Software and Hardware in India and China:

How the Firms Differ

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17 January 2005

We acknowledge with gratitude the financial support of the International Finance Corporation of the World Bank, survey research by the Confederation of Indian Industry in India and Renmin University in China, project management by EconAnalysis, research assistance by Qi Lei, and the intellectual contributions of Neil Gregory, Stoyan Tenev, Rita Bhagwati, and G. Srivatsava.

Track 4: International economics, …
Session format: Competitive

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Abstract

Both the Indian and Chinese software industries are large and fast-growing, but the Indian industry is internationally competitive while the Chinese industry is domestic. In contrast, the Chinese hardware industry is large, fast-growing, and internationally competitive while the Indian hardware industry is none of these. In this study we ask: What are the differences between Indian and Chinese software firms? What are the differences between Chinese and Indian hardware firms? Using new survey data from 319 firms in India and China, we offer a multivariate explanation of which among many firm level variables, market level variables, and business environment variables differentiate the two countries' firms in each industry. Our results suggest that Indian software firms have an advantage over Chinese software firms on several factors that are important to software development for international markets, such as more skilled workforces, and that Chinese hardware firms have an advantage over Indian hardware firms on factors that are important for hardware manufacturing, such as physical infrastructure. Other variables such as the role of non-residents, contrary to popular belief, do not differentiate the firms.

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The Indian software industry is well known worldwide. Its export growth rate throughout the 1990s exceeded 45 percent per year. Chinese software, however, is scarcely noticed internationally. In contrast, the Chinese hardware industry is large, fast growing, and export-competitive, whereas Indian hardware is a small industry and unknown outside India. The contrast raises questions about why these two large Asian neighbor countries show such an opposite pattern of industrial development. In particular, the question we ask is: What is it about Indian software firms that distinguishes them from Chinese software firms? What are the differences between Chinese and Indian hardware firms?

Software and Hardware Industry Profiles in India and China

We use software and hardware as short hand to describe industries within the information technology (IT) sector. Software includes software products and services and IT-enabled services (or business process outsourcing). Hardware includes computers, peripherals, telecommunications equipment, and industrial electronic components, but excludes consumer electronics such as televisions.

Indian software services and products was a sizable $16.5 billion industry in 2003-04, and it grew at a fast compound annual growth rate of 40 percent for the long span of years from 1990 to 2003. What is not as well known is the fact that the Chinese software industry is larger, with about $18 billion in sales revenue in 2003, and it was nearly as fast-growing over this period.[1] While the two countries' software industries are similar in

[1] See Table 1 for data on the two countries' software and hardware industries over time, and sources. The industries are not defined identically in each country, and therefore our comparison is approximate.

size and growth rate, they differ dramatically in the markets they serve: most Indian software is exported (nearly 80% and rising) while most Chinese software is domestically purchased (more than 90 percent). Furthermore, most Indian software is customized software services (more than 90%) while Chinese software is much more oriented to packaged products (more than 40% and possibly as much as two-thirds).

The hardware industries in each country also have nearly opposite features. In China, hardware manufacturing was estimated to be a very big $175 billion industry in 2003, and it was fast-growing – 39 percent compound annual growth rate from 1994-2003 – with an especially big increase in sales revenue in 2003. In contrast, the Indian hardware industry was $6.4 billion in 2003 and had been growing at a 5.5 percent annual rate. Exports account for about two-thirds of Chinese hardware sales revenue, but only 20-30% of Indian hardware sales revenue.

Theory and Evidence

In this study, we analyze firms in two industries in two countries, and make two comparisons: Chinese software with Indian software and Chinese hardware with Indian hardware. Our objective is to discover which among many potential variables differentiate them. Since we know that on the whole, Indian software and Chinese hardware firms have been performing better in the international arena compared to Indian hardware and Chinese software firms, by identifying the significant variables that differentiate these two sets, we will be able to recognize the factors that might have contributed to the international success of Indian software and Chinese hardware.

To derive hypotheses about the variables that differentiate the two groups, we make use of standard models of industrial competitiveness with recent adaptations tailored to high-technology industries. The growth and export success of software and hardware

companies in emerging market economies such as India and China will be influenced by the inputs they use, or their factors of production, by the demand and competitive conditions in the markets in which they participate, and by the business macro-environment in which they operate. We classify these variables into three groups: firm level, market level and business environment variables.

Firm Level Variables

Firm level variables are those that are under the control of the firm's management.

Labor. We are concerned with the supply of labor, its skill composition, wages, and productivity. Software development is labor- and skill-intensive. About 70% of the cost structure of a software company is accounted for by personnel-related costs (Khanna & Palepu 2004), and professionals account for the largest share of the workforce. Firms that have access to low-wage but high-skilled and productive labor should have a competitive advantage in export markets. India has a large supply of engineers and scientists (Ramamurti & Kapur 2001), while China has fewer (Brizendine 2002, Tschang 2003, Tschang & Xue 2002). The productivity of Indian software professionals was higher than that of their Chinese counterparts in one study early in the development of the industry (Heeks 1996). Wage rate comparisons are difficult to make, especially across countries, because wages vary with the job level considered, length of service, region of the country, and currency exchange rates and purchasing power parities, and the evidence reported to date is mixed (Carmel 2003, Saxenian 2002, Hu, Lin, & Foster 2003).

