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Sectoral system of innovation and patterns of specialization in the software industry: a comparative analysis of Brazil, China and Russia

Jorge Britto – UFF e RedeSist
José Eduardo Cassiolato – IE-UFRJ e RedeSist
Fábio Stallivieri - UFF e RedeSist

Introduction

In the context of a “knowledge economy” the software industry seems particularly relevant not only due to the embodiment of knowledge into products, systems and services but also because it provides the tools to adapt the characteristics of systems, channels, nets and organizations, accelerating the diffusion of new information and telecommunication technologies. The software industry is important not only because of its potential of direct economic impact – associated with a huge growth of industry and services productivity - but also due the critical leverage it perform for innovation across virtually every area of activity, playing a decisive role to improve intra and inter organizational learning.

The impressive growth of the software industry in India in the last ten years brought to the forefront the debate about the possibility of replicate this experience in others developing countries. In this sense, we can mention the emergence of some developing countries that followed India, becoming important players into the software industry, particularly some BRICs countries such as China, Brazil and Russia – see, for instance, Botelho, Tschang and Amsden (2003), Arora and Gambardella (2004), Commander (2003) and Carmel (2003). These countries have a complex, heterogeneous and sophisticated software industry, becoming effective alternatives to outsource software development and to exploit local capabilities in order to generate software solutions adapted to wider markets. Starting from this hypothesis, the analysis tries to use a sectoral system of innovation (SSI) approach to discuss the recent development of software industry in those countries. The analysis intends to understand the processes of competence building at the local level and their impacts to the improvement of knowledge diffusion and to the strengthening of innovation capabilities and competitiveness in the software industry.

The analysis seeks to explore analytical and methodological issues associated to the study of learning, innovation and competence building in the software industry, departing from a sectoral system of innovation (SSI) approach to analyze recent developments of the software industry in Brazil, China and Russia. The main focus of the SSI approach developed rely on the nature, structure, organization and dynamics of innovation and production, stressing the importance of some key elements (firms, networks, institutions, demand and knowledge characteristics) and of some basic processes to the improvement of productive and innovative capabilities in software industry. The study is also based on the hypothesis of the growing importance of localized innovations in the context of a “new learning economy” as defined by Lundvall and Johnson (1992). According to this view, the economic performance of firms, regions and nations is increasingly dependent on their ability to learn. Furthermore, although information and codified knowledge can be easily transferable across space, some crucial elements of knowledge remain deeply rooted in specific locations and institutional designs (Lundvall and Borrás, 1997).

The software industry presents some characteristics that might be considered in the analysis of learning, innovation and competence building processes. In this activity the critical productive factor is the knowledge embodied in qualified people with a creative and intellectual work capacity. Software

industry is consensually viewed as one of the driving forces of the structural changes generated by the ICT paradigm. The production of software is a design-intensive activity of intangible products, which are independent from the carrier media, and information is its basic material (Gaio 1992). In fact, the “products” generated by this industry are totally different from traditional industrial products, being basically made up of knowledge, an intangible factor associated with the creativity and intellectual capacity of specialized workers . In this context, the productive process does not present anything tangible, even if it has material support. The industry is also characterized by the dynamism at which innovations are converted into new products, services and technical solutions. The dynamism of the sector has an impact in terms of the high birth and mortality rate of firms as well as in terms of the volatility of company’s profile and market shares. The structural heterogeneity of the sector can be associated not only to the variety of products and services provided but also to diversity of competitive conditions associated with industries’ software segments. According to this interpretation, the strengthening of industrial competitiveness might also be articulated with local conditions that improve the potential of learning, innovation and competence building processes. The capacity to develop these solutions in a local base permits the accumulation of capabilities that makes possible the expansion to more sophisticated markets, including international ones.

The analysis to be performed tries to articulate this perspective to a discussion about the characteristics of the software industry in Brazil, China and Russia. The study tries to analyze and measure the learning, innovation and competence building processes within local productive systems, discussing the impacts of those processes to the strengthening of innovativeness and industrial competitiveness. Table 1 show that these countries have a very dynamic software industry. This industry has faced impressive rates of growth in the last years, followed by the strengthening of export orientation. The structure of the software industry in those countries seems also to be very complex with the presence of local firms in different segments of the industry and a spatial dispersion of them among different regions of them. Moreover, the evidences indicate that Brazil, China and Russia can become relevant players in the “second wave” of global outsourcing trend, followed the trajectories observed in countries like India, Ireland and Israel.

Table 1 – General figures of IT markets in Brazil, China and Russia

Country	Brazil	China	Russia
IT / GDP	1,3	1,7	1,6
IT growth 2004-2009 (%)	45	85	136
IT hardware - revenues (US\$ millions)	5.130	20.409	6.251
IT software - revenues (US\$ millions)	1.756	2.811	1.065
IT services - revenues (US\$ millions)	3.909	4.299	1.898
IT total - revenues (US\$ millions)	10.795	27.519	9.214
Growth revenues software 2004-2009	9,1	20,1	20
IT hardware – jobs	20.396	1.067.931	11.692
IT software – jobs	8.470	186.352	1.724
IT services – jobs	59.226	82.901	14.699
IT total – jobs	88.092	1.337.184	28.115
Growth jobs software 2004-2009	6,5	15,7	14,4
IT hardware – firms	298	14.902	642
IT software – firms	925	3.022	140
IT services – firms	2.208	3.958	2.264
IT total – firms	3.431	21.882	3.046
Growth of software firms 2004-2009	2,7	5,2	6
Software Exports 2004 (US\$ millions)	230	2.600	750

Source: “Expanding the frontiers of our digital future”, IDC and BSA – Business Software alliance , December 2005

The paper will be organized as follow. The first section involves an attempt to develop an historical perspective to discuss the processes of competence building in the software industry in Brazil, China and Russia, emphasizing specific characteristics of these processes in each institutional context. The second section presents some general figures about the software market in those countries, stressing the characteristics of its industrial structure and of the strategies adopted by local software firms. The third section tries to discuss the export orientation of software industry in Brazil, China and Russia, stressing the challenges and opportunities they faced in order to become relevant players in the “second wave” of global outsource software development. The fourth section develops an analysis about the geographical distribution of software activities in each country. The fifth section presents a discussion about the availability of human resources in software activities in the countries surveyed. Finally, the last section presents a synthesis of the main challenges faced by those countries to increase technological and productive competences in the software industry.

1. Software industry: historical perspective and political issues

1.1 - Brazil

The origins of Brazilian software industry lie back in a period of high protection and the “market reserve” policy to the informatics sector of the 1970/80s. As a corollary of a market reserve policy, particularly in the financial and government sector, computer users established in-house teams and organization competencies to develop software systems. The organization of software Brazilian industry is deeply articulated with the orientation of industrial policy to the IT sector as a whole. In this sense, the evolution of software sector in Brazil is usually divided in two main stages (Evans, 1995; Botelho, 1991; Tigre et al, 2001). The first period, before 1990, is characterized by import substitution, and the second, after 1990, by a progressive liberalization that induces a process of global competition. Until 1990, Brazilian policy for the software industry was mostly indirect, being subsidiary to a hardware policy oriented to the search of technological autonomy. During the “market reserve” period, the software industry got a pattern characterized by the development of copycats of the most popular programs. Despite the learning gains associated with this pattern there were also negative consequences related to the increase of hardware costs to final users, delaying and reducing the scope of IT diffusion and, more importantly, blocking their early development as sophisticated and mature software users.

After the liberalization of the 90s, a relevant change to software industry was caused by Law 8.249/91, which intended to give fiscal benefits to R&D activities. The essence of the legislation was to balance the liberalization with some supportive mechanisms for firms. It specifically aimed at providing assistance for local equipment manufacturing and R&D activities in the IT sector. Instead of emphasizing local technological development, the new legislation offered fiscal benefits if companies would commit themselves to a minimum level of local production. Government procurement policy should also, in theory, favors the acquisition of IT goods developed and produced in Brazil, as long as they had similar prices to imported equipment. In order to get these benefits firms should invest at least 5% of their sales from IT products (excluding software and professional services) on R&D activities, of which 2% should be through joint projects with universities, research institutes, or in government-sanctioned IT programs. The definition of “R&D activities” has been too broad (including training for example) and the government never implemented a monitoring program to assess the effectiveness of these measures.

