central planning/state-controlled role in the period of 1978-1985, where the goal was to guide the set of state human resources and scientific development institutions out of the morass of the cultural revolution period, to a more system wide (and not only state) reform of the entire innovation system during 1985 to 1991, and finally, to the in-depth market-oriented reforms of 1992 to the current (Li, Zeng and Zhang, 2003). Saxenian (2003) notes that the reforms from 1978-1992 were meant to address the problems of weak R&D, poor technical skills, inefficiency and too heavy a focus on defense and heavy technologies. This was done by seeking to acquire foreign technology by foreign investment and training, promoting university-based research, and high technology funding schemes. The market reforms starting in 1992 saw significant regional experimentation where government control was significantly loosened, foreign investment dramatically accelerated, and the opening of the technology sector to other (non-state) forms of ownership.

From 1988 to 1996, the number of state R&D institutions held fairly steady, going from an already significant total of 4933 to a total of 5101. In 1995, 352 of these were Chinese Academy of Sciences institutes – the most prestigious and well funded of the lot. Total state expenditures on science and technology went from 26.5 billion yuan in 1988 to 88.5 billion yuan in 1995, although this expenditure as a proportion of GDP actually went down from 1.88% to 1.52% in the same period. The government proportion of total domestic science and technology expenditures went from 45.74% down to 34.13%, reflecting the stronger role of the private sector, and the government's transition from a controlling to a guiding role.

However, these numbers actually mask the real R&D activity. Of the total number of R&D institutions in 1995, about 51 percent did not take part in R&D activities, and of the 320,000 staff in the 799 government-supported research institutions, only 82,000 were full-time R&D staff and 50,000 were actually employed on R&D tasks. Of these, the research institutes of the Chinese Academy of Sciences employed 58,000 staff and received 5.13 billion RMB of government support in 2000, and the National Engineering Research Centers, of which 100 out of a planned 200 had been established by 2000.

In aggregate, the government has helped to significantly increase the R&D resources of the economy. The total number of "science and technology personnel" increased from 2.29 million (including 1.32 million scientists and engineers) in 1991 to 2.91 million (including 1.60 million scientists and engineers) in 1999. Between 1995 and 2000, the gross expenditure on R&D went from 34.9 billion RMB to 89.6 billion, moving expenditure as a percent of GDP from 0.6% to 1.01% over the same period (U.S. Embassy, Beijing, 2002).

The pace of reform accelerated through the 1990s, and many state research institutes, including the Chinese of Academy of Science institutes, were pushed to obtain their "own" funding sources or start sinking. New market oriented policies like tax credits were instituted and the technology picking was abandoned. The CAS Institute of Software which performed fundamental software theoretical and applied research dropped its workforce from 500 to 125 between 1999 and 2001 (Saxenian, 2003). In fact, the total number of CAS institutes also shrank with mergers and job reductions. This series of policy decisions in part came about

from World Bank and other international organizations pushing the state to privatize and dismantle its research apparatus[10].

The number of CAS institutes has now dropped to 123, and further dramatic changes are in store, including a further downsizing of the numbers and a reorientation of the institutes to innovative and growth areas.[11] It has also been noted by others that much research continues to be duplicated in too many settings across the country, leading to a waste of funds. It is possible that fundamental research can be inefficiently, but presumably, applied research could be usefully duplicated since they can be more easily differentiated, and can lead to firm level competencies.

For the more fundamental technology and scientific fields, perhaps the most significant part of all this throughout the latter reforms periods was the government's funding of a broad array of basic research projects, started during the specific science and technology reforms of the 1980s. This was aimed at creating an impetus for developing more advanced, market-oriented technologies. These included the setting up in 1986 of the Ministry of Science and Technology's National High Technology R&D Program, commonly known as the "863" program, had funded 5200 projects and 230 topics by 2000 with a total of 10 billion RMB of government funds (a further 10 billion RMB came from enterprises and other sources). (Saxenian, 2003; U.S. Embassy, Beijing, 2002). More recently, the research and tenure system underwent fundamental overhaul. Older researchers have been retired, and tenure for many research faculty (except a portion of the staff) have been moved to renewable contracts. Many research institutes face simultaneous cutbacks and encouragement to seek funding from the private market and international sources.

Another major program that also had much to do with IT was the Torch Program, which was started in 1988 in order to develop high-tech industrial zones, market high-tech products, promote international cooperation with China's high-tech industries, and to train and attract talent (U.S. Embassy, Beijing, 2002). The Torch program had surpassed the 863 program by 1999, having supported 2742 projects with 29 billion RMB in funds. It was responsible for the construction of 19 software parks around the country, by way of requiring local authorities to submit their own policies for encouraging the growth of the local software industry before granting approval for the parks.

Some of the government research projects actually became the basis for Founder, Legend and other by now leading hardware companies to get their start. More recently, the government started a number of "Golden" projects to expand the country's e-commerce, infrastructure and various applications e-government areas (Lovelock et al, 1997). There are now 12 of these Golden projects, which are continuing on in different stages. These include the Golden Bridge - China's own information superhighway; Golden Card - a nationwide financial network to jump-start the use of electronic money; Golden Customs to let users calculate export taxes, settle foreign exchange accounts, and check export statistics; and Golden Tax – to computerize the tax-collection system.[12]

2.3. Origins of the Hardware Firms

[10] First author's meetings with Ministry of Science and Technology Officials (formerly a more powerful State Commission on Science and Technology), 1998.
[11] "China plans major shakeup of academy," *Nature*, 394(7), 1998.
[12] "Golden Projects bid to put nation on highway map," *South China Morning Post*, December 11, 1997.

The first Chinese IT firms were beneficiaries of these government technology policies, and managed to build their earliest competencies within the national system of innovative activities. Specifically, the first movers of the hardware industry relied on government R&D spending, training and fostering, and eventually turned these to their advantage with the increasing market orientation of the economy in the 1980s.

The earliest and most well-known IT companies have their origins in a variety of sources, with the more technology intensive ones coming from the various government research institutes, universities, and "green field" startups. In the case of the hardware sector, four prototypical case studies of firms and their sources of formation were identified by Lu (2000): (a) Founder, a private enterprise which commercialized university-researched technologies, (b) Legend, a spinoff from the government-funded research institutes in the Chinese Academy of Sciences, (c) Great Wall, a spinoff from a state run firm, and (d) the Stone Group, a green-field startup.

The enterprises all derived advantages in some fashion from government supported research. Founder, which got its start developing electronic publishing systems, relied partly on research from the government funded project 748 at Beijing university, which was created by the State Planning Commission to deal with a perceived critical need in 1974 for a Chinese language information processing system based on Chinese character fonts. This took place in the post Cultural Revolution era, when during Nixon's visit and China's subsequent opening to the world, the Chinese leadership perceived a deepening disparity between the rapidly advancing computing technology of the West, and that of China's. Founder has now become dominant in the electronic publishing business and in PC manufacturing.

Similarly, Legend, which started making PC language cards and is now a full-fledged PC manufacturer, was initially established as a "reaction by a state research institute to the changes in the state's science and technology policy" (Lu, 2000). Thus, all first 11 founders were from the Chinese Academy of Sciences' (CAS) Institute for Computing Technology (ICT). Gradually, Legend built its own network of exterior partners and relationships, and to eventually become as private as any company.

Other similar stories of the first companies can be found in Great Wall, a PC manufacturer, and the greenfield startup Stone. Stone was initially started by Tsinghua university graduates, but its first word processing products developed by the computer scientists from the CAS' ICT and state-owned enterprises.

In all the models by which firms arose, the government has had a profound influence through its provision of intellectual capital, training, research funding and capability, and incentives. The Chinese government also directly contributed to the hardware (broader IT) industry by its direct involvement in state run computer companies. Some like Great Wall were eventually privatized as successful PC makers. Perhaps even more interesting is that a number of the early hardware firms have also moved into software, at first as offshoots of their earlier software competencies or systems integration activities (integrating hardware and software). In the case of Legend, a new entity - Digital China – has been newly spun off as a software group.

These stories serve as examples of the general manner in which China has been developing its industrial system. The story is no different for software as it has been for hardware, notwithstanding the fact that many of these early hardware companies also became involved

in software development. It is worth noting that the fact that so many firms came out of the state's research resources is hardly surprising, given the fact that the state was responsible for funding most of the stronger scientific activity at one time, and that most of the best people were working in state funded organizations.

2.4. The Origins of Software Firms

The Chinese government also had an early influence on the software industries through the same means as it did for hardware. The sponsoring of the Torch and 863 national research efforts on "core technologies" deemed essential to the nation's computer industry directly led to some software technologies that were embedded in products. Much of the government's sponsorship of research comes through its support of research and development, especially in the national research institutes of the Chinese Academy of Sciences (CAS), a number of which also participated in the development of these core software and hardware technologies. The CAS institutes for computing, software, and natural resources that we interviewed have had spin-offs, some of which are fairly successful.

Another government tool commonly used in China is government procurement, especially at regional and municipal governments, to enable local firms to bid for and supply information technology, including both hardware and software. This has been instrumental in many cities like Shanghai and regions like Shandong. Many of the larger systems integrators like Wenda in Shanghai and Top in Chengdu have benefited directly from these policies.

Recently, the government has put in place a number of high level directives targeting the software industry. The most prominent has been the State Council's document Number 18, called the "Notice of Certain Policies to Promote the Software and Integrated Circuit Industry Development" (SIIA USITO 2002).[13] By putting these two industries in the limelight, the state council was effectively recognizing that these two industries were so key to other industries' development in China that they should receive preferential treatment.[14]

To accomplish its objectives, during the 10th Five Year plan, the central government of China will invest more than 4 billion yuan, of which 1 billion yuan will be used to support the development of software industry; and the remaining 3 billion yuan will be applied through the electronic information industry development fund, the "863" fund on special items, national outlays on science and technology to tackle "key problems" etc., though not especially for software development.

Because of the important role the government's sponsorship of research played in the formation of the IT industry, both in hardware and in software, it is worth examining the specific government or government-supported origins of the software firms. Of the 30 odd firms we interviewed, three came out of the Chinese Academy of Sciences, and another seven came out of the universities, making the proportion of our sample with state and university

[13] Cited in Saxenian (2003).
[14] The prominent policies in this document were for a reduction in the value added tax (VAT) for R&D and expanded production; for preferred enterprises, enterprise income tax elimination for two years and reduction by 50% for another three years; fast track approval for software companies desiring to use overseas stock markets for capitalization; exemption of software companies' equipment exports from tariffs and the VAT; and reductions in export hurdles for selected companies (SIIA-USITO, 2002).

origins to be about 30 percent.[15] The proportion of many parts of the industry, such as the largest firms, may actually be more than that. This is an artifact of the fact that most of the technical talent was in the state enterprise sector for many years. As such, even as privatization ensures, the large state sector will tend to skew the origins picture.

CAS Spin-offs

It would stand to reason that by virtue of their researchers' abilities, the software firms that are started out of the research institutes such as the Chinese Academy of Sciences or universities would tend to have a stronger basis in research than commercially started firms. This is borne out by the observation that most of these firms have gotten more involved in high end software sectors and products, such as security software and operating systems. Examples of such firms from our sample includes firms that appeared to match the model of hardware firms (represented by Legend) spun off from the CAS institutes. Three software firms were first gestated in then, directly spun out of CAS institutes (Red Flag, CASS and Supermap), while at least two more – Anyware and Beijing Listen – relied on CAS talent in an important way. All also had to rely on government or private capital to help them start up.