The hardware industries in India and China are less labor- and skill-intensive than the software industries. Empirical evidence about labor inputs in Indian and Chinese hardware is scarce and comes from consultants' reports that claim that Indian manufacturing in general is characterized by low labor and total factor productivity

(Accenture 2002), and that Indian electronics manufacturing has lower value added per worker than East Asian countries but also low wages (although China was not in the study)(Goswami & Dollar 2002). Chinese manufacturing firms, on the other hand, have larger scale and more skilled and disciplined workers (Chandry & Shastry 2002), and lower cost of manufacturing (Rajendran 2002).

In this study, we include variables for labor skill, productivity, and wages. We expect Indian software firms to have higher-skill workforces and higher labor productivity than Chinese software firms, but we expect Chinese hardware firms to have higher productivity, higher wages, and more capital intensity than Indian hardware firms. Because findings from previous empirical literature are bivariate comparisons and our analysis is multivariate, some of these hypotheses might not be supported.

Management. Indian software firms are usually credited with better management than Chinese software firms, but the opposite has been said for hardware firms. Qualitative judgments about the effectiveness of top management in software firms assert that establishment of work processes and systems enables Indian firms to achieve quality certifications and contributes to their success (Desai 2003, Commander 2003, Heeks 1999). A quantitative relationship was shown between project management capabilities and profit contribution in one Indian software firm (Ehiraj et.al. 2004). Indian software managers have been judged to be more capable than Chinese managers (Tschang 2003). Entrepreneurial orientation is claimed to be stronger in India than China (Huang & Khanna 2003). In contrast, Indian manufacturing management has been criticized for many weaknesses including excessive centralization and hierarchy (Accenture 2002).

In our interviews with Indian software company managers, some suggested that Indian professionals exhibit a tendency toward independence – to question rules and

policies – and that this behavior is especially well-suited to the needs of software development, which benefits from creativity and initiative. This trait has not been claimed for Chinese software professionals.[2]

We include in this study three indicators to address management differences. We expect Indian software firms to be more entrepreneurial, to have professional employees who are less willing to follow instructions without questioning them, and to be more likely to have quality certifications (the latter is also a technology indicator).

Technology. Although both software and hardware are considered high technology industries, few Indian or Chinese firms are at technological frontiers. Two studies have argued that Indian software firms should spend more on technology acquisition (Patibandla & Petersen 2002, Saxenian 2002), and the former study showed that Indian software companies that spent more on R&D and paid more technology fees abroad had higher value added per worker. For hardware manufacturing, we see conflicting claims about technology, including studies that claim that Indian manufacturing managers give low priority to R&D and innovation (Chandra & Shastry 2002), that Chinese firms are less advanced than Indian firms because of few foreign firm linkages with Chinese hardware firms (Tschang 2003), but that India ranks ahead of China in technology sophistication (Accenture 2002). R&D that is conducted by Chinese firms may be mainly adaptive rather than innovative because of the needs of the local market, including language.

In this study, we measure technology in firms both in terms of inputs such as research and development spending, and outputs such as patent filings, royalty receipts,

[2] This trait could stem from the low score for India on Hofstede's uncertainty avoidance cultural dimension. In contrast, China's national culture, for which uncertainty avoidance measures are usually not used, is highly collectively oriented rather than individualistic (Hofstede 1990) and therefore should not enjoy the same benefit for software development.

and product innovation. We expect technology indicators to favor Chinese software and hardware firms compared to their Indian counterparts, except for software quality certifications.

Capital. Capital is a small input in software companies, and its availability and cost should not be decisive. For hardware manufacturing, plant and equipment can be sizable inputs. Previous studies suggest that Indian companies face a higher cost of capital than Chinese companies (Accenture 2002, Chandra & Shastry 2002, Spencer & Sanyal 2002), but that access to capital, especially venture capital, is satisfactory in India (Heeks & Nicholson 2002).

International Linkages. The relationships that a firm in an emerging market economy has with foreign firms are likely to contribute to its performance either via access to scarce inputs such as technology or access to markets abroad. Linkages between local and foreign firms occur in different modes for Indian and Chinese software firms. Foreign ownership is found more frequently among Chinese software and hardware firms: one-third of all software firms in China are wholly or partly foreign-owned (Saxenian 2003), and perhaps one-fifth of Indian software firms are majority foreign-owned (Commander 2003). Among the biggest 20 Indian software firms, only one was a subsidiary or joint venture with a foreign company (NASSCOM 2004). In the hardware industry, 33% of Chinese firms had some foreign ownership compared to 13% for Indian firms (Hu & Sheng 2004). A different mode for international linkages is that of non-equity strategic alliances with foreign firms. Indian software firms have many of these alliances with purposes ranging from installation of a foreign firm's platform at a customer's site to co-equal software design and customer problem-solving (Siddharthan & Nollen 2004).

Both India and China have a sizable diaspora. Chinese abroad are more numerous and richer than non-resident Indians (NRIs), but their role is different. Overseas Chinese tended to be investors in export-oriented operations to Asian destinations (Huang & Khanna 2003, Ramamurti & Kapur 2001) whereas NRIs in the US and UK tended to be professionals.

We introduce indicators for all three of these potential international linkages, and we expect Indian software firms to be different from Chinese software firms in terms of more foreign alliances but less foreign ownership, and with a more important role for non-residents. For hardware firms, we expect Chinese firms to show more foreign ownership.

Agglomeration. Agglomeration or clustering geographically is associated with strength for knowledge-intensive industries because it facilitates the transfer of tacit knowledge. Among the 600 largest Indian software firms, 61% were located in Bangalore, Delhi, or Mumbai in 2002, and by including Chennai and Hyderabad, 81% of all these firms were accounted for (reported in Basant & Rani 2004). Chinese software firms are also clustered, with 71% of all firms located in Shanghai, Guangdong, and Beijing (Saxenian 2003). The difference in agglomeration between the two countries appears to be small.