A focus on promoting an export drive was maintained when the general focus of industrial policy change from import substitution to trade liberalization in the 90’s. To software industry, the major policy initiative to getting this aim was the creation of the SOFTEX-2000 in 1992. The program wanted to strength the software national industry and to promote the commercializing of its products and services abroad. SOFTEX 2000 had the target of exporting US\$ 2 billion worth of software in the

year 2000 and estimated that 50,000 new skilled jobs could be created. The strategy was to have agents responsible for the development of a foreign region through the establishment of local offices (Beijing, Tokyo, Silicon Valley, Boston, etc.). Offices assisted interested firms in market studies, setting up sales and marketing partnerships and participating in major trade shows (e.g. Comdex, Cebit, etc.). Since its creation, about 400 firms have participated in international software trade shows. At the end of 1996, the SOFTEX Society, a private non-profit organization, was established to manage the SOFTEX program. The emphasis of the renewed initiative became the promotion of entrepreneurship, training, funding and market orientation, as well as exports, although less so than before. Among other aspects, the idea of having offices around the world was dropped. The new perspective tried to replicate the pattern of Silicon Valley and Route 128 regions, which ascribed a critical role to incubators for the growth of high-tech firms, which did not exist at the time in Brazil. In 1997, SOFTEX launched Prosoft, a pilot credit program for software firms in partnership with the National Banks for Social and Economic Development (BNDES), with a budget of USD 35 million to run until December 2003. The limits of the export strategies coordinated by SOFTEX might stressed the difficult that firms form emerging markets face with they try to shift their orientation to export markets given the lack of experience and reputation. At its inception SOFTEX estimates deemed possible that by the close of the century the software exports of SOFTEX-supported companies would have reached USD\$2 billion. However, by 2000 all software exports, supported by SOFTEX or not, may have reached, USD\$100 million, twenty times less than promised. In this sense, the main real reason for the failure of SOFTEX export strategy was the absence of a client-led drive. Rather than trying to find first who are the clients that might be attended and then sorting out how and what products could be sold to them, the drive was put behind pushing what was available, without a focus in which segments and which markets could be properly exploited.

There are also another signals that the main policy focus – understood in a broader sense, including no only directly public agencies – began to change to the improvement of quality and productivity in the software sector. These changes underlie a process of “institutional learning” that was experienced by Brazilian institutions that support software industry. As an example of this process we can mention the built of the “New Brazilian Software and Services Industry Support Program” carried by SOFTEX and APEX (Brazilian Trade and Investment Promotion Agency), a medium term national program of certification, lined up to the international parameters, to reduce barriers to the entrance of national software in the international market. The general purpose of the program is to increase the competitiveness and the productive capacity of the sector, with the strengthening and magnifying of national companies penetration in the internal and external markets. The program wants to increase the Brazilian companies’ software and services exports, utilizing the high degree of quality that was reached in some segments, such as: financial and banking, security, telecommunication, electronic business, enterprise management and public services automation. The idea is to identify windows of opportunities in contracts for outsourcing of services, progressively building an international image of Brazil as supplying of software and services based on IT. It also try to foster the development of emerging segments with high growth potential, as wireless communication; digital TV; agro business; visualization and entertainment; applications for clusters and computer grids.

1,2 - China

The first impetus for creation of a software industry in China came during the 1980s, when the diffusion of the desktop computer introduced a need to develop operating systems and packaged software with Chinese language processing capabilities. Most producers of software during the early 1980s were government operated research institutes, while spin-off firms from these research organizations were only gradually emerging. Software production was primarily regarded as a research activity that was concentrated in the Chinese Academy of Sciences and research institutes under the

various sectoral ministries. Priorities for new software development were determined administratively under the planning process, and appear to have been dominated by the demands of key economic sectors and defense. Although software received more attention from policy makers in the 1980s, this activity did not gain a fraction of the resources set aside for the electronic industry in general, and there was no recognition of the need for extensive training of software engineers, support for application of software in society, or an independent software industry as such. By the middle 1980s, China became more open and some university and research institutes began contracting data entry and simple programming work from foreign companies. On the one hand, the changes that took place in the system of management of research organizations provided new incentives for entrepreneurial scientists and engineers to try to exploit their knowledge of computers and software in the market. On the other hand, the new markets for PCs and associated software products created by economic and administrative reform gave the entrepreneurs greater opportunity for developing new spin-off firms and to sustain growth through the early stages of development.

A significant impetus for new software development came from major research projects launched under the Sixth Five-Year Plan (1980-85). While the 1980s witnessed the birth of high-tech IT firms serving a new mass market formed in China, much of the industry was still dominated by assembly of microcomputers and software that was bundled with the computer sales. During the 1990s, however, the production of computers in China grew explosively and a wide range of organizations installed computerized systems for financial or administrative purposes. So, the diffusion of IT hardware in Chinese society created a fertile ground for the establishment of independent firms that would provide specialized software and services. The expansion of the telecommunications sector, including new systems for mobile telephony, provided another opportunity for domestic vendors with a technological strength in software development to capitalize on the emerging markets. At the same time, the institutional environment for creation of high technology ventures was becoming increasingly supportive, with initiatives such as the establishment of High and New Technology Industry Parks and the Torch Program setting up incubation centers, together with many acts implemented by local governments, giving a sense of encouragement that had not hitherto been available. However, the market for software was still heavily influenced by attitudes of users and government authorities that still had little appreciation for intangible products – with widespread illegal copying and marketing of software, which received little protection from legal authorities. Interestingly, the diffusion of software through illegal copying might paradoxically have helped Microsoft gain its dominance in the Chinese market through network effects. In this context, customized software and services (including services bundled with IT sales) were easier to sell, which in turn led to the predominance of administrative programs for specific sectors of the Chinese economy (telecommunications, financial sector, energy, education), as well as various forms of system integration.

The latest era of networking and extensive computerization of administrative tasks in Chinese public and private organizations has provided a key driving force for the current and future growth of the Chinese software industry. This process – associated with the concept of *xinxihua* [Informatization] – has been further fuelled by a number of policies promulgated by the Chinese Government since the late 90's. During the end of the 1990s it was observed a boom of Internet service providers (ISP) and content providers (ICP) that emerged by the thousands. A distinguishing feature of this era of software development in China is the new and extensive role of government sponsored projects in fuelling the market. During the early 1990s, several “Golden Projects” were launched for the development of advanced information networks such as the Golden Bridge for exchange of economic data, the Golden Card project aiming at the provision of a secure network for credit cards, and the Golden Customs Project with a network for foreign trade. These procurement projects sought both to support the domestic software industry and simultaneously to enhance key economic sectors such as finance and economic planning. More recently, a series of e-government projects have been initiated by national as well as local agencies, leading the establishment of more extensive networks in a wide range of sectors.

They are also followed by government-initiated enterprise on-line projects that will install web facilities in a large number of state-owned or controlled enterprises in China. Promoting e-commerce and e-citizenry in China, these projects are also intended to capitalize on the recently expanded telecommunications network and familiarize Chinese organizations and citizens with computerized transactions.

At the beginning of 2000, the Chinese government launched a policy package under the “No.18” document, called “*Some policy to encourage the development of software and IC industry*”. Following that, in 2002, the government launched a second very important document called “No 47” called “*The principle of rejuvenating the software industry*” which covers more than the earlier one including financing, exporting, human resources, government procurement and others. In the “No.47” document, it explicitly said that, from 2001 to 2005, the total national fund for R&D for software will be about 4 billion yuen. (CSIA, 2003) They not only opens a huge market for the software industry, such as e-government, but also gives local companies a good opportunity to development an autonomous operating system software for this strategy, exploiting the support from the government to Linux-based projects. The Chinese government has also intensified its direct support for software industry, for example, by encouraging the establishment of software parks (*ruanjian yuan*) or software bases (*ruanjian jidi*) in major Chinese cities. After the first wave of proliferation of software park initiatives, there has been an effort from the government to encourage more advanced facilities, and the Torch Program has certified 22 parks nationally.