The fact that the two companies that produced operating systems – CASS and Red Flag – had CAS backgrounds indicated the importance of scientific knowledge to the production of operating systems (OSs). This also indicates the importance that the government placed on the development of key technologies. CASS' original staff consisted partly of a hundred staff trained in Beijing University as well as American universities. It now has five subsidiary companies making everything from operating systems to enterprise resource planning and e-commerce software. CASS has benefited from national R&D programs such as the 863 and the Torch programs. In 1999, CASS designed its own Hopen embedded operating system, and has leveraged this to great effect within the electronics manufacturing sector.

Comment [SMU2]: http://www.cass.ac.cn/En-company.htm

Like CASS, the Chinese Linux company Red Flag has CAS origins. Red Flag is small, with about 100 people. Their experience with Unix (the foundation for Linux) goes all the way back to 1979, when CAS Professor Zhong XiChang started his research on Unix. In 1999, Red Flag started to research on Linux, an open source software substitute for Microsoft's Windows and other proprietary systems, and in 2000, the company started.[16] They started with venture capital from Hong Kong and Chinese venture companies, and have used product positioning, business models, and upper management with multinational experience to help them.

University Spinoffs

Like the hardware industry, many of the more recent software arrivals have come straight out of universities. In our sample of about 30 firms, at least seven firms arose directly from universities, either from students (two firms) or faculty (five firms). The firms spunoff by universities (i.e. started by university students or faculty) were Grand Horizon, SLJ, TongRan (or Neusoft), ASTI, and Calkai, Kingstar and Human Technology. In addition, three more firms were further separated from other companies that were formerly university-affiliated,

[15] While this sample was not collected as a representative sample of the total population of firms, for the most part, it was chosen to reflect the better known or growing software firms.

[16] Open source software is a type of software that is independent of any individual maker, so anyone can make it, contribute to it, and use it for free. However, more specific implementations of the software that rest on top of the base software and add more functionality or usability may be made privately and priced on the market, as with Red Flag's product. These will still derive the benefits of the "open" (worldwide) developer community, and have the future opportunity to work interoperably with many platforms.

namely, Digital China (from Legend), But One, and Tsinghua DASCOM, and some firms were setup by recent university PhDs who decided to become entrepreneurs.

As with the CAS spinoffs, we might expect that the spinoffs from universities are typically dealing in stronger technology sectors than the average commercial firm. For instance, Fudan Grand Horizon was established in 1988 by a group of professors from Fudan university - one of the country's leading universities, located in Shanghai. The lead management of the firm as well as faculty and students of the university continue to have joint appointments with the university and other close ties. However, like many companies its size, the company has also diversified into multiple product lines wherever it saw growth and opportunity: network security, education and distance learning, broadband and streaming media, and touch screen technology.

On the other hand, not all university-started firms had to have cutting edge research in their initial products. The opportunity to be first movers at some reasonable level of technology can sometimes be even more important. Kingstar, also initially started from Fudan university, consisted of a group of postgraduate students who took their project ideas from the university into the business arena. When they initially entered the market for stock exchange software, they found many competitors at a low level of technology. They decided to do a system architecture plan for their product's evolution. Their first customer was a local stock exchange, which offered to help them if they could successfully develop a system. This became the first basis for their company, and is now the sector they derive the most income from.

The fact that a sample of the better performing SME firms we interviewed came from university and CAS spinoffs tends to suggest that these are indeed an important contributor to capability building. However, this raises the question of how representative this is of the industry as a whole. Another examination we made of the top 20 software firms showed that of 11 that we found data on, four were state owned or had backgrounds in state research institutes, another four had university origins, and three were private. Together with our sample, this indicates that the government and public institutions have a significant role in fostering software firms.

Other Software Firms: Systems Integrators

As noted earlier, the large systems integrators form another visible category of software firm. SI is still one of the main activities within the software industry.[17] SI firms also started from a variety of sources, and as noted earlier, many of the largest SIs in fact also came from universities and government roots. Finally, other sources of software firms exist, including private entrepreneurs from other sectors who decide to fund software firms. Some firms in our sample have come from private entrepreneurs putting up the seed capital to start a company. (Refer to the Appendix for the list of top 20 domestic firms that we examined.)

[17] Systems integration came about because of the increasing use of computers in Chinese business and society. A large number of firms were required in order to do the configuration and installation of hardware and software in different custom arrangements for customers, i.e., the systems integration. This was shown in the customer maturity model as an early stage of customer development. This was needed in part due to the lack of sophistication of customers, and was not unlike the early stages of US software applications development, where firms had to build customized applications for small customers.

Chinese Software Firms' Origins: A Major Influence on Technological Capability

In our analysis, without the involvement of the universities and research institutes in forming new enterprises, the Chinese software industry would likely not have the level of technological capability that it has, particularly with regards to its product development capability. In the case of India, many of the software development skills were built up over time through the servicing of multinational clients, or through long term repeated exposure to foreign clients. In China, without having the same foundation for training new skills, the industry would have had a hard time advancing in capability. The government's support has had some effect on the domestic production of product development skills. Furthermore, with its research-derived capabilities, China's software firms can at least compete in its own domestic market, sometimes effectively against foreign multinationals. Whether this is a sufficient level of capability is not clear. By the same token, many of the firms such as the systems integrators did not have the benefit of research ties, and have not moved beyond systems integration, for a variety of reasons.

Inefficiencies of State Intervention

It is worth noting that not all government policies necessarily have favorable outcomes. For instance, the Torch program has led to the development of 19 software parks around the country, through the central government permitting local governments once they have a good policy framework in place.[18] Unfortunately, a number of the newer software parks (many of which are privately invested) appear to be more interested in the real-estate development aspects, or have over-invested in real estate and building infrastructure, sometimes in regions without any clear edge in software capabilities. At least one of the largest software firms – Top – is particularly known for focusing on the real estate aspects of software parks around the country, partly as a means of developing infrastructure for those regions, and may now be suffering from this overinvestment.

Many provincial and municipal government systems integration contracts also favor local firms, which appears to cause some of these firms to be dependent on continuing to obtain these large contracts. As we showed earlier, a number of large firms are still primarily systems integrators. For instance, according to sources, Wenda, an institute originally stocked with CAS trained people in Shanghai is still largely continuing its systems integration focus aided by large government contracts. This situation of having firms that have comfortable relations with government or other larger customers for "easy project work" can cause firms to be less than competitive in evolving markets.

Finally, some government programs that sought to educate talent have seemingly failed. Most of a group of a hundred top engineers trained in Beijing under a special software talent program left the country for the US, while another group in Shanghai left mostly for Singapore and other regions. In recent years however, the brain drain has reversed itself, with numerous entrepreneurs and trained IT professionals returning to China. One interviewee gave up a comfortable New York based position as an IT head in the United Nations to return to help manage the Fudan Grand Horizon company. It was, to paraphrase his words, a once in a lifetime opportunity for his career. On the other hand, at the heights of the dotcom boom, another returnee with a Ph.D. from Carnegie Mellon University and Silicon Valley experience found it extremely difficult to start an IT company, even with government contacts and his cutting edge knowledge, and eventually gave up. The potential for a "Taiwan

[18] Interview with Ministry of Science and Technology Torch program official.

style" industrial bloom combining overseas and domestic talent, technology and finance is there, but not everyone will benefit.

Thus, the government's involvement in the software industry's development has been a mixed blessing. Many successful software firms have started without government support, but others particularly in the strategically targeted areas have been given a fair amount of support. It appears that for the government-started and supported firms, the situation may have worked to firms' advantage in selected product markets. At least for now, government procurement in some product markets may not have been so overwhelming so as to make firms wholly dependent on it. Ultimately, it has provided some support to ensure that firms have the opportunity to face the broader competitive market, and a possible signaling mechanism to help the market identify some of the stronger firms.

3. The Domestic Market and the Growth of Software Technologies and Sectors

The main factors supporting the growth of the domestic software industry thus far has been a mixture of government support and the domestic market. The domestic market results from the Chinese economy's spectacular growth over the last decades. Since 1978, the Chinese economy has reportedly grown an average of 9.5%, and can be projected to be one of the world's main growth engines for the foreseeable future (Wong and Chan, 2003).[19] The economy itself has undergone major structural changes, going from a largely agrarian structure to a largely manufacturing structure, with increasing services sectors. Although China's exports are considered by many countries to be a competitive threat, in 2001, nearly 80% of its demand was still internally generated, presenting opportunities for domestic and foreign firms alike. Nevertheless, the share of exports in total demand is continually rising. Although China's exports of $266 billion in 2001 ranked it as sixth largest in the world in absolute terms, up to 50% of its exports were made by foreign enterprises, and up to half of its exports relied on imported intermediate products.

With its advancing economy, China's domestic need for information technology (IT) has concurrently increased and provided opportunities for domestic IT firms to grow fairly large. In general, the economy has also been undergoing a transition of capabilities, from a more labor intensive one to one that is based on productivity enhancements, not the least being enhancements based on IT. At the same time, IT user organizations are undergoing a gradual qualitative shift from users of basic systems to more sophisticated systems.

An Overview of the Main Software Customers

The software spending in China can be roughly characterized in terms of several trends. A positive force for software comes from the economy's continued expansion and technological advance across a range of areas. First, the sustained boom in the economy since the 1980s has led to increased business and government spending on infrastructure, including IT infrastructure ranging from computers to software. Second, the rise in household incomes has led to an increase in household spending on computers and other durable goods, which in turn has fueled a need for software applications. Third, the industrial production of products requiring software as intermediate inputs has been increasing along with the economy and its exports.

[19] Although GDP figures continue to be a source of dispute between some Western scholars and other scholars – both Chinese and Western.

As a result of all these trends, a variety of software has been needed. The main mode of using software also varies. The government and many large enterprises need customized software – the government because of its large scale, and the large enterprises because they are still not versed in software requirements. In the government and business sector, there are huge increases in demand for software. Procurement by government was about 14.2% of the overall software market in 2002 (CCID, 2002f), and was 19% in 2000 (IDC, 2001c). A considerable amount of this is for systems integration work, although the use of packaged software is increasing.

Comment [am3]: 19% is IT, not software

One of the big demands for IT in China comes from the small and medium sized enterprises. According to the CSIA (2000), there are about 20 million small to medium sized enterprises in China, which provides a substantial business user base.[20] This base is expected to increase the domestic (packaged) software market from US $10 billion to $100 billion in 5 to 8 years (CSIA, 2000). The areas covered by this application area range from the simpler tasks of office automation (e.g. basic payroll and accounting) to more advanced activities such as enterprise resource planning, middleware and security software. However, in 2001, about 50% of SMEs still had not computerized in any form at all, and only 4% had adopted IT applications (CCID, 2002a).

The large and more mature corporations have a higher need for software products than others which have less IT capability, most companies, especially the SMEs, require a mixture of products and services. This includes pure systems integration, which includes hardware, software, and systems integration service. In systems integration, a large component is in hardware, so many firms that do systems integration will also try to supply the hardware, and even smaller software product firms will try to combine their products with systems integration– something that both larger and smaller unsophisticated customers may need.

The home sector mainly requires packaged products for their personal computers, as do all the other sectors. The proportion of the population with personal computers is ever increasing. Installed personal computers in both households and businesses reached nearly 21.7 million in 2001, up 35% from the previous year (Gartner, 2002). Of the desktop PC sales in 2001, 39.6 percent were sold to consumers (CCID 2002d). The proportion of mobile telephone users has rapidly increased, reaching 145 million telephone users in 2000, of which 85.2 million were mobile users (Tan and Wu, 2002, citing various sources)[21]. This PC market was so large that it could comfortably sustain the expansion of a number of domestic manufacturers, with six of the largest vendors being Legend (9.1% of the PC market revenue, based on revenue of 271 million US for 235,535 shipments), Tonru (4.9%), Founder (2.9%), Great Wall (2.2%), and Langchao (1.2%) (Stone was also amongst the largest, but not tracked for this period) (Gartner, 1998). The low costs of Chinese PCs have caused US, Japanese and even Taiwanese to either lose market share or be forced into local joint venture operations.