Market Level Variables

Market level variables are characteristics of the product market that the firm faces and the industry in which it competes.

Market Competitiveness. We expect firms to be stronger internationally if the markets in which they participate are more competitive and the firms are more rivalrous. One indicator is the size distribution of firms in the industry. The Indian software industry is more concentrated than the Chinese software industry. The largest 25 Indian

software firms had about two-thirds of the industry's sales revenue in 2002 whereas it took 70 firms to account for half of the Chinese software industry's sales revenue (Tschang 2002). However, the four-firm concentration ratio in Indian software was still only about 22% in 2003 (below the US industry average concentration ratio of 36% (Gilligan 2004)). There are altogether about 3,000 software firms in India but more than 5,000 in China, most of whom are very small with an average firm size of 25 employees in 2001 compared to 174 employees in the average Indian software firm (Tschang & Xue 2002). While scale economies in software production are not important, it might still be the case that many Chinese software firms are too small to be effective international marketers in high value-added systems software (Correa 1996). From these studies, we infer that the Chinese software industry structure is different from that in India, and less conducive to international competitiveness by its firms, while the Indian software industry is not sufficiently concentrated to inhibit rivalry among firms.

In hardware manufacturing, some observers claim that Indian competitiveness has been hampered by protectionist international trade policies, tax policies that restrict trade between states, and small-scale set asides that prevent scale economies from being achieved (Accenture 2002), but there is no econometric evidence.

In this study, we seek to measure market competitiveness by the firm's pricing power, the gross margins in the industry, and the ease of entry and concentration in the industry. We expect that Indian firms face more competitive markets. Because competition arises from foreign sources as well as domestically, we also use indicators for perceived threats from imports and multinational firms operating in the host country.

Business Environment Variables

Business environment variables are the infrastructure and institutions within which the firm operates, and the government policies that affect it.

Physical Infrastructure. Comparisons of the physical infrastructure – electric power, telecommunications, and transportation – in India and China uniformly favor China (Chandra & Shastry 2002, Spender & Sanyal 2002, Mukherji 2002). Within India, differences in total factor productivity in manufacturing across Indian states were explained in part by differences in their physical infrastructure (Mitra et.al. 2002). The infrastructure gap between the two countries is consequential for hardware manufacturing but perhaps not so much for software because software companies can overcome problems with electric power supply by building their own back-up supply (though at extra cost), and they can overcome international telecommunications problems via use of satellite links.

Institutional Infrastructure. India's financial and legal institutions are better regarded than China's (Huang & Khanna 2003, IFC/BAH 2003); these affect both software and hardware industries. The legal system is especially important to software, and this soft infrastructure is a weakness for China (Hu, Lin, & Foster (2003). India's educational system that established high quality technical institutes long ago in the late 1960s, and the government's thrust toward science-based research is regarded as one explanation for the success of the Indian software industry (Heeks 1996, 1999, McDowell 1995, Miller 2001). At the same time, China's support for scientific research at state-supported universities is cited as favoring the development of China's hardware industry (NASSCOM 2002, Tschang 2003).

Government Policies. Governments can influence an industry's competitiveness through its international trade and investment policies, tax and subsidy policies,

regulations, and support of both physical and institutional infrastructure. In the case of India, the central government's policies were somewhat more favorable to the development of the software industry than the hardware industry and they were export-promoting since entry was made free from licensing requirements earlier (beginning in 1984), import of hardware inputs was conditional on foreign exchange earnings from exports (McDowell 1995, Correa 1996, Kraemer & Dedrick 2001), and net income from export sales of software was taxed at a lower rate or not at all, until 2005. However, the effectiveness of some of these policies has been questioned (Heeks 1996, Saxenian 2002). The Indian hardware industry was protected from foreign competition until 1991 by high import tariffs, did not receive very much foreign technology transfer due to restrictive inward foreign direct investment policies, and could not achieve scale economies due to the small size of the domestic market (Saxenian 2002).

The Chinese government has also supported its software industry by means of export incentives, duty-free imports in export processing zones, and tax concessions (Sethi 2002, Hu, Lin, & Foster 2003, Saxenian 2002). Government regulations and corruption are estimated to be slightly worse in India than China; for example, Indian managers spend more time dealing with government regulations than Chinese managers (World Bank 2004). This adversity affects hardware manufacturing more severely than software services (Goswami & Dollar 2002).

We include several variables in this study relating to firms' perceptions of the effectiveness of the judicial system, which should favor Indian firms, and difficulties they face with infrastructure such as public transport and power supply, which should favor Chinese firms, We also include several variables relating to the impact of government

policies that either promote or hinder the industry, such as tax concessions, marketing support, trade and investment policies, and bureaucracy.

Analytical Methods

Our objective is to analyze two sets of differences: between Indian and Chinese software firms, and between Indian and Chinese hardware firms. We use logistic regressions because the dependent variable has values of one or zero. The survey data we use offer a very large number of potential explanatory variables, and it is not possible to consider all of them in the same equation. Therefore we classify the explanatory variables into three analytically distinct groups: (A) firm-level variables that top managers control, (B) market-level variables, and (C) business environment variables that affect all firms in an industry. We make inferences from each of the three equations on the assumption that the three sets of variables are independent.