The Chinese government's emphasis on expanding the use of information technologies in schools, public sector agencies, and businesses has led to increased spending on computer equipment and should continue to affect demand in the future. Over the past 10 years, there has been a huge investment in China's Telecoms infrastructure and the country has seen massive growth in the market for mobile-phone services and improvement in the speed of Internet connections. The the number of telephone main lines (per 100 population) increase from 5.7 in 1997 to 16.7 in 2002. China also has the largest market for mobile-phone services in the world, with over 200 million subscribers. Another important evidence of the dynamism of IT markets in China is the impressive growth of the Internet basis. By July 2004, more than 87 million Chinese were "netizens". The Internet community in China has already multiplied 140 times in more than six years from 1997 to 2003. In 2003, according to CNNIC, 36.3 million computers are connected to the Internet. There are almost 626,000 websites, up 32.2% compared with the same period last year. China has also emerged as the second largest IT hardware producer in the world behind the United States and is followed by Japan and Taiwan, in that order.

1.3 Russia

In the former USSR software was traditionally a relatively neglected field outside the military sector. In the late 1980s, software comprised only 1.5 to 2 percent of the total outlays on computer systems, despite the fact that there were approximately 500,000 programmers. In the 1990s, Russia began a transition to a market economy, and many skilled software engineers left the low-paid state enterprises, research institutions, and universities. Between 1988 and 1994, a massive departure of software developers from Russia to the West occurred, resulting in a deterioration of its intellectual base due to emigration as well as a marked decline in funding for R&D generally. However, Russia not only retains vast pools of untapped technical resources, but also continues to produce large numbers of highly skilled graduates educated in the proud academic tradition preserved from Soviet times Forty percent of university degrees are awarded in technology and science, and Russian universities produced more than 45,000 IT engineering graduates in the 2003/2004 academic years, including more than 22,000 math and physics graduates. Many of those professionals that came from low-paid state enterprises, research institutions, and universities also moved to new Russian startups in the software

segment that had emerged in the late 90's. From 1994 to 1998, the growth continued and the first success on the international market was observed, with the creation of Software Development Centers of Motorola, Intel, LG, Sun Microsystems, Boeing and Samsung. From 1998 to 2002 we can observe the consolidation of local firms, which progressively moved from mere outsourcing to specialized products and services and partnership relations, based on intensive certification and through a process of penetration on the US market (such as VDI, Luxoft, Auriga, EPAM Systems, SPIRIT).

The position of the state to the software development industry has moved from complete ignorance towards consideration of the sector as an important engine to the economic growth. In this sense, the government support for IT has increased dramatically in the last years. In 2004 an intensive dialogue between IT Associations and the Government resulted in the official adoption of the resolution entitled the "National Concept for IT Market Development in the Russian Federation", which is characterized by the following key elements: (i) deregulation of IT exports (diminishing of bureaucratic barriers in tax and customs' regulation, in export control); (ii) support for the international marketing efforts of Russian IT companies measures ("computer for everybody", stimulation of IT consumption, etc.); (iii) support for the Quality Assurance certification efforts of Russian IT companies; (iv) domestic market stimulation; (v) support for an IT-parks development initiative, through the application of "special economic zone" regime, assistance to obtaining rights on land on the regional level, allocation of State investment in infrastructure, cut of taxes in IT-parks; (vi) tax holidays and favorable tax laws for the IT industry; (vii) state investment in industry infrastructure; (viii) creation of a state owned investment fund for IT businesses; (viii) enhancement of IPR Protection system in IT.

In 2003 the government of the Russian Federation also approved "*The Concept of the Development of the IT Market in the Russian Federation,*" proposed by the Ministry of Information Technologies and Communications. The concept of the industry's development contains proposals on modification of the legislative base in the field of IT, mainly concerning customs and tax regulations. The measures suggested are expected to induce a growth in the IT market of 30 percent annually between 2004 and 2010. If these measures are introduced, the IT market in Russia may be worth as much as \$40 billion in 2010 (according to the Ministry). The IT and Communications Ministry also intends to launch techno parks in Dubna, St. Petersburg and Novosibirsk, including tax breaks and an up-to-date communications infrastructure, trying to replicate the policies implemented a decade ago in India to stimulate the IT industry in Bangalore. Russian software firms are supporting this initiative such as LUXOFT that has already established its development center in Dubna. Other companies are developing techno parks in St Petersburg, Novosibirsk and Nizhniy Novgorod, with more to come.

The Ministry of Information Technologies and Communication is the official coordinator of the implementation of the "e-Russia" Program, which involves an intensive investment in Telecom infrastructure all over Russia, based on an agreement with the APKIT Association. Electronic Russia 2002–2010 is a US\$2.6 billion program approved by the Russian government, which intends to promote e-commerce and Internet use in the country. The goal of the program is the broad implementation of information and communication technologies, free distribution, transmission and receipt of information, and the training of IT specialists and users. Program objectives include the formation of an efficient IT legislation compliant with international laws, the effective and broad use of IT in social and economic spheres, IT-based training and the creation of conditions for development of e-commerce.

In the last years, some associations have also begun to perform an important role in the development of software in Russia. They organize specialized events for promoting technologies among local software companies, assisting them to access federal and local governments, organizing numerous events in Russia and abroad and mobilizing industry resources for solving strategic tasks of the software sector. Those associations have been following the path blazed by NASSCOM in India at the 1990s. The Russian offshore programming industry has formed RUSSOFT to promote the nation's

IT industry. RUSSOFT includes the largest and most technically competent software development companies and the chamber of commerce of the IT software and services industry in Russia, with more than 70 companies from major IT regions of the country and Byelorussia, mobilizing more than 6,000 highly qualified developers, generating export turnover of \$350M in 2002, covering all spheres of IT competence and having customers in the U.S., Canada, Far East, and all parts of Europe. A close interaction with the government in formulating National IT policies is one of many initiatives led by RUSSOFT, which also plays an active role in the international software community by providing up-to-date information on the Russian software market. Among the targets of RUSSOFT activities, it can be mentioned: (i) the creation of a highly competitive and internationally recognized sector of the Russian economy and to deliver exceptional solutions of high value to our customers; (ii) the promotion of existing export capabilities of the Russian software development industry in the International IT markets; (iii) the attraction of investments and the increase of commercial strength of the industry in the major markets; (iv) the introduction of internationally accepted project management and quality assurance systems throughout the industry; (v) the development of a lobby to the promotion of the export software industry, through the creation of a favorable and stable legal environment, a strong educational system and a advanced infrastructure. Another national IT association APKIT (Information and Computer Technology Industry Association) involves more than 200 companies, being the most representative non-profit IT organization in Russia. Its members are the largest domestic and international companies in software, hardware and equipment production, the leading domestic distributors, system integrators, Russian IT manufacturers and developers. The total sum of annual revenue of the Association members is more than \$ 3 billions, with their members hold up to 70% in a number of sectors of IT market. This association has acted as an umbrella which covers all segments of IT industry, acting as a direct partner to the Ministry of IT and Communication in elaboration of the “Conception of Russian IT market development” and participates in committees and public councils.