Finally, with the increasing intelligence of electronic and other products, more and more manufacturers are requiring software, albeit in the form of embedded software. Some companies see this trend, and some are opening up embedded software houses just to service this trend. The Jinan firm CVIC for instance had plans to double their work force with the

[20] Gartner estimates about 8.6 million SMEs, defined as companies with anywhere from 1 to 500 employees (Gartner, 2001).
[21] This is based on shipments of 7.4 million units in 2001 for China, vs. about 1.8 million for India. Nevertheless, India's PC shipments grew three times faster than China's in the same period (Gartner, 2002).

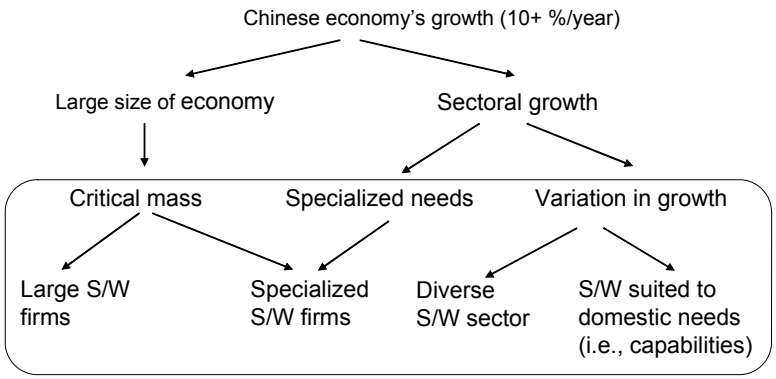
opening of an embedded software arm in Shanghai to service the large integrated circuit manufacturing enterprises there.

Advantages of the Chinese Economy

The overall growth of the Chinese economy can provide advantages to the development of the software industry in a few different ways.

1. The first is that the large size of the economy can provide opportunities for software firms to grow large in number as well as in individual size.
2. The second is the widespread growth across sectors, which allows software firms to enter into a variety of sectors. With the growth of individual sectors, software firms also have the opportunity to specialize in types of software applications specific to those sectors.
3. A third way can be expected as a result of a local domestic software industry working with other domestic industries and businesses is software that is more customized to local needs than perhaps foreign software products. This is one of the advantages stated quite frequently by local consulting firms (CCID, 2001). This depends on the degree of local knowledge needed and degree of uniqueness that Chinese business practices have.

The evidence we have collected also suggests that these major forces are at work in the Chinese software industry. We are seeing firms of significant size emerging, as well as firms emerging in a diversity of sectors. Although most of the larger firms are SIs, this is an artifact of the large customers' needs for IT. The entry of too many firms has also made the market highly competitive, which causes firms to try to diversify themselves. Other reports note that the software enterprises that focus on specific segments are improving, as well as a shift towards higher value added products (CCID 2002g). However, this is mitigated by many firms seeking to spread their work out across many industries. While this diversification may help them in general, some problems may also occur. For instance, their less profitable divisions could weigh down their profitable ones.



3.1. Software Sectors

Increasingly, Chinese software companies are getting more sophisticated by specializing in certain sectors, and by focusing on high value added products that are linked to services in order to sell them to clients. Domestic brands are considered good in fields such as financial

management, securities, information security software, Chinese document processing, e-government, and education. Furthermore, good progress was made in other areas such as communications, management software, office software, system software, middleware and platform software, as well as other applications (CSIA, 2003).

Lead sectors chosen by the government or touted as potential lead sectors by consulting firms include the information security sector, and software for manufactured products (including embedded software) (CCID, 2001). Furthermore, state designated key technologies such as operating systems, and more recently, middleware, will likely enjoy significant support.

We can also identify the important or leading software sectors in China by examining the relative size of the various sectors. The main software using sectors are shown by industry in the table below.

Table 6. IT Market By Industry Verticals (US$ M)

Industry	2000				Growth rate in % 1999-2000			
	HW	SW	SVC	Total	HW	SW	SVC	Total
Banking	84.5%	7.6%	8.0%	1515.4	24.8	21.6	38.0	25.5
Communications & Media	85.3%	7.2%	7.5%	1922.9	36.6	31.0	48.5	37.0
Construction	86.5%	6.7%	6.8%	52.8	-5.6	9.7	20.7	-3.3
Discrete Mfg	86.6%	6.5%	6.8%	817.5	32.4	22.0	38.5	32.0
Financial Markets	84.5%	7.6%	8.0%	759.0	24.8	21.5	37.8	25.5
Health Care	85.2%	7.2%	7.6%	121.0	132.1	130.3	162.2	133.9
Insurance	85.2%	7.2%	7.6%	149.7	221.1	256.0	305.4	228.5
Process Mfg	87.1%	6.3%	6.6%	39.5	33.8	22.2	40.0	33.5
Resource Industries	85.2%	7.2%	7.6%	143.3	98.0	102.9	131.9	100.6
Retail	85.6%	7.0%	7.4%	56.4	104.9	70.2	95.3	101.3
Services	84.9%	7.4%	7.8%	67.6	5.0	8.2	24.4	6.5
Transportation & Transportation Services	85.8%	7.0%	7.3%	425.6	27.1	17.2	32.8	26.7
Utilities	86.8%	6.4%	6.8%	190.8	49.9	43.8	63.0	50.3
Wholesale	86.2%	6.7%	7.1%	58.0	190.4	169.0	205.1	189.6
Education	87.8%	6.0%	6.3%	651.3	63.5	59.0	80.4	64.2
Government	87.7%	6.0%	6.3%	2276.2	37.2	29.5	46.8	37.2
Consumer	94.5%	5.5%	-	1753.6	72.2	67.2	-	71.9
Total	87.6%	6.6%	5.8%	11000.6	-	-	-	46.6

Source: IDC, 2001c

From the table, it appears that the banking/finance and communications (including telecommunications), followed by the government, consumer, and manufacturing sectors are amongst the largest sectors by far in terms of annual revenue. According to the CCID (2002e), by 2002, the preliminary stages of construction of IT infrastructure in telecoms and banking had been completed, thus slowing the growth in those sectors. The business restructuring that had taken place in areas like telecommunications, energy and civil aviation had to some extent reduced software purchases, but this was being supplanted by strong growth in the government, education and traditional manufacturing areas.

Note that the table does not help us take into view the strong growth in particular products and technologies which may cut across multiple sectors in the table. For instance, the security

products and operating systems are vital areas which the government is emphasizing. We will examine these technology areas in the next sections.

Banking and Finance

Finance was one of the sectors leading in its demand for specific "service industry applications", and increasingly, products like middleware and sector specific applications, e.g. back office automation. Banks will need a variety of software to effectively restructure their operations, including back office software like ERMs, as well as network development, CRM, and data warehousing. As with other commercial enterprises, such as the small and medium sized enterprises, the Chinese banking system has particular processes. They also have legacy systems that, what with the cumbersome bureaucracies and many branches, are difficult to change over time (CCID, 2002h). These may give Chinese software firms doing industry specific applications a local edge over multinational vendors. This is illustrated by the fact that 60% of the software in accounting, an area known for its highly local practices, is made by two domestic firms – UFSoft and Kingdee (IDC, 2001). However, this situation may not stay the same forever, since as Chinese firms adopt international standards of performance and processes, the Chinese software firms will have to meet those standards too.

Telecoms

As with other infrastructure sectors such as transportation and power, China's telecoms infrastructure continues to be built out and renewed, pushed along by reforms driven by the national government and policies in anticipation of the WTO. In terms of growth, the telecommunications industry is one of the more important sectors, and projections show that telecoms will eventually surpass and continue to outgrow finance as one of the largest sectors. In this regard, IT will become increasingly important in the sector. The hardware component of the telecom IT growth appears to be slowing down, and is being replaced by software applications such as billing and customer service systems, and network management (CCID, 2002b). Due to restructuring, partly forced by the government's privatization of the sector and by China's entry into the WTO, new industry structures will be shaped, and network management, billing and customer service systems, and other services will be needed. The opening of the market will also support new virtual telecoms operators, who will also need additional equipment and systems to ride on the existing communication backbones.

The telecoms area in China still has some way to go. The lack of standardized processes in the telecom firms means that many firms still cannot "absorb" packaged software to the extent that US telecoms firms can, and as a result, software firms have to do more systems integration for these telecom companies (Interview with Cheelosoft). Firms that we interviewed which specialized in the telecoms sector include But One, which focused on ERPs for the telecoms area, and Digital China and Cheelosoft, which attempted to specialize in systems integration for telecoms network and back office management. Size and specialization appears to be of primary importance in the telecoms sector, as witnessed by the specialization of these firms.

Other infrastructure sectors will see similar growth. For instance, the transportation industry will see growth in demand for IT applications, requiring hardware as well as various kinds of software ranging from middleware to network security and CRM products.

Government

The government portion of the overall IT market is substantial, ranging going from nearly 18% in 2000 (IDC, 2001b) to 14.2% in 2002 (CCID, 2002f). Growth is fairly strong, led by the government's strategic IT policies. The government has led with its promotion of and internal demand for software ranging from generic software such as office automation and operating systems, to specific applications and systems, e.g. social security systems software and e-government software. Security in both commercial and governmental transactions is also a major consideration of the government, and so the Chinese government has promulgated various laws pertaining to information security. Information services will continue to have an even greater role. In July 2002, the State Council's No. 17 document created a large e-government push by building two unified e-government network platforms, and the use of 12 business systems across agencies, in addition to ensuring the development of basic information resources and the accessibility of government departments to data resources (CCID, 2002f).

Consumer

As noted earlier, the operating systems and applications software categories are strong drivers in the consumer market. The multinationals appear to dominate some areas of the market, particularly Windows-based systems. Some local companies find an advantage in application areas that require more intimate knowledge of the Chinese language or cultural domain. Companies that we interviewed which produced for the consumer market included Kingsoft, one of the companies attempting to compete with Microsoft and other Western companies, and home educational software companies such as Human Technology. Kingsoft appears to have some advantage in areas like translation software, while Human Technology has some natural advantage in cultural content because the various educational products they produce are largely differentiated from anything a multinational can produce.

Manufacturing

Manufacturing consists of a broad array of companies. Already, PC manufacturers as Legend that have captured most of the domestic market are planning to expand overseas.[22] One of the chances for China's software firms to further develop is by linking up with the already strong manufacturing sector (this is discussed later in more detail).

3.2. Major Trends

In addition to the sectoral emphases shown above, from our study of the industry and the multiple secondary sources, four key factors can be discerned to be at work in the domestic industry market, some of which directly support domestic firms, and some of which do not.

1. The first is that the government is centrally concerned with the state of the domestic industry, and is doing a substantial amount to support what it views as the major software technologies and products. In some of these product areas or sectors, some domestic firms are holding their own amidst competition from the multinationals, sometimes barely so.

2. The second factor is that the already strong manufacturing sector may be able to provide substantial opportunities for software product firms. Again, some of these firms are also benefiting from government policies.

[22] "The Legend of Legend", p.34, Fortune Sept 23, 2002; "Haier Reaches Higher", p.42, Fortune Sept 23, 2002.

3. The third factor is that the Chinese business market have highly localized business practices which multinationals may be unable or unwilling to cater to, and this may actually provide the domestic industry with a window of opportunity to get into the market.

4. The fourth factor is that many Chinese enterprises, especially infrastructure and business enterprises, need custom software, and systems integration work is often needed to meet their needs. This has led to the rise of systems integrators.

We will explore each of these in turn.