Data

The data used in the empirical analysis come from original survey research conducted by personal interviews in India and China for the International Finance Corporation. The sample size is 319 firms, of which 179 are software firms (119 in India and 60 in China) and 140 are hardware firms (49 in India and 91 in China). The sample of firms in India was drawn from membership lists of five industry associations and an annual trade publication's review of each industry. The Indian software industry consists of a small number of medium- to large-size firms that account for most of the industry's revenue, plus a large number of very small firms.[3] The sample design included all the medium-large firms and a random sample of the small firms. The response rate from

[3] Firms with sales revenue of more than $50 million constitute only 1% of the number of firms in the industry but together have 90% of the industry's revenue, while 90% of the firms have sales revenue of less than $3 million.

software firms was 62%. A similar sample design was followed for hardware, with a planned smaller sample; the response rate was 30%. Interviews were conducted by the Confederation of Indian Industry in Bangalore, Chennai, Delhi, Hyderabad, Mumbai, and Pune. The Chinese sample was drawn randomly from a central government statistical report that identified the population of firms in Beijing and Guangzhou, to which we added firms in Shanghai based on local interviewers' knowledge of the industry. The response rate was 30%. Interviews were conducted by the Renmin University survey research unit. Characteristics of the sample firms are shown in Table 1.

The sample is broadly representative of the software industries in each country in terms of main line of business except that the Indian sample slightly over-represents software products firms (we control for products versus services in the regression analysis). The hardware sample for China represents the industry's main lines of business while the Indian hardware sample is somewhat over-weighted by peripherals manufacturers. In terms of firm size, the Chinese software firms in the sample represent the size distribution of firms in the industry, whereas the Indian software sample includes more than 90% of the industry's total sales revenue (median firm size in the sample is accordingly larger than the industry's median firm size). If firm size is measured by employment, we find similar results: Chinese software firms in the sample come close to industry medians while Indian software firms in the sample are larger than the median for the industry. The sample of hardware firms in both China and India has a larger average and median firm size both in terms of sales revenue and employment than the firms in the industries.

Empirical Models

We define the variables for the three equations for both software and hardware below:

A. Firm Level Equation

Labor Skill, Productivity, and Wages

- Labor productivity – output/employment, $/worker
- Entry level qualification for professionals – minimum education for employment (4 = postgraduate degree, 3 = undergraduate degree, 2 = senior secondary school, 1 = no minimum)
- Professional employment – professional employment/total employment
- Starting wage for professionals, $ per month
- Entrepreneurial orientation – 5-point scale consisting of three questions about top manager's perception of the company's emphasis on new processes, experimentation and alternative approaches to problem solving, and inclination to take on risky projects. This scale applies to software firms only[4].
- Agglomeration – 5-point scale consisting of two questions about the importance of the firm's geographic location for skilled labor availability and knowledge sharing for employees
- Follow instructions – manager's judgment whether professional employees follow instructions when they do not fully agree (value = 1) or whether they have to be convinced or it depends on the character of the instruction (value = 0)

Technology Variables

- Patent filing abroad – binary variable with value = 1 if the company filed for any patents

abroad in the last three years or value = 2 if no patents were filed.

[4] Entrepreneurial orientation is hypothesized to be important for software but not hardware firms, and a factor analysis of the five questions that potentially make up the scale does not produce satisfactory results for hardware.

- Royalties or technology fees received from abroad – binary variable with value = 1 if the

company received royalties or technology fees in the last three years or value = 2 if no receipts

- R&D expenditures in 2002 in % of total costs
- Innovation – number of new products or processes introduced in the last year
- Quality – binary variable with value = 1 if the firm has ISO or CMM SEI certificates (the latter applies to software firms only) and value = 0 if not

International Linkages

- Foreign non-equity strategic alliances – number of foreign non-equity strategic alliances.
- Foreign ownership – share of foreign equity holding in total equity, %
- Importance of non-residents' role – 5-point scale with four questions about possible

benefits (access to capital, management practices, markets, and technology), with values ranging from 5 = very important to 1 = no benefit for each of the four possible benefits

Control Variables

- Software services firm - binary variable with value = 1 for software service firms and value = 0 for software products firms
- Capital intensity – fixed assets/employment.
- Firm size – sales revenue in 2002

Market Level Equation

- Pricing power. – manager's perception of customers' reactions to a 10% price increase

where 1 = do not accept and 5 = accept willingly

- Entry into the industry – 5-point scale where 1 = very easy entry and 5 = very hard entry
- Industry concentration – manager's report of the size distribution of firms in the industry, where 1 = many small firms and 5 = few big firms
- Import threat. – manager's perception of competitive threat from imports into the firm's market where 1 = no threat and 5 = big threat
- FDI threat. – manager's perception of competitive threat from foreign firms producing in the host country where 1 = no threat and 5 = big threat.
- Gross margins – manager's perception of size of gross margins compared to the average for all industries in the home country where 1 = lower and 5 = higher

Business Environment Equation

Institutions and Infrastructure

- Judicial system – confidence in the judicial system to enforce contract and property rights measured in a five-point scale where1 = no confidence and 5 = full confidence.
- Public transport – seriousness of problem from public transportation failure where 1 = no problem and 5 = serious problem
- Power cuts – seriousness of problem from power cuts or surges from the public grid where 1 = no problem and 5 = serious problem
- Own power supply – binary variable where 1 = firm has its own facilties and 2 = does not

Impact of Government Policies

These variables are measured on a 5-point scale where 1 = little impact and 5 = great impact.