2. Software industry: main figures and market structure

2.1 Brazil

In the last two decades Brazil develops a dynamic and large software industry, becoming an important player in a sector that has faced an impressive growth. However, a rigorous identification of the dimension of Brazilian software market is not an easy task. Data from different sources are often contradictory in the evaluation of the size this market. Two elements make particularly difficult this kind of evaluation. First, software activities are usually extremely integrated with other IT activities at the business level, in a way that ones of the most important firms of the market do not have software as its core activity. Second, the business model of the relevant players is also quite heterogeneous, sometimes being based on product, sometimes with the services assuring the larger slice of their sales. According to IDC Consultancy Group (2006) the Brazilian Software and Services market occupies the 12th position in the global market (considering the amount of domestic sales) in 2005, with sales of approximately 7,45 billion dollars, equivalent to 0,95% of the Brazilian GDP that year and of 1,1% of the global market. Out of this total, 2,72 billion referred to software licensing, which represented close to 1,2% of the global market and 41% of the Latin American market. The remaining 4,69 billion referred to others services. According to IDC, an amount of 7.760 companies would exploited the sector, from which 6,040 would be involved directly with the commercialization of software (being 1,850 dedicated mainly to the development and production of software and 4,190 to resale and distribution activities) and 1,720 mainly oriented to the supply of software services. Among the firms oriented to the development and production of software, 667 could be classified as “micro” firms (with less than 10 employees), 1,075 as small firms (between 10 - 99 employees), 94 as medium firms

(between 100 - 500 employees) and only 14 as large firms (with more than 500 employees). Studies also forecast an annual average growth rate over 11% by 2009. Despite the fact that the Brazilian software market is still largely supplied with foreign software, whose participation is about 71%, forecasts indicate that this participation should drop to 66% in the next five years, with increase of domestic products participation in the market.

The origins of Brazilian software companies are quite diverse. We can observe an intense process of firm creation during the previous decade, but there are some evidences that this process lost part of the impetus during the last years, being replaced by a tendency of firms' consolidation and specialization. According to a survey coordinated by Botelho et alli (2002) the majority of software companies were established from existing firms, part as a true "spin-off" of the mother company and the majority as independent companies created by employees of the mother company that spotted a new opportunity in the course of their work. Three others alternatives seem to be relevant as patterns of firm creation in Brazilian software industry. First, there are a lot of individual start-ups created by the talented entrepreneurs to explore new opportunities emerged from the industry growth. Second, there are a limited number of university spin-offs, most of them oriented to segments where the previously market experience seems not to be indispensable. Finally, we can mention the prevalence of strong government software firms, usually specialized in the manipulation of a high volume of data (SERPRO, as example).

The main focus of Brazilian software industry is the internal market, contrasting with the international market orientation of software industry in countries like India, Ireland and Israel. The emphasis on internal market must be explained by the huge internal demand and by the sophistication of productive structure of Brazilian economy, despite the macroeconomics problems it have faced during the last two decades. The extensive diffusion of informatics since the 70's and the explosive growth of IT in the last part of the 80's and 90's generated a string demand for virtually all kind of software products and services. Data from IDC also indicate that approximately 47% of the sales of software products in 2005 are from applications for specific users, followed by sales of infrastructure software (including management software for systems and networks, security software, storage and backup software and operating system software) with 33% of the sales of software products. Concerning software services, the sales are almost equally distributed between system integration (development of IT solutions to meet technical specifications defined by the customer to meet its business needs), outsourcing (in which a service provider external to the organization assumes responsibility for the management and operation of all or part of the customer's IT infrastructure) and support (software installation, customization and configuration, as well as technical support services to users). The software markets may also be classified according to vertical market criteria. These criteria consider the productive segment attended by software products and services. In this sense, evidences show that that financial services, general services and industry are the segments that concentrated the larger number of firms in the sample. Although they offer services for diversified areas, the majority of the activity is concentrated in a few sectors, with which they have been working for some time and for which they develop sophisticated solutions. In fact, since the 70's the financial segment and the public sector have been responsible for a huge demand of software products and services. IDC (2006) indicates that approximately an half of software sales are divided between industry and finances services, followed by services, trade, government, agricultural industry and others. IDC also points out that, from the point of view of software users, IT investments is supposed to increase by 16% in 2006.

The structure of Brazilian software followed a pattern in which the multinational enterprises tend to reinforce their positions in the horizontal market, leaving for the Brazilian companies the vertical segment, as is the case of national banking software. Despite the fact that they control only 20% of the sector, we can found an important presence of Brazilian companies - most micro and small firms - in almost all areas of the software market. Brazilian software firms often have various lines of business and simultaneously develop service and product activities, with a greater or lesser

preponderance of each of them, a pattern that can be found in countries in which the majority of companies develop services, like Brazil, India or China. Since national companies that develop software are small-sized and that competition in this sector is closely related to concentration and fragmentation, the market strategies may follow the following alternatives: *i)* “niche strategy”, when a company tries to specialize in meeting the needs of a particular group of clients, accumulates knowledge/information that will allow for the development of products that incorporate specific functions; and *ii)* “interstice strategy”, where companies must take advantage of the multidimensional character of software for the implementation of product differentiation in order to occupy markets of large proportions, left behind by leading companies, keeping in mind that the line of products of the later will never have total inclusion, offering all possible varieties.

Although the possibility of generating continued gains from those strategies, we can identify a general process of industry concentration in Brazilian software industry. The increase of international competition and the sophistication of consumer demands - elements that tend to reinforce the importance of availability of financial resources and distribution channels - contribute to this process, making harder the maintenance of market shares. To local firms the impacts of these tendencies might be disruptive: large users tend to adopt a risk averse purchasing attitude that favors the selection of established foreign suppliers, whereas small and medium sized enterprises (SMEs) are not willing to pay a premium for the domestic firms’ unique knowledge. These tendencies might also be observed from data extracted from annual surveys about the Brazilian software industry. Due to the increasing competitive pressure of foreign firms on their vertical niches domestic firms may try to stay ahead of the foreign competitors by constantly entering new growth market segments. These markets should be large enough to generate margins to finance the development of component-like products, which can assist suppliers in facing up foreign competitors when these niche markets mature into full blown markets. Local firms should also be able to provide a superior service and semi-customized products at low cost to an expanding number of SMEs, especially in areas where these are also growing to become larger and more competitive, perhaps with international ambitions. They can also try to ship software/software components and services of high added value, followed by customizable products. A corollary of this process is the attempt to maintain and improve relationship with more profitable customers.

Concerning property rights, data collected by MCT-Sepin from a sample of 446 firms indicated that 16,5% of firms used to register copyright rights in a systematic way and 6,5% occasionally. In this sense, Brazil’s legal system is moving in step with international intellectual property protection standards, with the country being a signatory of the Agreement on Trade-Related Aspects of Intellectual Property Rights (“TRIPS”). Intellectual Property protection includes Copyright Law No. 9610/98 (the “Copyright Law”), Software Law No. 9609/98 (the “Software Law”), and several other secondary laws. Brazil was the first country in Latin America to enact legislation specifically designed to protect software by copyright. Concerning the question of property rights of software, we can note that the piracy rate of 64% is still high, but not as high as China or India, and Brazil is making efforts to reduce it.

As regard the technical qualification, data collected demonstrate that only 18% of software firms got quality certification standards such as CMM or SPICE. Brazil software process improvement in the last ten years have favored the ISO 9000 certification, generating a situation in which the number of local firms that have reached high levels of CMM is extremely limited. With regard to process qualification, it was observed that only a small number of Brazilian software firms have high maturity certification in the software development process (CMM level 3 or higher). Data collected from a survey carried out by Mayer & Bunge Informatics Consulting in 2004 with 461 firms Brazilian software firms show that only 5% of the firms surveyed had got CMM quality certification in 2004 and only 0,8% a level equivalent to CMM level 4 or higher. Since 2004, these figures have evolved in a positive way. According to the Integrated System Diagnostics– ISD-Brasil, a subsidiary of the

American ISD Inc is authorized to make official evaluations about CMN conditions, there are 49 firms that are in process of getting CMN certification and 21 firms getting CMNI certification in Brazil in 2006. Among them, there are one firm that have already gotten a level 5 CMNI (EDS, an US-based MNC) and 6 firms that have already gotten a level 5 CMNI certification (BRQ Soluções em Informática; IBM, Stefanini and Tata Consultancy Services). The Brazilian Software Process Improvement (MPS-BR) is also an initiative oriented to the creation and dissemination of a Reference Model for the Software Process Improvement in Brazilian industry, enabling the assessment, quality improvement and products and services productivity adequately to Brazilian companies' culture and profile and responding to software quality international standards. The MPS-BR involves a set of public and private agencies - SOFTEX Society (Project Leader), COPPE/UFRJ, CenPRA – Campinas, CESAR & SOFTEX - Recife, ABNT & CELEPAR (Standards and Guides) – in order to create and improve a Process Reference Model (PRM) and a Process Assessment Model (PAM), compatible with CMMI, based on the reality of the Brazilian firms. The idea is to implement and assess the MPS Model in the Brazilian software companies, mainly oriented to the small and medium-size enterprises (SMEs), in all regions of the country, with feasible costs. The program is also based on the built of an “Accreditation Forum” responsible for certification.