3.3. Government Support for Technology and Products

Because the overall economy is growing across the board in many sectors, the Chinese software industry also involves a great variety of sectoral applications. The sectors that are most talked about include the ones which the government is most focused on, and as such, are the ones we focus on. Since it is very hard to understand the priority placed on these sectors without appreciating the government's role and priorities, we will first examine the foundation the government is laying.

Government Policy

Earlier, we noted how the government's support of research played a formative role in the industry, ultimately culminating in numerous spinoffs. In recent years, the government has been using procurement policies strategically to further support various firms deemed to be doing software in the national interest, including Red Flag's Linux, CASS's Hopen, and Beijing University's Jade Bird and its database management program (intended to rival Oracle's). At the end of 2002, the state drafted a document detailing state procurement, which went so far as to specify the number of procurements to be made. The intention is to get the departmental absorption of domestic software to go from one third to 100 percent. The government is well aware that WTO regulations will not let them protect companies after 2010, and so they are using every means to protect their software industry till then.[23]

Ultimately, the government is strategically targeting areas such as Linux, security, middleware, electronic government systems, and even Internet videogames for such support. In addition, it maintains a list of key software enterprises, which can enjoy preferential tax treatments. The list had 106 enterprises at the end of 2002. (CSIA 2003, p.91).

Identification of the Leading Products

By looking across various types of software, we can further appreciate why certain sectors or product types are lead ones in the eyes of the authorities. The table below focuses on selected types of software used largely by business users.

[23] Other policies have also been developed, including at the Beijing city level, the setting up of an export promotion league to get lead firms to try to help smaller firms move into software exports.

Table 7. Types of Software and Growth Rates in 2000

Horizontals	2000	1999-2000
	mill US	%
Total Packaged Software	**1282.28**	**40.6**
Applications Solutions	**561.4**	
Consumer Applications	72.9	41.7
Collaborative Applications	16.9	40.0
Authoring Applications (incl. word-processing)	29.5	38.5
Speech and Natural Language	21.1	37.0
Enterprise Resources Management (incl. accounting, ERP)	180	31.9
Services Industry Applications (across multiple service sectors)	147.1	47.0
Product Supply Chain Spec Applications	88	47.2
CRM	5.9	110.9
Applications Development and Deployment	**260.5**	
Information and Data Management S/w (incl. relational databases)	174.2	28.3
Application Design and Construction	23	27.0
App. Life Cycle Management	1.4	39.8
App. Server S/w Platforms	9.9	45.6
Info Access and Delivery (incl. spreadsheets)	53.5	38.9
System infrastructure software	**460.3**	
Systems Management Software	15.4	36.1
Network Management	30.7	40.8
Security Software	60.7	52.2
Middleware	20.9	92.1
Storage Software	33.3	39.7
Serverware	11.1	59.1
System Level Software	288.2	45.0

Source: IDC 2001a

Some of the software types such as operating systems, and personal computer applications like word processing, translation software and spreadsheets, are used in both the home and offices. Other types like enterprise software management are only used in business and industrial settings.

While the demand for systems software like operating systems is slowing, as enterprises focus less on base infrastructure and more on getting services out of their IT systems, the demand for other kinds of systems software like middleware as well as applications is picking up (CCID, 2002e).

Systems Software

Systems software has long been a government priority. The goal national has been to insulate the country from potential security problems inherent with using commercial (US) software, as well as to gain a share of the very large market and to ensure that China has its own "technology base" to work off of. In the systems software category, operating systems are by far the largest subcategory, with security software coming in second. As noted earlier however, the demand for middleware is rapidly increasing.

Operating Systems

Operating systems are used by all three major users - consumer, governmental and business-industrial. The majority of the revenue belongs to Microsoft Windows, IBM operating

systems, and Sun's Solaris operating system (IDC, 2001a). Chinese firms like Red Flag Linux are attempting to break into the market, and in fact, they have benefited from the government's desire to see a Chinese operating system, and the government's drives for preferential procurement. Red Flag Software Co., Ltd. (Red Flag Software) was co-funded by the Chinese Academy of Sciences' Software Research Institute and Shanghai New Margin Venture Capital in June 2000. Additional venture capital came from CCID Capital (a government supported firm which provides venture capital and information services. Their technology was based on two decades worth of research on open systems conducted by the Chinese Academy of Sciences, as well as ten years experience of Chinese language system development.[24]

Red Flag's business covers national and local government, finance, energy, education, transportation, post, telecom, media, lottery, as well as a number of government branches and industries. Red Flag is especially closely tied to government procurement. The government supports Red Flag for both political-economic reasons, namely that it views operating systems as one of the critical computing technologies that cannot be left in the hands of Microsoft (or any other foreign vendor for that matter), and that it should find some way to keep part of its own market.[25] As a result, Red Flag has secured some important government projects from the State Development Planning Commission, the Ministry of Information Industry, the Ministry of Science and Technology, the Beijing Science and Technology Commission, and the Beijing Economic and Trade Commission.

Red Flag's Linux operating system is based on open source software (i.e. a worldwide community developed) code, making it cheaper by the copy than Microsoft's Windows. Linux is an unusual platform in that it provides the company with unparalleled access to resources, namely the worldwide Linux community, which is willing to help test and refine pieces of code for the generic Linux base, while the company can focus its efforts on an effective implementation of Linux.

Red Flag's products are fitted to desktops, servers, high performance computing and embedded systems. Some Chinese PC original equipment manufacturers (OEMs) have actually installed Red Flag Linux in lieu of Windows. Red Flag delivered over 1.15 million sets of desktop software to PC original equipment manufacturers in 2001, and sold another 100 thousand sets by retail. Red Flag CEO Liu Bo[26] claims that their product's OEM price was only 2 to 4 percent of the cost of Microsoft's.[27] While they cannot make much money if at all from open source code, their strategy is to customize the systems for a variety of clients.[28] The Chinese government has been encouraging the adoption of Linux in its various agencies, but the amounts purchased thus far have not been large, and ongoing regulations may actually put more teeth into the purchasing policies. In fact, the government now plans to support more Linux efforts in universities, companies and research institutes.

As another Red Flag executive we interviewed noted, they are partly relying on the army of open source developers worldwide for both coding and testing, which gives them essentially a huge free resource of developers, obviating the need for a large development staff as

[24] Based on website information.
[25] Liu Bo, CEO, Red Flag. Presentation to IandI Asia, Jan 11, 2001.
[26] Liu Bo was actually the deputy general manager of Microsoft China and also involved with another US Linux concern before he joined Red Flag.
[27] http://news.com.com/2100-1001-932927.html
[28] Liu Bo, ibid.

Microsoft has for its Windows. However, one general problem with open source software is that there are far less applications available than for Windows. For now, these local software makers are relying on other vendors, like Sun Microsystems and its free office productivity applications suite, Open Office (a version of its commercial Star Office). Partly to address that deficiency as well as to expand the compatibility of their product, Red Flag Software has formed strategic alliances with foreign firms as IBM, Intel, HP, Oracle, BEA, as well as domestic firms as Founder, Langchao, Dawning, Tongfang and TCL.

While independent verification of end user satisfaction of Hopen's and Red Flag's products was not available, both are heavily pushed by the government. Red Flag Linux has won an award by Computer World in 2000, and Hopen has won several national awards. It is entirely possible that they both represent further examples of the mode of China's industry leapfrogging over the slow technological upgrading process, first identified by Lu in the case of hardware (Liu, 2000).

Nevertheless, all these developments have been concerns of Microsoft's, particularly after its legal attempts to bring down piracy of its products backfired and generated so much ill will. Microsoft has recently attempted to become more constructively involved in China, increasing its public relations efforts with industry and government alike by joining the Chinese Software Industry Association, starting a joint venture with a local Chinese enterprise, and otherwise trying to project a neighborly image. It has already created an R&D center headed by a young Chinese returnee prominent for his long list of publications. Microsoft recently announced that it was further investing US $750 million in China.[29] From one perspective, the kind of software training Microsoft could bring to China is potentially tremendous, and Red Flag could well end up partly as a pawn in a larger foreign investment stakes game.

Middleware

Another way of identifying lead sectors or product types is to focus on the fastest growing sectors. While all the types of software are growing, some are growing at much faster rates than others. Middleware had the second highest growth rate, and was the fastest in the system infrastructure category. Middleware[30] is an area increasing in importance since, as the Chinese domestic market matures, they will need more advanced software applications that can work across platforms in an integrated and modularized manner.

Because of the growth of middleware, the strategic position it occupies in new software systems (being the link between new applications and systems), and the relative newness, a number of government departments are already listing it as a new target for emphasis.

Software like middleware may be more challenging to do, partly because of the newness of the area and the degree of foreign competition (since this area was itself defined by the MNCs). Since the area is new and the principles are not well known, the knowledge to produce products like middleware is also less easily available. Despite this newness of the software and the advantages that MNCs held, the domestic middleware producing companies managed to account for 49.7% of the market in 2002 (CCID, 2002e). At the time of the interview, there were only three or four companies that had developed good middleware products and solutions in China, of which we had interviewed two. The small number of

[29] IDG news report, May 23, 2003.

[30] Middleware is essentially the software that acts as an interface between applications and the network software, that integrates protocols across platforms for communications between applications and needs.

companies could be due to a variety of reasons: either the newness of the technology may not be attracting many imitators, and may also make it more difficult for companies to get into it, given that it requires a combination of familiarity with the technology and ways to package and sell it – ways quite different from the PC applications that are easy to familiarize with. It is also possible that areas like middleware have barriers to entry where few domestic competitors can compete in due to a lack of capabilities. In fact, until about 2001, it was difficult for companies like TongTech to get customers to understand and use middleware, and they had to devote much effort to the education of customers on a sector by sector basis.

Tongtech is one of the more successful specialized middleware companies in China. Tongtech started life as a systems integrator, initially decided to become a combined products and systems integration company, but in the face of other systems integrators' distrust of Tongtech's linking of products and systems integration services, decided to focus on middleware products exclusively. They are quite successful, having sold about 100,000 licences for their product and controlled about 30% of the market (IBM and BEA systems holding the other two leading market shares).

Increasingly, the domestic companies face increasing competition from established foreign firms like IBM and BEA. These multinationals offer more complete solutions and services with which they can bundle their middleware.

Security software

Security software is another huge market, representing the seventh highest in the table in terms of revenue, and one with relatively higher growth of 52.2% in 2000, and 61.8% in 2001 (the latter according to CCID [2002c]). The security sector's growth reflects government and business concern with security as e-government, e-business and e-commerce initiatives start to take off. However, the smaller base in such software and early stage of maturity of the sector (relative to other software sectors) could also account for the more rapid growth rate.

Security software companies numbered over 1000 in 2001 (CCID 2002c), up from 230 in 2000 (CSIA 2000), reflecting the positive expectations of firms entering in the sector. Most domestic companies made simpler anti-virus software and firewall software. At least a few domestic firms are doing well, partly because they have a faster response time than the MNCs when dealing with local viruses (IDC, 2001a). Nevertheless, the multinationals are considered to have better network security products (CCID, 2001). Some of the major vendors making security software include Neusoft, IS-One, Talent-IT, Rising and CA-Jinchen, as well as foreign brands like Checkpoint and Netscreen. Some Chinese firms are doing well. IS-One has focused on the telecoms and banking sectors, and has a list of large clientele, including the five largest telcos in China and The Peoples Bank Of China. Rising has recently started to export its products to Japan.

Shanghai Fudan Grand Horizon is one of the few local companies focused on network security (amongst other things). As noted earlier, being a university spinoff, it had the rich research resources of Fudan university behind it, as well as the CEO being the head of a computer science laboratory specializing in networking technologies.

At least in the security sector, it appears that the pressure from foreign competition may not be as intense as in the other sectors. It is claimed that Chinese companies actually have

almost 90 percent of the market share for security products like virus killers.[31] This may be due to the lack of large, internationally dominant multinationals, which are the companies that tend to exploit emerging markets more aggressively. The smaller specialized security companies from the US and elsewhere appear to spend most of their efforts on the English language markets, much as small Chinese firms do to their own.