Policies to Promote Company Growth

- Provision of infrastructure
- Tax concessions.
- Marketing support
- R & D Support, help in accessing technology.
- Liberalized import policies

Policies that Hinder Company Growth

- Travel restrictions, visa regulations.
- Bureaucracy and paperwork requirements
- Decreasing protection from imports.
- High import tariffs and import restrictions

Empirical Results

We first present the analyses of differences between Chinese and Indian software firms in Table 2, column 1. Panel A contains the firm-level analysis, Panel B has the market level analysis, and Panel C presents the business environment analysis. The dependent variable in all equations is binary, indicating that the firm is Chinese (value = 1) or Indian (value = 0). The coefficients are maximum likelihood estimates from logistic regressions.

Differences Between Indian and Chinese Software Firms

Indian software firms are predominantly software services firms (76% of the firms in our sample) while more Chinese software firms are products firms (only 22% are services firms). This variable, entered as a control dummy variable, separates firms from the two countries in the multivariate analysis, and permits results from the other potential

explanatory variables to be interpreted without resort to the products-services difference between the firms in the two countries. The results for the other variables confirm some popular beliefs about the Indian software industry, and refute others.

Labor. The labor forces in Indian software firms differ from those in Chinese software firms. Indian firms have more skilled workforces. They employ more professionals and demand higher entry level educational qualifications from them. In addition, Indian professionals display greater independence. Fewer than eight percent of Indian managers report that their professional employees follow instructions even if they do not fully agree with them, whereas more than 37 percent of Chinese managers say their professional employees follow instructions without regard to the situation and without needing to be convinced. This difference, thought to be important to the creative process in software production, differentiates firms from the two countries. However, Indian labor productivity lags behind that of the Chinese firms.[5]

Two other aspects of labor force behavior that are widely thought to be important do not matter in our multivariate analysis. First, Indian software firms are not more entrepreneurial than Chinese software firms, according to managers' reports. Second, the presumed benefits of agglomeration – availability of skilled labor and informal knowledge sharing among employees – are more important to Chinese than they are to Indian software firms. Chinese software firms appear to be as clustered if not more so than Indian software firms. Alternatively, the greater export business of Indian firms and the prevalence of on-site workers at the customer's place of business might diminish the realized benefits of clustering in the home country location.

[5] We also used value added by labor (calculated as labor cost plus profit) in the equation as an alternative to labor productivity, and found the same result.

Technology. Chinese software firms are more engaged in technology than Indian firms. Chinese firms spend more on research and development and they introduce more new products and processes. Until recently, Indian software firms participated mainly in the less technologically advanced segments of the customized software business such as programming, testing, and maintenance, for which R&D and product or process innovation was scarcely necessary. However, higher R & D spending by the Chinese firms hasn't resulted in superior export performance, perhaps because Chinese R&D expenditures are adaptive rather than innovative, devoted to adapting English language programs to the Chinese language, which is an expense that Indian firms do not need to incur.

Quality certification differentiates Indian from Chinese software firms. More Indian firms have Capability Maturity Model (CMM SEI) certifications, and those that do have more of them at higher levels. To possess this quality award that is unique to software is a positive reflection on the management of Indian software firms; it is not only a result of technology activity.

International Linkages. Indian firms have more non-equity strategic alliances with foreign firms than their Chinese counterparts, which is consistent with their dominant export business. The magnitude and strength of this difference (60 percent of Indian software firms have such alliances while only 12 percent of Chinese firms have them) suggests a crucial role played by these alliances in the growth of the Indian firms. (Foreign equity ownership may be greater among software firms in China than in India.) The role of non-residents has often been cited as important to the success of Indian software firms in export markets. However, in our multivariate analysis with other

potential differences accounted for, the role of non-residents does not distinguish Indian from Chinese software firms.

Firm size is not a differentiator between the countries' firms when other variables are accounted for.

Market Competitiveness. Our results suggest that Indian firms face a more competitive market than Chinese firms. Customers of Indian software firms, most of whom are foreign in contrast to the mainly domestic customers of Chinese software firms, accept price increases less willingly. Entry into the Indian industry is easier, according to top managers. Indian firms operate in international markets while Chinese firms mainly serve their domestic market, and accordingly Chinese firms' managers feel a greater threat from imports. The difference in the size distribution of firms between China and India does not differentiate the countries in the multivariate analysis.

Infrastructure and Institutions. Although physical infrastructure is reported by Indian software managers to be a greater problem than it is for Chinese managers, it is not a factor that distinguishes one set of firms from the other. The reason appears to be that most Indian firms – 87 percent of them – have solved the chief problem, which is electric power cuts or surges from the public grid, by installing their own facilities (only 23 percent of Chinese software firms have their own power plants). This is a significant differentiator between Indian and Chinese software firms. Contrary to popular belief, the ability of the judicial system to protect the contract and property rights of companies is not different between Indian and Chinese software firms, according to their top managers.

Government Policies. Government provision of infrastructure has a greater impact on Indian than Chinese software firms, which might be due to the greater severity of the infrastructure problem in India. In addition, government import policy liberalizations

have a greater impact on Indian software firms; they allowed Indian firms to import the hardware with little or no customs duties that was necessary to produce software for export markets. In contrast, government efforts to support marketing have a greater impact on Chinese firms. Other government policies that are widely discussed as promoting the development of software industries, especially relief from corporate income tax, are regarded by managers both in India and China as having substantial impact, but the difference between the two countries is small and does not differentiate their software industries.

Some government actions hinder software industry growth, and they adversely affect the Indian firms more than the Chinese. Indian managers report a greater negative impact from government bureaucracy and paperwork, and they report a more adverse impact from travel restrictions and visa regulations, which are imposed by the US government, and which affect Indian managers more than Chinese managers because of the sizable export business of the Indian companies.