The patterns of segments' specialization of Brazilian software companies affect directly the intensity and distribution of innovative efforts. Concerning this point, there are evidences that companies that are active in more structured market segments, in the areas of telecommunications, integrated management software and industrial automation, as well as in banking and financial software, form part of a group that is outstanding from the point of view of investments in technological qualification and Research & Development (R&D). Software for e-business and document and content management occupies an intermediate position, appearing after a group in which systems integration and the governmental area are included, which shows that is it associated with activities having fewer R&D requirements. Re-investment of their own capital constituted the main source for financing the growth of companies, but recently almost all the companies obtained external financing, through private risk capital and governmental programs. Despite that, the financial mechanisms, especially for small and mid-sized innovative companies, seem to be inadequate to give the proper infrastructure to finance R&D efforts in the software sector. In this sense, we can observe that one of the main financial instruments for software company growth is risk capital, with the consolidation of venture capitals markets by the initiative of institutions like FINEP (the Brazilian government agency dedicated to the financial support of innovative activities) can giving an important contribution.

Due to the extension of internal market, Brazil can explore a lot of comparative advantages is areas such as banking and commercial automation, telecommunications, enterprise management and automation of public services and free software. Beyond the experiences of these segments, there are others opportunities that can be exploited by Brazilian software companies. Because of the broadly impact of IT, the development of digital games to PC, mobile phones and Internet is a software segment that had experienced a huge growth during the last years. This segment is very young not only in terms of firms that have recently entered into the market but also due to the age of technicians and entrepreneurs that are responsible by the development of those games. Despite their small size, approximately 50% of the firms have already a presence in international markets. Some research centers in the area have a pattern of excellence, being articulated with universities such as PUC-RJ and UFPE. The local market for digital games is estimated in somewhere between R\$ 70 million and R\$ 300 million. The firms from the segment have already developed 35 games to PC in the last two years. Currently, we have also 25 games being developed by the sector. The international market to the segment is estimate in around US\$ 22 billion. Another segment that seems to be attractive is related to the development of visual applicative to petroleum industries in areas such as geosciences, engineering, environment management and operational security. Petrobras, the Brazilian state petroleum company,

is the main client of those technologies, particularly through 10 centers of virtual reality installed in its units. In the broadcasting area there are also opportunities for software firms that have been opened by the diffusion of digital signals associated with the advent of high definition television market. The dynamics of innovative efforts in software industry can also be articulated with the growth of free software / open source software (FS/OS) that can be produced by Brazilian firms. In this segment, Brazilian developers tend to become highly professionalized, with a predominance of qualified professionals: systems managers, network technicians, entrepreneurs, researchers, and college students. Among development companies, however, small companies prevail, but larger companies have already adopted this model as well. The market for FS/OS-based operating systems in Brazil is estimated to have a minimum volume of R\$ 77 million, considering only the sale of Linux distributions and related services, with potential to grow 2.5 to 3 times by 2008.

2.2 China

Actually, software is inserted in a very dynamic IT market, which has faced an impressive growth in the last years. China's IT hardware output doubled between 1999 and 2002 due to China's lower production and labor costs, investment incentives, and relatively reliable infrastructure. U.S., Japanese, and especially Taiwanese suppliers have established a manufacturing presence in China to gain market access, but domestic firms, such as the Legend and Founder Groups, now present a significant competitive challenge to the foreign subsidiaries as a result of aggressive pricing tactics and their close-knit relationships with government buyers. The manufacturing of IT products in China is growing more rapidly than China's overall industry: from 1990 to 1999, the Chinese IT industry grew at a rate of 32 percent per annum and from 2002 to 2003 at a rate of 34 percent to reach \$235 billion, with China becoming the third largest IT equipment producer in the world. IT exports also continue to grow rapidly. For example, in 2003, China exported \$80.6 billion, representing approximately 50 percent of its total production.

While IT services represents a relatively small portion of the total IT market compared to hardware, this segment is expected to grow substantially as the notion of procuring IT services becomes more widely accepted in China. According to International Data Corporation (IDC), China's market for IT products and services reached \$22 billion in 2002 and is expected to exceed \$40.2 billion by 2006, representing nearly a 16.3 percent compound annual growth rate (CAGR) during these years. In 2002, hardware accounted for 73 percent of this overall market, followed by packaged software (10 percent) and IT services (17 percent). China's software industry has been growing at an annual rate of about 30% during the past several years. By the end of 2002, the number of registered software companies reached 6.282, with revenue of 110 billion yuen or 13.3 billion US dollar. But generally, the Chinese software industry is monopolized by foreign companies. The operating system market is dominated by Microsoft, while domestic companies only get one third of total Chinese market. Besides the operation system, the main application software in the banking, securities, civil aviation and metal industry use imported software. Application software such as pre-packaged financial services, security systems, electronic publishing or education products (65% of sales) dominate the product market, followed by smaller shares of supporting software such as application development tools (21%) and system software (14%). In 2004, according to the Software Industry Association, the market would reach RMB 210 billion, representing annual growth of 29%, with system integration and software services together reaching RMB 109 billion compared to RMB 101 billion for software products. The majority of software companies are located in Beijing, Guangdong, Zhejiang and Shanghai, with private and foreign software companies dominating the market

For accounting and financial systems, the domestic producer's share is even larger, but also fragmented with many small software firms and regional specialization. The large share captured by domestic producers is related to the unique accounting practices and management standards adopted in

China. Meanwhile, increasing demand from small and medium-sized enterprises is also helping to drive the enterprise software market. In 2003, the market size for small/mid-sized enterprise software was RMB 1.9 billion, which is expected to increase to RMB 5.5 billion in 2008. The total enterprise software market is estimated to grow to RMB 9.7 billion in 2008, representing a CAGR of 19.6% from 2003. Government investment in software represents a major market for software companies. Evidences indicated that 30% of the governments IT investment was spent on software and IT services. Investment in this area is expected to remain on a growth trend for the next several years. In 2004, forecasted total e-government expenditure to hit RMB 40 billion, including RMB 14 billion in software and services. E-government spending is expected to grow to RMB 49 billion in 2005. The government channels a portion of its software purchasing to domestic companies to support the domestic industry.

The domestic industry is extremely fragmented, with thousands of very small enterprises with fewer than 50 employees that lack economies of scale or distinctive competencies. These firms typically focus on developing niche applications tailored to unique needs of the domestic market (e.g. systems integration or specialized financial software developed for China's unique accounting practices) and adopting products to Chinese language platforms (e.g. education software.) Given the rapid growth of the markets for software products and services in China since the late 1990s and the policies introduced since 2000, there has been a very high rate of growth of new entrants into the industry while, at the same time, a group of Chinese software firms with established reputation have become relatively large. In 2002, there were 5700 software companies, among which only 50 companies had more than 1,000 employees, while two companies had yearly sales revenue more than 5 billion RMB Yuan (about US\$ 600 million). Domestic Chinese software and systems integration firms with an annual income in 2002 of more than 500 million RMB Yuan represented 0.8 per cent of all firms in the sector, while those with annual revenue less than 10 million RMB Yuan constituted 75 per cent. Nevertheless, the proportion of software and systems integration firms that earned revenues larger than 10 million RMB Yuan in 2002 formed almost 25 per cent of firms in the sector. A small group of 19 firms had revenues exceeding 1 billion RMB Yuan in 2002. In other words, although a group of Chinese domestic software firms had become reasonably large, the majority is very small.