Other Types of Products

Enterprise Software and Services Industry Applications:
Enterprise resource management (ERM), which mainly includes the same line up of products as ERPs, in addition to accounting software, is the largest type of software in the applications solutions category. Accounting software had the largest market share of 64.3% within ERM software (IDC, 2001b). If accounting software is included along with all the other enterprise applications, local software vendors like UFSoft and Kingdee show up as the largest firms, while if only ERPs are included, foreign multinationals will clearly be in the lead position.

Home and Office Applications:
In other application areas, one can also see stiff multinational competition and selected domestic firms rising to meet the challenge. According to IDC, even though Microsoft dominated the word processing market in 2000, local companies like Kingsoft were starting to make some headway. Kingsoft is a diversified company started by a successful businessman. It now has a leading translation product, and also makes office productivity software and game software. [32] It is quite possible that in areas like translation software, the Chinese familiarity with their own language as well as their research into software translation could help them, particularly against multinationals that do not have that domestic advantage. However, the smaller size of Kingsoft makes them somewhat vulnerable to larger foreign competitors that have stronger products and larger sales and support organizations. Kingsoft has been claimed to offer very little after sales support, and their products are also considered technically inferior to Microsoft's (Saxenian, 2003).

Education is another area where local products can be more suited to the local population's preferences than foreign imports. Companies like Human Technology (or Hong En) specialize in educational content for the home. Human focuses on children's education, computer tutorials and language training. They only have about 2 or 3 serious contenders in their market, and hold a lions share – about 30% - of the market (CSIA, 2000). The technology is not sophisticated in this sector and is still fairly customized (hence a large systems integration component exists), thus most of their product development people are specialists in the fields of education and other non-computer areas. However, in educational software, technology is less important than the ability to appropriately combine different kinds of media with educational content.

3.4. Manufacturing: The Rise of Embedded Software and New Opportunities

With its strong growth and substantial capabilities, the manufacturing sector holds some hope for China's software sectors. On top of its vaunted capabilities, the manufacturing sector has an increasing demand for embedded software in all sorts of electronic products, ranging from

[31] http://english.peopledaily.com.cn/200211/13/eng20021113_106755.shtml.
[32] Based on an interview with a Kingsoft project manager. However, to some extent, their strategy of moving from market to market as their last market gets occupied appears to reflect a business mentality of generating profits rather than a specialized software company's desire to focus and do well in one market.

personal data assistants (PDAs) and mobile phones to more intelligent household appliances, automobiles. Fortunately, embedded software standards are not set in stone or dominated by monopolies. Thus, a number of Chinese firms are in the thick of this application area. One need of this is for substantial engineering as well as software engineering talent - which China has good amounts of.

In some sense, this was a fortuitous area for Chinese firms, some of which had developed good technical know how but possibly had poorer competitive strategies. Working with China's manufacturers may give them a better insight to how to fulfill requirements, much in the same way contract manufacturers learnt from their best customers. CASS produces operating systems for a variety of manufactured products. CASS's Hopen OS, based on their earlier work on the Unix operating system now competes favorably with Microsoft in the Chinese market of manufacturers for handheld and other smaller electronic devices. In part, the Hopen OS's market penetration was possible because their software was specifically developed for devices requiring less functionality and more minimal memory requirements, and can be flexibly tailored to a variety of products. They have managed to secure contracts with large Chinese companies, e.g Legend's lower end products, and a TV maker. This was a result of the Chinese market which tends to offer less advanced but lower cost products than those in developed countries. As a result, CASS's product actually fits with these products better than Microsoft's, which are geared to more expensive higher end and higher functionality products. Another way of saying this is that the Hopen software kernel or core code is smaller than Microsoft's, making it more efficient in terms of space, but less complex and therefore less able to drive more devices with greater functionality.

Recently, the Hopen system was further developed as the NUWA Project[33], in anticipation of the increasing market for embedded software. The NUWA project focuses on developing the NUWA-Hopen OS as a basic embedded software platform to work across a variety of information appliances. Like the TRON system in Japan, the NUWA product is at the vanguard of pervasive computing platforms, which allow intelligence to be embedded in all household products. This can unite a variety of software clients making different appliances, which is particularly useful in a single country where manufacturers may desire products that are interoperable or able to exchange information with one another. This includes chip designers and manufacturers, consumer appliance manufacturers, as well as software developers, and information service providers. Currently CASS is actively cooperating with chip manufacturers (including Motorola, Panasonic, National Semiconductor, and Winbond), appliance manufacturers (e.g. Legend, ChangHong, and TCL), and software developers in other fields such as mobile computing platforms, home information environments, communication computing platforms, in-car computing platforms, industry/ business controlling platforms, and e-commerce. In one example of cooperation, CASS cooperated with Legend to develop the "TianJi810", which was used in PDA products. Another application the TCL's HiD299e high-definition TV, which uses the NUWA Hopen embedded real time operating system (RTOS).[34]

Comment [SMU4]: http://www.cass.ac.cn/en-nuwaproject.htm

While CASS operates as a contract supplier, a few other firms are attempting vertically integrated strategies. For instance, the TOP Group (within which TOP software is a unit) has has like many firms, diversified into a broad range of industries. TOP invested three hundred

[33] Named after a Chinese goddess.

[34] While there is no independent verification of the proven nature of CASS's products, in May 2001, they won the Excellent Software Products of 2000 Award by the Chinese Software Industry Association (a government body).

million RMB in manufacturing facilities in its home city of Chengdu, with an annual production capacity of one million cell phones, 500,000 palm computers and 200,000 laptop computers (CCID, 2001).

Another well known vertically integrated telecoms manufacturer is Huawei, which is threatening Cisco as the next possible giant in networking. While Huawei is in the telecoms equipment sector, modern advanced networking equipment such as switches can comprise of 50 percent or more of embedded software. Since software is critical to their success, Huawei is setting up very strategic investments in software, including a large development center with over 400 engineers in Bangalore. Although Huawei's needs for embedded software are internal, i.e., produced for the company's main telecom products, the fact that they set up shop in Bangalore as opposed to developing their software in China suggests that for the medium term at least, the Chinese software capability, even in embedded applications, may not be as good as India's. Interviews with Huawei executives in Bangalore showed that they believed that Indian process capability was better than China's, even though the Chinese knew more in terms of telecoms domain knowledge and at least as much in terms of software development theory.

China's software companies are developing for a diversity of fields and manufactured and industrial products. For instance, the Shandong Luneng Jicheng Company (SLJ) develops software for products for electrical network automation, e.g. the automation of electric power dispatching. While their products currently only support the electric power industry, they will be branching into other industries. They only have two or three domestic competitors in China at the moment, but they also have to compete at the high end against foreign companies like Siemens and ABB, sometimes with favorable outcomes.

3.5. Does the Domestic Economy Provide a Window for Growth? The Case of Enterprise Resource Management Software

One of the major software product areas in use across a variety of business sectors is enterprise resource management software. While the ERM sector is not the biggest sector overall, it is the largest sector of the applications market.[35] The enterprise resource planning market consists of applications that deal with financial management, human resource management, distribution and inventory control, and production and operations. According to IDC, the more advanced part of this sector – ERPs – only made up 3.8% of China's total software market in 2000, but the ERP sector was growing at the rate of 26.9% in 2000. This reflected not only the gradual growth of the software customer enterprises' capability, but also that enterprise software was being adopted in a broad diversity of software sectors. In 2000, the largest user of ERPs was the manufacturing industry, at 68.2% of the total ERP market, followed by the distribution, transportation, telecom and health industries (IDC, 2001b).

Various estimates put the number of small to medium sized enterprises in China at between 8.6 million to 20 million, and the number of large sized enterprises at 15,000.[36] All this provides a substantial business user base. Whereas 60% of Fortune 500 companies have an ERP installed, only 2% of the top 500 Chinese firms have one, suggesting that there is much market potential (IDC 2001b).This base of users is expected to increase the domestic

[35] Defined by IDC to include industrial business and consumer applications.
[36] Figure of 8.6 million is cited in Gartner (2001); figure of 20 million is in CSIA (2000).

(packaged) software market from US $10 billion to $100 billion in 5 to 8 years (CSIA, 2000). However, as noted earlier, many of these enterprises are hardly using any software, and many have difficulties absorbing software.

Most Chinese ERP customers require just the basic ERP functions or modules, such as distribution, manufacturing, finance and accounting, and human resources. Many enterprises and their top management, especially state owned enterprises, do not have a good idea of what ERPs can do for them, let alone a good understanding of their own business processes. Furthermore, they have lower IT budgets and weaker internal IT staff. All these make successful implementation difficult (IDC, 2001b). In light of this, many enterprises value service more than anything else, and require ERP vendors to have strong customer support, let alone a good understanding of their business process. This is something Chinese vendors are more prepared to do than multinationals, which would rather just sell a product with minimal additional cost of localization.

Even within this software sub-sector, the somewhat low levels of customer maturity, the dispersion of customers across different sectors, and the barriers to selling across geographic boundaries causes the market to be highly fragmented. Further fragmentation could be due to customer enterprises and their business practices being very different from one another. ERP makers often have to make a "half-finished" product, which is then further customized for individual customers, but these difficulties make the needs for pre-installation customization and post-sales services even greater.

Despite this, it is precisely because of this uneven market that presents the opportunity to many local firms. The technology barrier to getting a working ERP system is lower than in other sectors, especially since many customers do not require the sophisticated systems that would require much more experience to make. Many firms that we interviewed were developing or getting into the development of ERPs, including CASS, But One, Calkai, Digital China, and ChongRan. The ease of entry to new entrants in some sub-sectors like ERPs could be due to the technology barrier being relatively lower in them than in other sectors, although domain knowledge is quite important. This results in heavy competition amongst local firms, as our sample appears to indicate: Chinese software firms compete heavily with each other at the "lower" end of areas such as office automation and ERPs, but revenues are harder to build up because these clients are less sophisticated, which tends to require uniquely developed projects or much handholding, which works against the software firms achieving scale economies.

On the other hand, MNCs like Oracle and SAP dominate the high end of these areas internationally, and the smaller and less sophisticated domestic firms are at a disadvantage with regards to winning over and servicing the larger and more mature customers. The table below shows the shares of the largest ERP firms, with the foreign multinationals clearly dominating the sector. Companies like Oracle are making aggressive moves, with Oracle entering into distribution agreements with local systems integrators and other distributors, as well as partnerships with educational institutions and domestic software firms like Red Hat. Oracle had 1,100 distributors in China, and was taking steps to localize its products, with the opening of a 100 engineer product development facility in Shenzhen, and another one slated for Beijing (Gartner, 2001c).

Of the top 10 ERP makers, only three domestic firms were in the top 10 – Being RIIAMB, CASE and Kingdee - ranked seventh, eighth and tenth, but they were said to be improving in

performance and other ways (IDC, 2001b). Kingdee is an example of the new breed of Chinese firm which is doing well in the ERP market. Kingdee also recently acquired CASE. Founded in 1993, it had actually grown to 1500 employees and the tenth largest ERP software company by 2001 (Gartner, 2001a). While Kingdee was originally a financial and accounting software company, like many such firms, it moved into ERPs.