Summary of Main Differences. If we synthesize results from the three software equations, we can suggest in a few words the key differences between Indian and Chinese firms. Indian software firms have more skilled workforces that are culturally suited to software development, and better management. They are more able to get quality certifications and alliances with foreign firms, despite less technology activity than Chinese firms. They operate in a more competitive industry and are accustomed to international markets. Although they face more serious infrastructure weaknesses and hindrances from government, they are able to overcome them. We can also suggest what does not differentiate Indian from Chinese software firms, contrary to popular belief.

Non-residents do not make a difference, nor does agglomeration favor Indian firms. Neither the judicial system nor government tax concessions work in their favor.

Differences Between Indian and Chinese Hardware Firms

We present results from the logistic regression analysis of Indian and Chinese hardware firms in Table 2, column 2. The dependent variable is again the country of the firm, with value = 1 for China and value = 0 for India.

Labor. Chinese hardware firms differ from Indian hardware firms and exceed them in some labor- and management-related aspects. First, Chinese professional employees exhibit more independence of action – their managers report they are less likely to follow instructions without questioning them and it is more likely that their response depends on the situation.[6] Second, more Chinese hardware firms have quality (ISO) certificates. Both these results are the opposite of the results for software firms. They suggest that both more independent professionals and more quality achievements are associated with the more internationally successful industry without regard to the country. Third, the advantages of geographic clustering for labor supply and knowledge sharing are more important for Chinese than Indian hardware firms, as was also true for software firms.

Otherwise, Chinese hardware firms do not have higher labor productivity than Indian hardware firms, contrary to our expectations. Professional employment in hardware firms is less than in software firms, and this labor variable does not differentiate between Chinese and Indian hardware firms, unlike the case for software firms. Entry

[6] The argument that manufacturing success depends on an obedient and disciplined workforce might still hold for Chinese hardware firms; we refer to independence among professionals rather than production workers.

level educational qualifications for professionals are higher in the Indian firms, as in the software industry.

Capital intensity does not contribute to an explanation of differences between Chinese and Indian hardware firms.

Technology. Technology activity does not differentiate Chinese from Indian hardware firms, unlike the results for software firms.

International Linkages. Chinese hardware firms have fewer foreign non-equity strategic alliances than Indian firms despite the Chinese firms' greater export intensity. No other international linkages explain differences between these firms – neither foreign ownership nor the influence of non-residents abroad.

In our sample, Chinese hardware firms are not larger in terms of sales revenue than Indian hardware firms, but in the multivariate analysis firm size is a significant differentiator between the countries' firms, and larger firm size is associated with Chinese firms.

Market Competitiveness. Indian hardware firms face a more competitive market than Chinese hardware firms, according to the perceptions of top managers, which was also true for software firms. Indian managers believe that their customers are less accepting of price increases and that entry into the industry is easier. However, Chinese hardware firms are more threatened by foreign firms, both from imports and from foreign firms operating in their home market. These outcomes might occur because of the pattern of international business in the hardware industries in the two countries. Chinese hardware firms in our sample are more export oriented than Indian hardware firms, but their domestic business outweighs their export business. If Chinese hardware firms are less protected by import tariffs than Indian hardware firms, they would feel more

threatened by imports than Indian firms. In addition, foreign ownership of hardware firms is greater in our China sample than in our India sample, and Chinese hardware firms accordingly might feel more strongly the competitive threat of foreign firms operating in their home market.

Infrastructure and Institutions. One element of physical infrastructure – public transport failures – is a more serious problem for Indian than Chinese hardware firms. Electric power problems in India are overcome by firms installing their own facilities, as was the case for software firms. The effectiveness of the judicial system does not differ between the two countries, according to managers' beliefs.

Government Policies. The impact of government policies to promote industrial growth differentiate Chinese from Indian hardware firms in two ways: Indian firms see a greater impact from government provision of infrastructure, and Chinese firms see a greater impact from marketing support. These results are the same as we obtained for software firms. In addition, Chinese hardware firms perceive a greater impact from government support of R&D and access to technology. Tax concessions offered by governments do not differentiate the two countries' hardware industries.

Two government actions that hinder the growth of the hardware industry differ between China and India. Indian managers perceive greater adverse impact from government bureaucracy than Chinese managers, as was the case for software firms. High import tariffs and import restrictions have a greater adverse impact on Indian than on Chinese hardware firms. This difference might be due to the prevalence of assembly operations that use imported components among Indian hardware firms.

Summary of Main Differences. Chinese hardware firms have several advantages over Indian hardware firms. They have professional workforces that are more

independent and that achieve more quality certifications, and they benefit more from agglomeration. Larger firm size distinguishes them from Indian hardware firms. They benefit more from government actions, notably marketing and R&D support, and they are hindered less by inferior infrastructure, which is especially critical to hardware manufacturing, and have less need to incur the costs of building their own power supply. They suffer less from government bureaucracy. On the other hand, Chinese hardware firms surprisingly do not exceed Indian firms in labor productivity or in technology activity, and there is no difference in benefit from tax concessions or the effectiveness of the judicial system, as was also true for software firms.

Conclusions

Both the Indian and Chinese software industries are large and fast growing, but the Indian industry is an export oriented industry that produces mainly software services while the Chinese software industry is domestically oriented and makes more products than services. In contrast, the Indian hardware industry is small, slow growing, and mostly domestic in its sales whereas the Chinese hardware industry is very large, fast growing, and export oriented.