Software producers in China also include a group of fairly large companies. Telecommunications firms are very active in the sector, reflecting the role of the market for digital communications and wireless switching system in China during the last decade. The increase in revenue from embedded software products is especially important for telecommunications equipment producers such as Huawei, ZTE and Putian Eastcom, which now earn 20-35 per cent of their revenue from embedded software. Services such as systems integration has been a crucial component of the information technology market in China, and this type of service is still very important, partly on account of the low level of IT systems users. Domestic producers have captured major shares of software markets related to management and administration in Chinese organizations. The two leading domestic providers of enterprise resource planning (ERP) systems in China, UFSOFT and Kingdee, supplied approximately 32% of the 1.6 billion yuan market in 2002, while international vendors SAP and Oracle together provided less than 20%. Among China's top software companies it can be mentioned: Huawei Technologies; ZTE Corp; Eastcom Group; Digital China; Beijing Ericsson; Beida Founder; Microsoft China; Neusoft; CS&S and Datang Telecom.

Software services, primarily of systems integration, account for more than half of China's total software output. This is at least in part due to the extremely high rates of piracy in the industry (over 90%) that provide a strong disincentive to develop new products, while services do not face piracy risk. It is also very difficult to be a specialized software producer in China: there is great pressure to become not just a producer of software technology, such as an office automation product, but also to become service provider and also a systems integrator for the same customer. As a result many of the largest software developers in China are diversified IT firms, such as Founder and Legend. Telecommunications equipment manufacturers, Huawei and Zhongxing, for example, are among the

largest software producers in China because they develop most of their own software internally. System integration services are also important sources of revenue for many firms. Dedicated software firms like Microsoft (China), NEU-Soft and UFSOFT only represent a minority of the largest companies. UFSOFT and Kingdee are the main specialized domestic software companies. This reflects their dominance of the financial software market, with the two firms being responsible for about 60% of China's accounting software market. This is due primarily to their privileged knowledge of Chinese financial and managerial practices. They have also benefited from the preferential purchasing practices of Chinese government agencies. Simultaneously, multinationals have developed large operations in the Chinese market. Foreign corporations, including Microsoft, IBM and Oracle, dominate the software product market in China--accounting for over 65% of packaged software sales--because of their established brands and products. In fact, China is the largest developing country market in the world, and, for certain products, it is rapidly becoming one of the overall largest markets in the world. Many foreign goods must be localized to meet the special requirements of the Chinese market. In this sense, his market has become increasingly competitive in recent years with new entrants as well as the emergence of new niches. Not only big foreign software companies have entered into China's software market, but also medium and small-sized international companies have also begun to enter it. Years ago it was mainly American, European and Japanese companies, but today large and medium-sized Indian software companies (Tata Group, NIIT, QAI etc.) have joined entered, too.

In this sense, China's software industry exhibits a high level of heterogeneity, with a group of large firms producing software for telecommunications and another group offering systems integration dominating the sector. Few of the dedicated domestic software firms have reached a level of revenue that includes them among the 50 largest producers. In terms of ownership patterns, the software industry is dominated by more than half of the firms operating under a limited liability registration and twenty per cent under private ownership, while state ownership remains a small minority and around fifteen per cent is under foreign ownership.

Most of the companies in China are using legacy mainframe-base data systems that are being transformed into or replaced by new systems. In this sense, the setting up manufacturing bases in China by global companies tends to accelerate the demand of enterprise resource planning (ERP) and supply chain management (SCM) applications. Banking and telecom were other potential areas for software products and services. Chinese companies have not established formal procedures, processes and quality control systems that, for instance, Indian firms have. Nevertheless, close to 58,000 ISO 9000 certifications have been handed out and many China software companies are attempting to qualify for international standards, such as the CMM. By March 2004, more than 100 software companies in China passed CMM2, 45 had passed CMM3, and 9 companies had passed CMM4 or CMM5. Concerning international cooperation, some Indian software firms including Infosys, TCS, Satyam, WIPRO, ZenStar, and Pentasoft have already set up bases in China. Similarly, a large Chinese telecommunications firm, Huawei Technologies, has set up a research and development center in Bangalore where 180 Chinese programmers work alongside locals.

In fact, due to the dynamism of the internal market, China is becoming an increasingly important location for R&D facilities in a wide variety of industries, including software and electronics. In this sense, a number of US software firms as well as US, European, and particularly Taiwanese electronics firms have established R&D facilities in China. Most of these operations are geared to adapting products for the local market or doing production engineering; however, some are developing global product mandates or are doing research for the firm's global operations. However, international packaged software firms are having some difficulty in the Chinese market due to uncompensated software copying. Though China has joined the World Trade Organization, it seems likely that these difficulties will continue. The Business Software Alliance (BSA) estimates that the rate of software piracy has witnessed a modest drop from 97 per cent in 1994 to 92 per cent in 2002. Based on this rate, the BSA estimates that US\$ 2.4 billion were lost in retail revenue due to piracy. Observers attribute the

widespread disregard of intellectual property rights to culture factors, related to a long historical tradition of learning by copying. It is also emphasized that the price differential between legal software and pirated copies put legitimate copies out of the reach of many consumers. However, the ease of access to pirated copies of software programs in China is also a result of the poor implementation of existing laws and of the fact that some of the firms that thrive on production of pirated software are protected by local government officials. In this sense, one possible answer to the uncompensated copying is the current Chinese effort to move to open source software.

2.3 Russia

According to the IDC Euromonitor IT markets in Russia have grown from US\$4,093 billion in 2002 to US\$ 9,28 billion in 2004 (reflecting an annual growth rate of 37%). In 2004, this market is divided into hardware (US\$ 6,34 billion), services development (US\$ 1,87 billion) and packaged software (US\$ 1,07 billion). A forecast of the market evolution from 2005 to 2009 indicates an annual growth of IT markets of 18%, reaching a level of US\$ 21,9 billions in 2009. Hardware is the major IT segment and accounts for 80 percent of the whole Russian market. The hardware industry is well developed in Russia, and local companies meet the majority of market demand. Although IT penetration is low, with only 11 families per 100 having PCs, the dynamics are extremely rapid, reaching an annual growth rate of 15% over next 10 years. These trends can be explained by the favorable economic conditions and by the huge demand generated in the corporate sector (especially from industries with healthy cash flows, such as oil and gas, metallurgy, finance and insurance, telecommunications and retail) The total number of computers (PCs, laptops and servers) reached 13 million in 2003, with an annual growth of around 20%. PCs market is dominated by domestic brands with foreign components, with imports of around 15-18% of total sales but peripherals, networking and larger system hardware are dominated by imports. The annual growth the Internet penetration was around 35-40 percent in 2004, reaching approximately 15 million users at the end of that year. The number of domain names “ru” got 235,000 in 2004, with a 2-3 % monthly growth. The continued industrial growth spurred increased IT spending by industrial enterprises, retail and wholesale companies, as well as telecommunication service providers. However, due to the excessive cost of high-speed Internet services, broadband are limited primarily to ISPs and large corporations that can afford it. The recent introduction of digital networks in large cities has added some new means for Internet access, though most areas are still using mostly outdated analog cables. Rostelecom, the public telecommunications provider, still monopolizes international and long-distance switching and transmission. The distributors of IT products are expanding from their traditional markets in Moscow and St. Petersburg into others Russia’s regions (with an annual sales growth of 36 percent in those regions).