Table 8. China ERP Software Market Revenue Breakdown by Vendor, 1999-2000

	mill US	% share
SAP	14.52	29.74
QAD	4.40	9.01
Oracle	4.21	8.62
Fourth Shift	3.30	6.76
Symix	2.60	5.32
SSA	2.21	4.53
Beijing RIAMB	1.93	3.95
CASE	1.73	3.54
Attention	1.48	3.03
Kingdee	1.41	2.89
Others	11.04	22.61

Source: IDC, 2001b

Faced with increasing pressure from the foreign firms, the local software firms have focused on their ability to cater to the local conditions and business processes peculiar to China. At the same time, with the growth in ERPs has come a gradual deepening of IT capability in some Chinese software firms, reflected in more and more sophisticated product offerings. For instance, in 2001, Kingdee offered a more advanced product with 22 application modules and 10 modules with web-based capability (Gartner, 2001b). They also allowed upgrading to supply chain management and customer relationship management modules, which gave their domestic customers an upgrade path from simpler capabilities to advanced ones.

Since ERPs cut across many sectors, the heterogeneity of business practices across these sectors allows many local ERP software firms to specialize to a degree within sectors. Two examples are CASS' ERP division which focuses on manufacturing concerns, and But One's ERP products which are geared to the telecoms sector. Another example of a focused firm is that of Shanghai's Kingstar, a medium sized Shanghai company which only focuses on certain financial products such as software for large financial institutions, e.g. stock exchanges, banks and exchange markets. They have now obtained a national market share of 70%. They have no competitors in the exchange markets, and only three competitors that produce stock exchange software. On the other hand, they face many competitors in banking software.

In 2000, whereas the top ERP supplier – SAP – was used in 290 sites; Scala, the leading supplier in terms of numbers of sites, had 315 sites; and the leading domestic supplier, Beijing RIAMB, was installed in 70 sites. However, this gives Beijing RIAMB a revenue per site of $27,571 USD, versus $76,421 for SAP and $30,730 for Oracle (the third placed in numbers of sites). This suggests that in the current market, the local suppliers' capabilities are actually matched at about the same level of complexity as the foreign suppliers' (IDC 2001b).

3.6. Systems Integration and the Fulfillment of Highly Customized Industrial Needs

One artifact of the immaturity of China's software market is the fact that much of its software market involves systems integration. As shown earlier, the largest software firms in terms of revenue are mainly systems integrators. Even most of the firms listed as product developers, such as the ones we interviewed, actually do as much systems integration as product development. There have been suggestions that the bulk of the industry in unable to move beyond systems integration and into broader software work.

In the telecoms, finance and government sectors, as well as other sectors, large systems are the norm. As shown in the table, a large percentage of the total IT spending in various sectors is on hardware, indicating the need for large amounts of rudimentary systems integration.

Table 9. Hardware-Software Breakdown for Total IT Market

1999			2000		
HW	SW	Svc	HW	SW	Svc
87.6%	6.9%	5.5%	87.6%	6.6%	5.8%

Source: IDC, 2001c

According to the IDC, for 2000, out of a total of 16.122 billion USD or 128 billion yuan for IT spending, hardware accounted for 87.6 percent, software for 6.6 percent and services[37] for the remaining 5.8 percent. For the telecom sector, the 2000 spending was about 21 billion yuan, of which hardware was about 84.5%, software was 7.6% and services was about 8%. This illustrates why, as a Digital China executive noted to us, they focused on SI in order to gain additional revenue.

Using a different classification scheme and total base revenue, CCID reported that IT applications spending in 2001 for telecoms was over 30 billion yuan, of which hardware accounted for 66%, services including systems integration was 19.2%, and software was 14.6% (CCID, 2002). If we take into account differences in the years of data used, this shows the CCID total to be a bit higher than the IDC total, even though the latter is supposed to include media activities as well.

Taken either way, the numbers provide a powerful reason why so many software companies – product firms and systems integrators alike – are doing systems integration. In our interviews, as many firms, even product firms, noted that it was difficult to survive on products alone, and that they tried to reap hardware and systems integration revenues along with their product sales.

This also dovetails with the other reason stated for the high prevalence of SI: that many customers need handholding. The fact that services revenue is as high as software in the IDC numbers also indicates this.

User Capability and SI

To understand why SI is so dominant, or why product firms struggle to meet customer requirements and must sometimes sell products hand in hand with SI, it is useful to understand China's domestic software customers. As noted earlier, Chinese enterprises' IT capabilities vary widely from hardly any to fairly sophisticated, with much of them being in the less sophisticated range (Brizendine, 2002). If anything, most Chinese organizations tend

[37] In IDC's terminology, services consists of consulting, implementation, operations, training, and support services.

not to think of IT as a competitive advantage, unlike their Western counterparts. At the same time, many enterprises do not share common business processes, which, coupled with their lack of IT savvy, means that they need greater amounts of systems integration and services. For instance, one engineer that we interviewed noted that a number of clients of his former company had leaders who did not understand IT systems, and so were unable to effectively utilize sophisticated systems. This made the implementation of ERPs all but fruitless. Another executive from Fudan Grand Horizon noted that Chinese enterprises typically did not have strong in-house IT departments, unlike those seen in US corporations. This made it difficult for them to be able to articulate their requirements, and as a result, they expected the software firms to do so.

In China, many users are still at early stages of IT maturity. The three stages of user evolution could be considered as follows: In China, businesses traditionally purchased "hardwired" IT solutions, which systems integrators pieced together with computers and off the shelf or custom applications – what we call systems integration. In the second stage, these types of systems were networked with rudimentary networking technology, such as file sharing capability. For some customers, this stage has only occurred during the last few years in China. Finally, in a parallel to the early stages of enterprise IT use seen in the US, some Chinese enterprises' use of IT has advanced in the last few years, with the introduction of packaged software, networked PCs, advanced client-server applications. At this stage, more complex systems solutions have emerged, effectively more complex applications tied together with multiple-layered software protocols and distributed hardware.

With the advent of more complex software needs and a more commercial environment for software products and services, more mature product focused companies have arisen. However, in our interviews with these stronger product developers, it appears that many are still doing systems integration as well, because of the overall lack of sophisticated users.

In all, this suggests that much of the market is still unable to absorb more sophisticated kinds of work like products, and that customers may not be sophisticated enough to determine their product requirements, then to dictate their integration into the enterprise. In such cases, the software firms must do systems integration.

Systems Integrators

Partly because of the need to grow revenue in a market of uneven user capabilities, some of the large SI firms have ended up with a mixture of low and higher end capabilities. In one large state-related firm that we visited, the software work being done ranged all the way from (low end) localization of products, to product development. Trying to reform entire companies like this will be a substantial task. In addition to this, the State Council's Number 18 Document seems to suggest that the government is interested in promoting firms regardless of their ownership. This could lead to problems if the "wrong" firms, i.e. those incapable of reforming themselves, are supported.

Recently in 2002, a selection of the 20 largest systems integrators appeared not to be growing as fast, suggesting that deeper problems in them. Putian's revenue growth was negative 2.13%, Neusoft's at 9.02%, and CS&S at about 4%. One possibility is that at such sizes, some of these firms have trouble securing new large scale work to grow anymore, or that there is not enough work to go around all the firms. Furthermore, recent mid-year reports for a few listed software companies showed that costs were increasing, but profits were not. This was compounded with the problem of lack of standardization across customers, which meant

that software firms could derive repeated use out of their efforts, and reduce their development costs by treating them as one time costs across multiple customers. The success of the systems integration model would appear to depend on the firm's ability to manage and control such a wide array of activities and businesses. It would seem that these firms are challenged by the fact that the software market is also uneven, making it possible for the SI firms to suffer internal contradictions in software capability.

3.7. Summary of Trends

The main trend that can be seen in the various accounts of Chinese end user sectors is that there is a tremendous build up of hardware infrastructure and basic software such as operating systems. This phase is transitioning now to more specialized needs for software in various services, requiring ever more complex software products, such as ERPs, network security and middleware.

At the same time, the lack of standard business processes and the somewhat early stage of customer maturity continues to require large amounts of systems integration work to tie together new hardware systems with a combination of customized and packaged software.

The Chinese companies' sales amount to only about one third of the 50.74 billion yuan software market in China. Most of the advanced products such as system software, database software, middleware and application software belong to foreign firms. The Chinese government is cognizant of this, and has taken major steps to try to boost the domestic firms in selected sectors deemed to be vital. Areas that the home brands are dominant in are finance management, security software, Chinese information processing, information security, electronic government affair, education, typesetting, and negotiable securities. Some of these are simpler in technology, while in others, strategic state attention has caused more investments. Furthermore, the industry had also made much progress in communication, management, office software, international application software, system software and middleware, platform software (CSIA, 2003).

Comment [SMU5]: Annual Report of China Software Industry 2002-2003, CSIA, p.80

There is increasing competition in the Chinese market for Chinese vendors, as witnessed by the increasing (or non-decreasing) number of firms, and the increasing share of foreign firms in certain sectors. Possibly as a result of this and other market conditions, a number of large software corporations are not growing as fast as before.

Generally speaking, despite the seemingly large pool of software firms, the good firms in a number of product sectors are few in number, and consolidations are likely to continue. Many firms compete with each other on the low end, while on the high end, particularly in sectors with large, strong multinationals, competition is also fierce. The local companies sometimes derive some local advantages from working in China. But in sectors such as middleware, local firms can only service the small and medium sized companies.

While there is some hope for Chinese companies, and while there is government backing, they have a long way to go to fulfill their promise as a possible next pillar of the economy, as the state intends them to be.[38]

[38] As stated in State Council Document Number 18.

4. Growth Factors in the Software Industry

In the last section, we showed how the Chinese software industry is building capabilities in many sectors and in many products. In some cases, these still do not measure up well against the stronger multinationals' capabilities. This section seeks to examine more closely what factors can be of importance to the growth of the industry, and what factors may be limiting the industry's growth. The factors affecting growth can be divided into three types.

1. The first set of factors involves the level of capability of the software firms, as represented by the scale of the enterprises (which tend to be too small), software talent (of which these may be a shortage), and the lack of core technology.

2. Related to this is a second set of factors: labor. Some observers have noted that Chinese talent is not cheap for the quality of software worker. The issue of capability is also related to the broader business environment, including the potential financing available. Some of these issues are and will continue to be of concern to firms.

3. The third set of factors involves the nature of the domestic market, including the level of competition and the level of capability of the customers. Our evidence suggests that the market is still weak and the structure is uneven, either of which can cause problems to the industry. Furthermore, piracy continues to dog the industry, as does the increasing multinational presence.

4.1. Scale and Capability of Enterprises

As noted earlier, the average size of a Chinese software firm is very small. There are about 160,000 software professionals distributed across over 6200 software companies, giving an average firm size of about 25 software developers. Distribution wise, enterprises with less than 50 staff comprised about 55%, those with staff between 50 and 200 comprised 42%, and those with staff over 1000 were rare.

The issue of technological capability essentially involves the ability of Chinese companies to make quality software products. In some ways, this is a moot point, since they are satisfying the domestic need for less advanced products, but to the extent they rely on this too much, this could reduce their ability to compete at times when they may have to compete in advanced products markets. A similar situation exists with regards to outsourcing. Currently, Chinese software firms are doing some outsourcing for Japanese firms, but many of the jobs are lower level ones that do not have much scope for increasing the level of sophistication of the work. Unless the situation changes, the Chinese firms will remain at relatively low levels of sophistication.

As far as capability level, the SEI-CMM certification is viewed by many product firms as a lower priority on the way to making good products. Many software firms do not seek rapid certification, and there is only one CMM level 5 company – Neusoft. Of the 11 listed companies in 2001, only 2 had passed CMM level 2 and another two had passed CMM level 3. The companies that are most interested in exporting software will be the ones seeking higher levels of CMM certification earlier.

One problem that software firms face in China is the ability to get financing. While many of the firms that we interviewed were able to get the first stages of venture financing, the traditional capital markets are not as forgiving. Since China's banking system requires an

asset mortgage or third party guarantee in order to secure loans, software enterprises without traditional assets face a unique problem. Furthermore, the capital markets offer little help to software firms. Of the 1000 listed companies in China, only 11 are enterprises. The accumulated financing of the listed software companies is about 5 billion yuan, as opposed to 499 billion for the entire securities market in 2000 (CCID, 2001).