Indian software firms have an advantage over Chinese software firms on several factors that are important to software development for international markets. The Indian firms have more skilled professional workforces whose behaviors are adapted to software production. More Indian firms have achieved quality certifications. They have more foreign non-equity strategic alliances. Their industry is more competitive. Although infrastructure is inferior in India, this disadvantage is not decisive because some infrastructure is not critical to software production and that which is can be built-around or supplied by government in special technology parks. The factors that differentiate

Indian from Chinese software firms are those that are important to international business success.

In the hardware industry, Chinese firms exhibit some of the same characteristics as Indian software firms. These variables differentiate the firms both in the two countries' software and hardware industries, acting as mirror images. Chinese hardware firms have more quality certifications just as more Indian software firms do. Chinese hardware professionals act more independently just as Indian software professionals do. Both these features are associated with the more internationally competitive industry.

Other variables favor either one country or the other consistently across both industries, but they have opposite effects for international growth in the software versus hardware industries. Physical infrastructure, which is better in China than in India, is important to hardware manufacturing, and it differentiates the larger and faster growing Chinese hardware firms from their smaller and slower growing Indian counterparts. Both Chinese hardware and software firms have less skilled professionals than Indian firms, but professional employment is less important in hardware than it is in software, and this differentiation for hardware is not critical. Chinese hardware firms, like Chinese software firms, have fewer foreign non-equity strategic alliances, but these alliances are less necessary in hardware than in software.

Chinese hardware firms get greater benefit from government policies than Indian hardware firms, even as they are hurt less by infrastructure weaknesses and government bureaucracy. Chinese firms benefit from government marketing support and from R&D support and access to technology, neither of which had as high an impact on Indian hardware firms.

Some variables do not differentiate either software or hardware firms in the two countries, and others do not have the effects that are popularly believed. Non-residents, thought to be more important to Indian than Chinese software companies, are not. Neither the effectiveness of the judicial system nor tax concessions from government differentiate either country's software or hardware firms. Indian software firms do not have higher labor productivity than Chinese software firms, and conversely Chinese hardware firms do not have higher labor productivity than Indian hardware firms.

We suggest that this analysis of the factors that differentiate Indian from Chinese software and hardware firms will assist future research into the explanations for the performance of these firms.

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Table 1
Values of Explanatory Variables for Software and Hardware Firms
in India and China Samples, 2002

Variables	SOFTWARE		HARDWARE	
	INDIA	CHINA	INDIA	CHINA
FIRM LEVEL VARIABLES				
Number of firms	118	59	49	89
Software services firms (% of all firms)	76%	22%	n.a.	n.a.
Labor productivity (median output/worker)	$25,567	$29,625	$46,900	$30,000
Wages: starting wage for professionals (median $/month)	$315	$330	$137	$240
Skill: entry level qualification for professionals (median)	Prof/post-grad degree (17 yrs)	Dipl/under-grad degree (13-16 yrs)	Dipl/under-grad degree (13-16 yrs)	Dipl/under-grad degree (13-16 yrs)
Skill: professional employment/ total employment (median %)	69.1%	29.2%	23.4%	18.2%
Entrepreneurial orientation (mean of 3-item 15 point scale)	11.2	11.1	n.a.	n.a.
Follow instructions (% who follow instructions without questioning)	7.6%	37.3%	27.1%	12.5%
Agglomeration (mean score of 10 point scale)	7.5	8.9	7.2	8.1
R&D expenditures (median % of total cost)	5.0%	22.5%	2.8%	6.0%
Patent filing last three years (% yes)	20%	33%	8%	45%
Royalties & technology fees received (% yes)	79%	88%	98%	92%
Innovation: number of new products or processes (mean)	2.34	2.62	4.74	7.33
Quality: have CMM (software) or ISO (hardware) certificate				
% yes	47%	7%	71%	87%
mean number (those with certificates)	2.1	1.0	1.3	1.3
Foreign ownership				
mean stake, all firms	23.5%	28.7%	15.4%	32.7%
% with some foreign ownership	58.2%	32.2%	36.8%	38.5%
% with 100% foreign ownership	10.2%	22.0%	8.2%	23.1%
Foreign non-equity strategic alliances				
% with alliances	60%	12%	33%	22%
mean number (those with alliances)	6.9	4.9	5.4	5.7
Non-residents' role importance (mean of 4-item 20 point scale)	6.2	2.3	2.3	2.6
Capital intensity (fixed assets/employment)	$9,450	$5,425	$8,325	$6,763
Firm size (median sales revenue in 2002 in USD)	$6,451,000	$1,891,200	$7,140,000	$6,715,200

MARKET LEVEL VARIABLES (means of scales)				
Pricing power with customers (1=do not accept, 5=accept willingly)	2.48	3.25	2.02	2.60
Entry into the industry (1=very easy, 5=very hard)	3.03	3.72	2.76	3.49
Industry concentration (1=many small firms, 5=few big firms)	2.96	2.67	2.71	2.97
Threat from imports (1=no threat, 5=big threat)	1.98	4.28	2.89	4.38
Threat from foreign firms producing in home market (1=no threat, 5=big threat)	3.02	3.31	2.94	3.97
Gross margins compared to other industries (1=lower, 5=higher)	3.64	3.16	2.35	2.80
BUSINESS ENVIRONMENT VARIABLES				
Infrastructure: power cuts (1=no problem, 5=major problem)	3.12	1.92	3.16	2.60
Infrastructure: public transport failures (1=no problem, 5=major problem)	2.58	1.61	2.65	2.39
Infrastructure: have own electric power facilties (% yes)	87%	23%	82%	47%
Institutions: judicial system will enforce rights (1=disagree, 5=agree)	3.48	3.53	2.92	3.46
Government policies to promote growth (1=little impact, 5=great impact)				
Tax concessions	4.04	3.56	4.00	3.72
Provision of infrastructure	3.79	2.97	3.92	3.31
Marketing support	2.63	3.71	2.04	3.65
R&D support, accessing technology	2.81	3.58	2.68	3.43
Liberalized import policies	3.51	1.44	3.71	2.79
Government policies that hinder growth (1=little impact, 5=great impact)				
Bureacracy, paperwork	3.62	2.50	4.04	2.76
Travel restrictions, visa regulations	3.85	2.46	2.12	2.59
High import tariffs, import restrictions	3.20	2.02	3.82	2.63
Decreasing protection from imports	1.92	1.78	2.83	2.46