The software market in Russia is developing fairly rapidly (30% to 60% a year), beating practically all other sectors of the Russian economy. For 2004, we can talk about turnover of \$1 billion. This sum covers both works done by Russian companies and research institutes and by foreign vendors' research centers working with Russians in Russia. Many Russian programming groups that specialize in software have good logistical infrastructure, mainly physics and mathematics. This has attracted leading global IT companies to Russia. They are currently working with developers at research centers they have established in various cities. Virtually all software companies are privately held, so it is difficult to estimate the market’s size more precisely or even to identify clear leaders in particular areas. There are about a dozen companies with 50 to 300 programmers which are partly or wholly foreign owned. Most Russian companies in the IT industry do not restrict themselves just to selling computers, also providing system integration services. Due to the low level of informatization in Russia, system integration is recognized as one of the most profitable businesses in the IT market. The sales of ERP systems reached \$80 million in 2003.

The independent Russian software industry consists of small firms. Concerning onshore activities, it was possible to distinguish two groups of firms in Russia. First, there are around 100 companies of 10 to 20 programmers doing small jobs and getting contracts through friends and acquaintances. In March 2005, the largest Russian local software developer, Luxoft, had over 1,000 employees. The average Russian software company employs about 100 people. This allows it, on the one hand, to be market flexible and manage its staff efficiently. On the other hand, the small size restricts the range of projects the company can undertake, particularly outsourcing projects. Many major Western companies are represented in Russia at least through sales offices. Some of them have gone further and have set up their own software development departments in Russia, to take advantage of the skills of Russian scientists and engineer: (i) Motorola launched a laboratory in St. Petersburg in 1993 with a small group of programmers. Today the department employs more than 200 software engineers and recently achieved CMM Level 5 status; (ii) Sun Microsystems came to Russia in 1989 and now employs more than 300 specialists in Moscow, St. Petersburg and Novosibirsk. These programmers help to develop new products and to maintain existing ones; (iii) Intel created a department in Nizhny Novgorod in 1993 which today employs some 200 software developers and has announced plans to expand that number to 500. (v) In 2002, Borland acquired TogetherLabs, Inc., along with its software development center in St. Petersburg, employing more than 100 developers. Naturally, the trend of setting up offshore development centers in Russia is likely to continue as international companies focus their efforts on cutting costs in the difficult economic climate.

Concerning the internal demand, customers include government institutions, heavy industry and major companies in leading industries such as banking, gas and oil production. There are some companies which are targeting smaller-scale enterprises and individual customers, although computer piracy is truly strong in this market segment. Low purchasing power among consumers is one major impediment to development of this sector. The education sector also has a low level of ICT penetration, especially in rural areas. Universities and colleges are better equipped with PCs than secondary schools, though they, too, face challenges such as obsolete computers and ICT illiteracy among both teachers and students. Resource allocation varies greatly by region, with huge discrepancies in Network Access between schools in Moscow and those in rural regions. Distance education has been getting more attention and has created high hopes for reaching more rural areas. In B2B e-commerce, there are a huge potential for greater ICT application in fuel and energy, metallurgy, banking, consumer goods production, and trade. By providing security and consumer protection for online transactions, the recently approved e-commerce law and electronic digital signature law could facilitate further e-commerce development in Russia.

Concerning technical qualification, it can be noted that Russian firms are rapidly adapting themselves to quality assurance techniques based on the international CMM (CMMI) and ISO 9001/2000 standards. The first certification to CMMI in Russia as well as the first ever certifications to CMMI Level 4 and Level 5 in Europe, were achieved by RUSSOFT members. In September 2003 RUSSOFT became the first East-European organization, which obtained status in the Quality Assurance Institute Chapter. Also the intensive activity in quality assurance has been a vital element of Russian accession to the leading position in the field of CMMI certification in the whole of Europe (6 companies at CMM/CMMI Level 5 and Level 4 have been certified).

3. Exports and outsourcing

3,1 - Brazil

An argument that has been systematically mentioned as a deficiency of Brazilian software industry comprises the limits of its export orientation. In fact, the current Brazilian annual export level is limited to around US\$ 250-300 millions. Among the weaknesses identified to justify this trend, is

usual to stress the presence of a policy structure that is adverse an export drive, particularly due to the so-called “Brazil Cost” and to the absence of incentives for exportation. The limited experience of companies in the open market, which only began in 1990, is also mentioned. The hypothesis is that the fragmented structure of the market also generates disincentives to cooperation between small and medium firms, preventing a process of the inter-organizational consolidation that is necessary to improve the capacity to compete internationally. The absence of an image that can be associated with Brazilian Software abroad is also mentioned as an obstacle. Finally, it is also argued that Brazilian companies do not have a salary level difference for competing in the low value segment, whereas the small size of companies and their insufficient qualification limit the possibilities of establishing relations with potential customers in high value segments.

The characteristics of Brazilian industrial structure in the software sector affect decisively its export orientation. Approximately 79% of Brazilian exporters are multinational companies that use Brazilian subsidiaries to attend international customers. As a consequence of multinational intra-corporate transactions and of other exports that are hardly accounted by the Payments Balance, we can estimate an amount of approximately 85% of Brazilian exports as taking part of a “grey” market. The amount of tax duties is usually mentioned as the main argument to justify the phenomenon, but we must also consider that multinational could by pass these duties through the intra-corporate channels mobilized to export. In this context, the local firms, responsible for 21% of the amount of exports, tend to privilege the segments of industrial automation and integrated management in their exports. They also tend to use small offices abroad and customers’ connections as the main channels to access international markets. Sales by the Internet have been an effective alternative of distribution only to software products. Information from the Central Bank indicates that, in 2004, the twenty largest software exporters were responsible for an amount of export close to US\$ 230 millions. From this amount, approximately US\$ 110 millions would come from software products and US\$ 120 millions from software services. Data collected from IDC consultancy group (2006) era more modest, point out an amount of US\$ 177 millions of software exports in 2005, from which US\$ 35,3 millions were exports of software products and US\$ 142 millions of software services. Although the controversies about the proper way to evaluate the export performance of Brazilian software industry, all the figures seem to be disproportionably low when compared with the economic dimensions of that industry.

The Brazilian government would aims to grow software exports five-fold between 2004 and 2007 to reach 5.4billion reais (US\$ 1.5 bi) at the end of the period, thereby approaching the level of revenue generated by countries like China. Despite the fact that this target probably will not be attained, the software market was selected as one of four business areas the government has prioritized for growth by the industrial policy, the others being biotechnology, semi-conductors and pharmaceuticals. According from data collected by BRASSCOM (Brazilian Export Association of Software & Services Companies) 300 software firms have demonstrated an interest in become exporters, searching for the different kind of support provided by Brazilian export agencies. BRASSCOM have an expectation to increase the amount of exports from US\$ 230 million in 2004 to US\$ 470 million in 2009. There are still only a few companies present in the international market, and those that have already taken this route prefer the North American market, accessing this market through the internal channels of multi-national companies or by their own subsidiaries abroad. Countries such as Germany also buy software systems from Brazil. Germany's Siemens plans to spend US\$ 79 million on Brazilian telephone software during 2004-2008. In 2004 that the largest markets for Brazilian exports were (with US\$ 78,3 million of exports, corresponding to 33,3% of the total) and USA (with US\$ 48,1 million of exports, corresponding to 18,3% of the total. The table also shows that the amount of exports per firm is greater to the firms that exports to Mexico, comparing with other international markets. Probably, part of this flow can be attributed to a regional specialization of multinational companies in Latina America area.

Although the problems mentioned, we can identify some elements that might act as stimulus to strengthen the export drive of Brazilian software companies. First, the huge increase of global outsourcing in software industry opens new opportunities for countries like Brazil, where we can find a complex industrial base and a lot of qualified working teams specialized in software activities. Second, the competences accumulated by the industry permits to develop applicative and software solutions to broader range of activities, particularly to financial markets, insurance, social welfare and governments activities. Third, there are a lot of new dynamic niches where some small Brazilian software firms began to position themselves, such as the areas of digital games and specific applicative to telecommunications.