Finally, another related problem is that many firms spread themselves out over a wide number of sectors, partly reflecting opportunism, partly the perception that its necessary to earn revenue wherever it grows the fastest. This could continue to damage the scale the companies need to compete for larger sized (and more complex) contracts. One smaller firm noted to us that they did not have the size to compete for such work, so they were trying to expand their payroll in order to do so.

4.2. Human Resources: Looming Quality and Quantity Problems

China's large number of fairly well-trained human resources are an important reason why it has been able to move into most software sectors somewhat effortlessly. Highly skilled human resources are a key to the support of IT industries. However, while Chinese software workers have the theoretical knowledge to handle the basic tasks and are fairly sophisticated analytically, they lack the process skills of Indian software workers. Because the nature of most of their work involves less process than development of products, customization and systems integration, they have been able to get away with lower process skills thus far.

The table below shows that the total number of graduates in computer related fields and workers in the software industry is steadily growing. Other estimates put the pool of IT professionals at about 150,000 in China for 2001, versus about 522,000 in India, based on graduates of 50,000 and 73,218 per year respectively, and a total demand of 350,000 and 400,000 respectively (Gartner, 2002). Like India, China also suffers an outward migration of graduates (often from leading institutions like Tsinghua University) to the U.S. and other countries.

Table 10. Software Workforce (Source. CSIA, Table 1-24, 1-26)

Year	Number of software professionals	Number of graduates in computers and software
1998	132,000	29,000
1999	150,000	33,000
2000	186,000	41,000
2001	250,000	62,000
2002	300,000	89,000

Many universities do not have computer science or software engineering programs. It has also been reported that many software workers need retraining long after they have entered the workforce, suggesting that the educational system is not meeting the needs of companies (CCID, 2001). Since many companies may not have adequate training capabilities, or those training capabilities do not exist out in the open market (though occasionally, companies will hire consultants on software process from India and elsewhere), new staff may not be trained well enough before and even after they arrive at a company. In fact, the boosting of program enrollments nationwide year over year may worsen the quality problem.

Recognizing that the quantity and quality of software graduates is far too low, the national and local governments are instituting larger scale plans, such as the designation of 35 universities nationwide as national software engineering programs. This will contribute another 17,500 graduates a year to the industry. Cities like Shanghai and Jinan are actively developing software engineering curricula and enlarging existing institutions to feed their growing local industries. However, with the industry's comparatively lower level of software engineering capability, such efforts can be expected to be limited in this respect. Shanghai has also attempted to boost software engineering awareness by setting up a software engineering network to exchange information.

As we noted earlier, the software skills in China are more theoretical than practical. Especially when it comes to software engineering, industries such as those in Jinan have found that the local software engineering programs needed bolstering on their software project and other practical skills, and the local government and companies try to help the local Shandong University with its software engineering programs by assisting in the training. These are also apparently going to be increasingly supported by Indian educational providers such as NIIT which are opening more and more training sites across China.

Generally speaking, there is a shortage of certain skills in China, and further, that the hourly wage rates for professionals (i.e., developers with about 2 years experience) can range widely, from about US $4,846 - $6,057 in China, versus about $4,913 - $9,212 in India (Gartner, 2002). This reflects the uneven nature of the labor market in China (as well as India), since some professionals will be paid higher than others, depending on their experience, and the company's financial resources. The monthly wages vary considerably, and in fact, sometimes do not take into account a very good set of benefits that companies may provide, including housing and transportation. Some companies are even building campuses to house their employees and create a more convivial working atmosphere and corporate culture.

In general, many companies appear to be lacking project managers and other managerial talent.[39] Various younger companies such as Tangram, which makes educational system software, and Intrinsic Technology, which makes mobile device software, noted that it was difficult to develop and grow because they lacked managers who can take off with the company's vision. By the same token, the improvements in better enterprises is also attributed by industry observers to corporate development efforts. It may also be true that since Chinese firms are not exposed to standard Western practices, they may not even be aware of what they are lacking. However, even the larger firms seem to recognize that wholesale transplantation of Western management philosophies would not work in China. An executive with Digital China noted that they were benchmarking to some degree, and expressed their wish to fuse the best of Chinese management with Western management.

In general, the impression in the industry is that high-level system analysts and project engineers are fewer than necessary, and software blue collar workers like coders are also scarce. As a result of this, the software talent structure is considered by some to be of an unreasonable structure, that is, not being like a "pyramid" but like a "spindle", that is, with a middle part that is (relative to its needs) that is larger than both its ends. This lowers the competitiveness of the national software market; and also causes a number of undergraduate programmers to undertake simpler coding work. This makes manpower cost higher than

[39] Far East Economic Review, June 14, 2001, p. 39. Saxenian (2003) also indicates this.

expected, and also influences the competitiveness of software products. It is worth noting that in many of the firms that we interviewed, there did not appear to be major shortages of most types of personnel. This could be because they were product firms that were growing at a much slower pace. They seemed to believe that as long as they were able to hang onto their technical people, especially if the core team happy enough not to leave, that seemed to make labor turnover manageable. However, a few of the companies that we interviewed, such as Shanghai Grand Horizon, did note that the highest level technical-business people such as product managers were difficult to come by. Some other companies swore by having good sales staff with the connections to make big deals happen. However, not all our interviewees seemed to believe that this as a problem.

A greater problem could be posed by the general quality of skills of the workforce. Only about 10% of the IT workforce has experience with complex programming tasks, and project management ability continues to lag India's.[40]

4.3. Nature of the Domestic Market

The final factor is how the market behaves, and its implications for software firms. Our interviews, secondary analysis and earlier discussion of the sectoral evidence provides at least four lessons about the domestic market.

First, to reiterate the logic in Figure 1, the booming economy has created wealthier consumers and growing industries, and these in turn are increasing their demand for software, which will give software firms opportunities to grow. This effect alone benefits both domestic and multinational software firms.

Second, as noted earlier, the market has uneven capabilities, and many user enterprises still have a barely nascent ability to absorb and use IT. This requires software firms to provide more in the way of services or customized software. Domestic firms may be better positioned to do this, and further, believe that they have a deeper understanding of their own markets than do the multinationals (CCID, 2001). Many of these will be systems integrators making custom projects, but product developers can also benefit from "local requirements". The need to cater to so many disparate customers, often at more mundane service levels, will not necessarily help software firms to reap any economies of scale.

A third and related issue that was noted in our interviews by many small and medium sized software firms was that markets were quite fragmented by provincial boundaries. For instance, the Jinan company SEPCO develops software for both the back end (office automation) as well as the front end (running power plants). However, it faces a market with a large number of competitors, each one with an advantage in its own region. (SEPCO is not related to the other Jinan company, SLJ, although they both have the name Luneng in its Chinese name, and the same investor – the local Luneng power company). Thus, at least some markets for software are quite fragmented by provincial government authority and preference, and size appears to be important in these sub-sectors.

Fourth, as we noted earlier, there are too many small and financially weak software firms, and their small scale limits them from expanding themselves (CCID, 2001). As one interviewee from SEPCO noted, the many small firms compete with them on low cost and

[40] Far East Economic Review, July 11, 2002, p. 38.

quality, consequently eating into SEPCO's ability to service multiple customers or customers at higher levels of value added (since customers may then choose low cost over higher cost and quality).

Finally, the market is also getting increasingly sophisticated, and foreign multinationals are increasing their presence, all of which adds up to competition at the high end (in addition to the already fierce competition at the low end). The open question is whether Chinese software firms can match this increasing sophistication with their products, or are able to graduate along with their market from being systems integrators or developers of less sophisticated products, to comprehensive packaged software solutions providers. If not, the multinationals will more easily dominate this emerging situation.

The combination of high competition on both the high end (from multinationals) and low end (from the many local competitors) can put a "squeeze" on the firms in the sector. This compounds the already difficult task of scaling operations over a diverse set of customers.

Other factors in the business environment also work against effective capability building in and growth of the software firms. Piracy is often mentioned as something that continues to hurt the software industry, and is now being officially recognized as a problem. One problem is that many software pirates are simply firms or individuals who cannot afford the software, and who the state may be loath to hit out against. Ideally, a form of price discrimination could be practiced, since software has almost zero marginal costs of reproduction, but we have not seen any strategies in firms along these lines. As a result, many firms report very high piracy rates, with Microsoft being one of the hardest hit, with a reported piracy rate of 95%. It was also pointed out by TongRan that the user firms who really need their software services will not pirate, hence, the need for services appears to mitigate piracy.

4.4. Strategies for Coping with the Market

All of these factors cause a great deal of uncertainty or difficulty for software firms, and because of this, it can be difficult make revenue and to scale easily across different customers. In our interviews as well as in the industry proper, two distinct strategies were seen.

One strategy is consolidation. In the ERP realm, this is happening, as domestic firms gear up to compete with larger, better funded foreign competitors. Kingdee's acquisition of another large firm – Case – in 2001 was an example of this. It is expected that many more consolidations will occur, at least in ERPs.

A second strategy was specialization, which is increasingly seen in the good product firms. Examples of this include Kingdee, Kingstar, and Red Flag. Specialization is one way of deepening competencies and differentiating oneself from other firms that cannot do so. It also connotates the ability to brand effectively, but this is also not easy. Specialized firms can presumably target higher up the value chain of their clients, so this goes hand in hand with more maturing or newer sectors. Indeed, Kingdee is very much aiming at maturing ERP users, while Red Flag is aiming at newer markets (but dealing with sophisticated manufacturers). Specialization can help differentiate when there are hundreds of look-alike competitors. Of all the hundreds of companies developing ERPs, but many may only be developing for very localized markets, and may only be doing it for one client at a time, i.e., it will look more like project work than a packaged product. It is possible that many of these

firms that claim to be developing ERPs may in fact be developing MIS systems (or precursors to the ERPs of today), rather than full fledged ERP systems. Without the scale economies, it is unlikely that these firms will graduate, whereas firms that can specialize enough to get scale economies can then graduate out of the pack. Thus, the ERP space is fairly easy to enter, but in reality, the bigger ones and ones specialized in ERPs like But One and Kingdee appear to be doing better, and are probably more likely to survive than the others.

A third strategy was diversification, although at the relatively small scale that these firms are at, diversification does not appear to be the best alternative. Many of the firms we interviewed were diversified across a few product lines or more, and systems integrators are diversified even more so. Diversification could either be chosen in order to chase revenue in emerging sectors, or to survive, by moving away from the original product lines when their income prospects get reduced. Diversification in services could also help firms to fund their main activity with steady income. Diversification could be across product lines, or across service lines. Finally, diversification could involve combining different types of products and services. That is, some firms may combine products with broader systems integration work. This also gives them the benefit of earning more revenue from the hardware sales and services.

Some firms could also be characterized as diversifying across a highly limited set of specialized areas, which they maintain as their core. While this may not be providing economies of scale, at the current level of product sophistication, they do not appear to need more than some proportion of their development team to focus on any one particular product.

This raises a final issue, that of whether firms that are benefiting from the window presented by the weaker users, can upgrade themselves along with their users. This depends on the ability of the firms to execute an upgradeable strategy for their clients, as in Kingdee's ERP product.

5. Conclusions

The theoretical benefits that the domestic market can provide are to some extent observed in our analysis of the industry and its situation. The Chinese market is indeed providing opportunities to some firms to grasp a share of the market, as well as opening room for specialization in a variety of products and sectors. At the same time, the market also has open doors to foreign competition. This in essence is the difference between India and China. There is much less competition in India, and the lower cost basis of Indian software development has thus far outweighed any US rivals it may have had. China has a greater problem in dealing with its multinational competitors in that they have in effect long ago amortized their product development costs, and are trying to resell the same, if not modified products, locally.