Source: IFC Survey

Table 2. Differences Between Chinese and Indian Software and Hardware Firms
Dependent variable indicates country of the firm: India = 0, China = 1
logistic regression coefficients

A. FIRM-LEVEL VARIABLES

VARIABLE	1 SOFTWARE FIRMS	2 HARDWRE FIRMS
Software services firm (1=services, 0=products)	-1.738** 0.937	n.a.
Labor productivity (output/employment)	<0.000*** <0.000	<0.000 <0.000
Starting wage for professionals ($ per month)	<0.000 <0.000	0.005* 0.003
Entry level qualification professionals (4=postgraduate degree, 1=no min. requirements)	-5.434*** 1.537	-4.796*** 1.723
Professional employment (%)	-4.555** 2.101	1.903 2.236
Entrepreneurial orientation (scale of three questions)	-0.178 0.216	n.a.
Follow instructions when not fully agreed (1=yes, 0=other)	3.823*** 1.306	-2.497*** 0.882
Agglomeration (scale)	1.758*** 0.539	0.478** 0.289
Quality certificates (SEI CMM for software, ISO for hardware) (1=have, 0=do not have)	-4.741** 2.360	1.470** 0.605
R&D expenditures (% of total cost)	0.055** 0.024	-0.040 0.030
Filed for patents abroad in last 3 years (1=yes, 2=no)	-1.260 1.393	-2.065* 1.1510
Received royalties or fees from abroad (1=yes, 2=no)	0.496 1.341	-1.126 1.836
Innovation (number of new products last year)	0.640** 0.286	-0.058 0.048
Capital intensity (capital/employment)	n.a	<0.000 <0.000
Foreign ownership (%)	0.026* 0.017	0.009 0.010
Importance of non-residents' role (5=very important, 1=no benefit)	-0.044 0.077	0.034 0.006
Foreign non-equity strategic alliances (number)	-0.739*** 0.290	-0.495** 0.221
Firm size (sales revenue in 2002, $million]	<0.000 <0.000	<0.000*** <0.000
Constant	5.153 6.080	15.286*** 5.901
Number of observations	152	106
-2 log likelihood	46.465***	65.295***

B. MARKET-LEVEL VARIABLES

VARIABLE	1 SOFTWARE FIRMS	2 HARDWRE FIRMS
Software services (1=services, 2=other)	-1.803*** 0.638	n.a.
Pricing power: Customers' reaction to price increases (5=accept, 1=do not accept)	0.830*** 0.343	0.539** 0.258
Price competition among firms: response to price increase (1=raise, 0=not raise)		1.090* 0.618
Ease of entry into the industry (5=hard, 1=easy)	0.983*** 0.408	0.478* 0.260
Industry concentration (5=few big firms, 1=many small firms)	-0.431 0.366	-0.046 0.252
Import threat (5=big, 1=small)	1.969*** 0.430	0.975*** 0.270
FDI threat: foreign firms producing home country (5=big, 1=small) [	-0.012 -0.393	0.540** 0.250
Gross margins compared to other industries (5=higher, 1=lower)	-0.420 0.393	0.547* 0.326
Constant	-9.660*** -2.755	-9.187*** 1.762
Number of observations	161	136
- 2 log likelihood	70.467***	93.069***

C. BUSINES ENVIRONMENT VARIABLES

VARIABLE	1 SOFTWARE FIRMS	2 HARDWRE FIRMS
Software services (1=services, 0=other)	-1.137* 0.698	n.a.
Power cuts (5=major problem, 1=no problem)	0.258 0.327	-0.507 0.367
Public transport failures (5=major problem, 1=no problem)	-0.213 0.375	-.995** 0.430
Have own power supply (1=yes, 2=no)	3.071*** 0.860	3.177*** 1.192
Judicial system will enforce rights (5=agree, 1=disagree)	0.459 0.416	0.695 0.445
Government actions to promote growth (5-point scales)		
Tax concessions	0.595 0.404	0.037 0.484
Provision of infrastructure	-0.818** 0.358	-1.588** 0.679
Marketing support	0.744** 0.319	1.183*** 0.362
R&D support, accessing technology	0.379 0.305	0.898** 0.428
Liberalized import policies	-0.677** 0.324	0.074 0.285
Government actions that hinder growth (5-point scales)		
High import tariffs, import restrictions	-0.017 0.429	-0.834** 0.378
Decreasing protection from imports	0.542 0.394	0.069 0.390
Bureaucracy, paperwork requirements	-0.732** 0.319	-1.797*** 0.589
Travel restrictions, visa regulations	-0.627** 0.309	-0.216 0.314
Constant	-4.416** 2.099	1.531 3.175
Number of observations	150	121
-2 log likelihood	65.731	

Standard errors below estimated coefficients. ***, **, * indicate statistical significance at the 0.01, 0.05, and 0.10 levels respectively; n.a = not applicable