Thus, the Chinese software industry is clearly an industry in transition. Being forced to compete in its domestic market against well endowed multinationals, and with too many local firms, may actually be a tough order. The domestic market is fragmented and composed of many ill-equipped firms which need much handholding, and have somewhat unique business processes and needs. This both helps the Chinese software industry, being work that multinationals are less interested in doing, and possibly hurts, since most of the work involves systems integration coupled with services and lower levels of technological

sophistication. Eventually, the customers' capabilities and needs will mature, which presents the industry with another problem of whether it can match its customers' increasing sophistication.

The government has shown itself supportive and willing to go the lengths to support this still nascent industry. It is a real question whether major new players will come from the old guard of systems integrators. None have made a transition to major product players, and slowing growth might be affecting them. On the other hand, the medium sized and growing product development firms do apparently have opportunities to grow in a number of sectors. Thus, government handholding should also be taken with caution, but where this simply gives already strong firms a boost in already competitive markets, this may still help more than it hurts.

References

Brizendine, Thomas "Software Integration in China" *The China Business Review*, March-April 2002: 26-31

CCID (2001). Research Report on the Software Industry's Development in China, 2001.

CCID (2002a). 2001-2002 Annual Research Report on China's IT Application Demand Market for SMEs: Executive Summary.

CCID (2002b). 2001-2002 Annual Research Report on China's IT Application Demand Market in Telecommunications Industry: Executive Summary.

CCID (2002c). 2001-2002 Annual Research Report on China's Network Security Software Market.

CCID (2002d). 2001-2002 Annual Research Report on China's PC Market for Individual Consumers.

CCID (2002e). 2001-2002 Annual Research Report on China's Software Market: Executive Summary.

CCID (2002f). Analysis of China's IT Application Market in Key Industries.

CCID (2002g). Growth of China's Software Market Fell Back in 2002, News & Ideas, http://202.108.101.203:87/detail?record=1&channelid=288&presearchword=ID=1312

CCID (2002h). 2001-2002 Annual Research Report on China's IT Application and Demand Market in Banking Industry: Executive Summary.

CSIA (2003). Report on the Chinese Software Industry 2002, China Software Industry Association.

CSIA (2000). Report on the Chinese Software Industry 2000, China Software Industry Association.

Gartner (2002). Comparison: Indian and Chinese Software Services Markets. Gartner Research M-16-1762, May 2002.

Gartner (2001a). Financial Software Selection for the Chinese Market, Gartner Research DF-14-5486, November 2001.

Gartner (2001b). Kingdee Seeks the Throne in China's ERP Realm, Gartner Research, P-13-4714, May 2001.

Gartner (2001c). Oracle's Expansion in China Faces Obstacles. E-17-4283, July 2002.

Gartner (1998). Chinese PC Vendors in Profile, Gartner Research, PCIS-AP-DP-9807, August 1998.

Grewal, B., Xue, L., Sheehan, P., Sun F., 2003. *China's future in the knowledge economy,* Victoria University/Tsinghua University Press, 2003.

IDC (2001a). China Software Market Overview, 2000-2005, Markets, IDC #CN380204H, June 2001.

IDC (2001b). ERP Market Trends in China, Markets, IDC #CN380209H, May 2001.

IDC (2001c). PRC IT Spending and Industry Segmentation, Users, IDC #AP380126H, August 2001.

Heeks (1999). Software Strategies in Developing Countries, Working Paper No. 6, Institute for Development Policy and Management, University of Manchester (also published in *Communications of the ACM*).

Li, Zeng and Zhang (2003). Innovation Systems in China, 1978 to 1998, in *China's future in the knowledge economy,* Grewal et al, 2003 eds., Victoria University/Tsinghua University Press, 2003.

Lu, Q. (2000). *China's Leap into the Information Age*, Oxford University Press, 2000.

Lovelock, P., Petrazzini, B. and Clark, R. (1997). The Golden Projects: China's National Networking Initiative. *Information Infrastructure and Policy*. 5(4): 265-277.

NASSCOM (2000). *The IT Software and Services Industry in India: Strategic Review 2000*. New Delhi: NASSCOM.

Saxenian, A. (2003). *Government and Guanxi: The Chinese Software Industry in Transition.* London Business School: Global Software from Emerging Markets May 2003.

Schware, R. (1992). "Software Industry Entry Strategies for Developing Countries: A "Walking on Two Legs" Proposition," *World Development*, 20(2): 143-164.

SIIA USITO 2002, SIIA-USITO Trade Mission to China, June 24-July 2, 2002.

Tan & Wu (2002), Global and National Factors Affecting E-commerce Diffusion in China, August 2002.
http://www.crito.uci.edu/publications/pdf/GEC2_China.pdf

U.S. Embassy, Beijing (2002), An Evaluation of China's Science & Technology System and its Impact on the Research Community, October 2002.
http://www.usembassy-china.org.cn/sandt/ST-Report.doc

Wong, J. and Chan, S. (2003). "Why China's economy can sustain high performance: An analysis of its sources of growth," Asia Programme Working Paper no. 6, London: The Royal Institute of International Affairs.

Appendix

A. Firms Interviewed During Fieldwork.

Company	City	Origin	Employee	CMM	Revenue (yuan)	Founded
GrapeCity	Xian	Private (Started in Japan)	70		10 Mn	1988
Calkai	Xian	XJTU	100			>10 yrs
But One	Xian	Split off from Calkai	360			1994
Sunny	Xian	Private, Diversified from HW	86		50 Mn^	1999
Suntek	Xian	Private				2000
ICE	Xian	Govt Investment Co, GM from XJTU	40		1.5 Mn	2000
Huawei	Shenzhen	Private				
TongRan(Neusoft)	Shenyang	Not available	5300	Lev. 5 (2002)	2 Bn, 9.02% Growth	1991
Kingstar	Shanghai	Private	300	Lev. 2, ISO 9001		1995
Shanghai Fudan Grand Horizon	Shanghai	Government	260	ISO9000	97 Mn* 160 Mn^	1988
ASTI	Shanghai	Private	80			1990
Digital China	Beijing	Spin off from Legend Group	400	Lev. 2	02/03 Turnover : HK$12,511 million, 18.9% growth in 02-03	2000
CVIC	Jinan	Not Available	600	Lev. 3 (2003)	0.92 Bn^	1991
Cheeloosoft	Jinan	Diversified from HW	1300	Lev. 2	1.5 Bn	2000
Shandong Luneng Jicheng (SLJ)	Jinan	University spin off	176	ISO9001	32 Mn	1999
SEPCO	Jinan	Government	488			2000
Human Technology	Beijing	Graduates from Tsinghua	400			1996
Kingsoft	Beijing	Government	400-500			1988
Anyware	Beijing	Private	41			
Tsinghua TongFang DASCOM	Beijing	Tsinghua University spin off				1997
Supermap	Beijing	Spin from govt funded research institute Chinese Academy of Sciences(CAS)	170	ISO 9001:2000	400 Mn*	1997
Beijing Listen	Beijing	CAS	30 Tech			1996
Tongtech	Beijing	Private	200			1992
CASS	Beijing	Government	500		60-70 Mn	1985
Red Flag Linux	Beijing	Spin from govt funded research institute CAS	100	Lev. 1	3 Mn profit Desktop Linux	1999
Netsky	Beijing	Diversified from HW	6+6			
Chongran(CS&S)	Beijing	Diversified from HW	400 (1 site)			1980
Luan Xiang (Legend)	Beijing	CAS	12000			1984
Yong Yu	Beijing					

* FY2000, ^ FY2001

Note:

In addition to these firms, a venture capital firm and government officials from the following were interviewed:

1. Ministry of Science and Technology, Torch Office
2. Chinese Academy of Sciences – Institute of Software
3. Beijing IT Promotion Center
4. Xian Software Park
5. Jinan Software Park

B. Top 20 Software Firms by 2000 Sales (based on CSIA [2000] listing)

Company	#	Product	Solution	Service	Sector	Size	Origin	Capability
Founder	1	ePublishing, Word Processing, Digital Media	Customised Industry Solution	Call Centre	Govt, Insurance, Post, Bank, Security	5000, >1000 SW engg.	Peking University	ISO 9001
Pu Tian	2	Network-related, Operation-support (billing)	-	-	Telecom	>54000	State owned	-
Legend	3	-	Customised Application Svc	Consulting, System, Customised Appl.	Govt, Insurance, Telecom, Finance	12000	Chinese Academy of Sciences funded 20 scientists	-
Dong Fang	4	-	-	-	-	-	-	-
CS & S	5	Operating System Information Security Product ERP,SCM Multilingual Translation Software Middleware Platform Products OA series E-government/E-commerce Call Center	-	-	Taxation, military, finance, telecom, transportation, post-service, suing management, trading, tourism and tobacco.	2020	State-owned, set up by Planning & Dev. Comm.	ISO 9001
Pansky	6	Banking IS, Agr Bank IS, Int Clearance IS, Airport IS, Airline Op. Ctrl System, Securities Clearance Sys, Taxation IS	-	-	Banking, Securities, Aviation, Taxation and Social Security	700	Shareholders – CICC (jointly invested by Morgan Stanley US, GIC SG, AB SWEDEN, Bank of Constr CHN)	-
Tsinghua Tong Fang	7	-	e-govt, e-comm, digital city, e-learning, e-home	-	-	-	Tsighua University, Support from State leaders	-
Yan Tai Dong Fang	8	-	-	-	-	2021 Tech	-	ISO-9001
CVIC	9	Middleware,	-	-	Banking,	>600	-	-

		Finance			Transport, Govt, TV stations, Retail			
Sichuan TOP Group	10	(1) system integration for software research and development, (2) R&D and sales for TOP brand products, (3) information services for supply chain management, (4) vocational training and education in information technology, (5) operations services for financial products, (6) services for ecology and gardening. Prod – Category DB Appl System, embedded OS based on Linux, e-government administration information system, ERP software, e-tax information system, OA software, etc. Svcs - networking, technical support, IT management consulting.			Finance, Securities, Taxation, Postal Svc, Telecom, Comms, Enterprise Info, Social Welfare, Housing Sectors	>6000 [Top Software – 788 employees]	Mr. Song Ruhua, the Chairman of the TOP Board, with his two friends. All academics from UESTC	ISO-9001 SEI-CMM3
UFsoft CO., LTD	11	ERP, Insurance, CRM, Accounting.	Insurance, Banking, Securities, Industrial, Commerce, Medicine, Real Estate, Chemical, Manufacturing, Financial Centralization	Execution Sys of ERP, Consultation	Finance, Mfg, Circulation Svc	-	Private	-
Kingdee	12	ERP/CRM/SCM/KM and e-commerce packages, middleware software	N/A	N/A	Mfg, telecom, financial, transportation, energy, real estate, and government	>2200	Private	CMM-3 (Dec. 2002) ISO9001-2000 (2001)
Tai Ji	13	-	-	-	-	-	-	-
Nanjing Luan Chuang	14	-	-	-	-	-	-	-
Beida Jade Bird Group	15	-	-	-	-	-	Peking University	-
Hua Dong	16	-	-	-	-	-	-	-
Tian Cai	17	-	-	-	-	-	-	-
Digital China	18	Sm@rt Banking, Sm@rtBoss Billing CTAIS taxation series. ERP	-	-	Telecom, Finance, Govt, Mfg	-	Spun off Legend	-
Shanghai Ji Suan	19	-	-	-	-	-	-	-
HS Digital	20	-	-	-	-	-	-	-

*# by SW Firms Sales 2000, CSIA, 2000.