Some local initiatives can be particularly important to exploit those opportunities. BRASSCOM, for instance, was created as copy of the Indian NASSCOM, being oriented to consultancy services of quality management and marketing. BRASSCOM was founded in 2004 as a new effort to position Brazil in the growing market of software and IT Global Sourcing, mobilizing some of Brazil's leading software companies such as CPM, Datasul, DBA, Itaotec, Microsiga, Politec, Promon Tecnologia and Stefanini that together project US\$ 2 billion in revenues for 2005 . BRASSCOM wishes to play an important role on the creation of Brazil's Software brand. The first action taken in this direction was the contracting of A.T.Kearney, one of the leading International Consulting Firm in the IT Global Sourcing Market, to develop a study about the new directions and ways to strengthen Brazilian offer in the IT Offshore outsourcing market. Public entities such as FINEP, MDIC, MCT/SEPIN, BNDES and ABDI are taking a strong role in this effort, contributing directly in discussions. Another initiative that can be mentioned is the creation of export consortiums such as the Núcleo Brasileiro de Exportação de Tecnologia (NEXT), which includes 15 Brazilian software companies, with more than 11 thousands workers and annual sales revenues of R\$ 1,19 billions.

Outsourcing is already a trend in Brazil. In this sense, the annual business volume in the services sector for the wireline and wireless service providers is around R\$ 3.8 billion – approximately US\$ 1.8 billion. In this sense, geographic specialization permits that outsource services might be distributed according to resources costs and local technological competences. Currently, México is the greater exporter of IT services in Latin American with an amount of US\$ 500 million of exports per year, with Argentina, Brazil, Chile, Costa Rica being viewed as exporters potentially competitive in those outsourcing services. According to the last evaluation developed by A.T.Kearney Consulting, Brazil occupied the 10th position in the “Offshore Location Attractiveness Index” of 2005, falling down from the 7th place occupied in 2004. In the three years of publication of this index, Brazil has remained itself as one of the 10 more attractive destinations for offshoring. This index suggest that the attractiveness of Brazil as a player in the offshore market has been affected by structural conditions, such as the general level of education, social costs that affects the contraction of workers, the relative inflexibility of the labor market and the appreciation of the local currency. However, Brazilian supply of IT services also presents some relative advantages. Among these advantages, we can mention the size and sophistication of the internal demand, the qualification already demonstrated to develop world-class solutions for specific segments (such as financial services, retail, government and telecommunications), the business culture similar to the main market targets (North America and Europe), the good infrastructure of telecommunications and the proximity with the main market targets,. Due to the intensification of the concurrence, the main challenges that might to be faced by Brazilian companies refer, basically, to the construction of an image of technological reputation, as well as to the improvement of the quality of services provided. The improvement of local human resources seem also to be very important, as well as investments in innovation to domain new technological platforms. Finally, an adaptation of the local the tax burden with international patterns should also be pursued.

Concerning the improvement of export drive it is important to consider the specificities of different segments of offshore outsourcing markets. For low aggregate-value services such as coding (of computer programs) it is only necessary that IT infrastructure works well – the determinant factor is the cost per tested line of code, and communication is simple and determinative. The client-supplier relationship does not need to be long-term, and contracts may be short-term. Going up the value scale, communication becomes more complex, more interactive: the dialogue between client and supplier needs then a common language, and English is the sector's universal language. On higher aggregate-value deals, with contracts of longer duration, it is fundamental the perspective of continuity, because the client must assure that the fulfilled requirements will continue to exist for a long time after contracts are signed. On service development, it is difficult to compete in the lowest market segments, given that these are based above all on the use of very cheap labor where Brazil is unable to compete with China and India. Competition in this segment should become even fiercer with the entry of second line competitors (e.g. the Philippines and Russia). However, the increase in sales, and especially of exports via outsourcing, is of vital importance to the Industry's sustainable development, because it increases its credibility and establishes confidence with the market agents. Moreover, it may also have an important impact on the trade balance, generating a considerable growth in the number of jobs and, indirectly, increasing the industry's talent pool.

Despite the problems to gain competitiveness in the low added segment, it is possible to explore the competences accumulated in higher added value software services in vertical areas where current Brazilian customers are of world class. Telecommunications, e-government, data and network security, financial or retail services constitute niches in which the qualification and maturity of Brazilian software companies may be able to stand out. Another field that seems to be profitable concerns the complex integration outsourcing, through the development of large scale customized systems for governments and large companies with many users spread out over a large geographic extension. In these big projects, Brazilian integration firms making use of software factories in regions with lower labor costs than those of big domestic demand centers, and their expertise in defining requisites and breaking up development into parts will show a unique competitive advantage, which would be difficult for potential competitors to replicate. But to explore these opportunities, the requirements related to cost and quality must be attended, what can be done either through reputation or investment in process certification schemes, such as CMM and CMNI.

3.2 China

From 2000 to 2003, software exports increased from \$250 million to \$2 billion in China. Software exports have grown rapidly, but still constitute only a relatively small share (11.2%) of the total software production in China. Most of the Chinese software exports in 2002 have gone to Japan (60%) and other South East Asian countries (21%). The US market (12%) and Europe (6%) have become more important destinations for software exports recently (CSIA, 2003, p. 106-107). The reason for most exports going to Japan is the similarity in cultural background, the use of double byte coding for characters, and traditional business ties, particularly in the Northeastern provinces of China (Dalian and Shenyang) in which several firms have developed strong export orientation towards the Japanese market. Outsourcing software services in China can be characterized as being in the same position as India was 12 years ago, with a large supply of low cost workers and a huge internal market in which to base an outsource services sector. The Chinese software services industry would like to follow the same development path that Indian firms took and leverage China's vast supply of cheap programming talent and growing English language skills. A recent evaluation of offshore markets stress that the cost advantage of outsourcing to China is high, given IT salaries in the range of US\$3000-8000 and the access to highly competent university graduates. However, due to a lack of entrepreneurial, managerial,

and technical skills in the software sector, Chinese companies lag far behind larger, more established companies in India and the Philippines.

The immaturity of the Chinese software market, coupled with the large demand from China's big domestic market means that China will have a hard time replicating the success in exporting software services that other Asian nations have achieved. One of the leading Chinese software firms, NEU-Soft in Shenyang, survived during the early years on the basis of outsourcing contracts for Japanese clients, entering into a joint venture with the Japanese auto-electronics firm Alpine later. However, since the firm achieved a successful expansion on the domestic Chinese market in the late 1990s, exports only provided ten per cent of its revenue in 2000. The dynamism of the domestic market has also implications in terms of a trade-off between exports and local sales: as an example, we can mention the case of like Shanghai Huateng Software Systems that was established in a joint venture with US-based Tandem Computers and which did a great deal of outsourcing in the early 1990s, but had abandoned later much of its export work to focus on more lucrative domestic markets in the financial sector

Despite the impressive growth, the Chinese software export industry faces many obstacles. It is extremely fragmented, and few firms are capable of designing complex software systems. Another important issue is that Chinese companies have not established formal procedures, processes and quality control systems that Indian firms have. As of 2003, only six Chinese firms had received certification through the Carnegie Mellon Software Engineering Institute's Capability Maturity Model Integration, and most of these had not achieved CMMI Maturity Level 3 (China Venture Capital Research Institute 2004). In contrast, all top 30 Indian software outsourcing firms had already received CMMI Maturity Level 5. One of the biggest barriers that Chinese companies face is the Indian companies proficiency with English is much better than Chinese – many Chinese software engineers and managers don't speak English well, much less develop programs in English. Another major issue that China's software services industry faces is the political climate in China.

However, given China's role as a manufacturing center for the global economy, many manufactured products it exports contain embedded software. Programmers preparing embedded software often need to work closely with designers and manufacturers and there is some evidence that a portion of this work may be relocated to China. At the moment, there are no estimates of the size of this market, but it could be significant. A number of the large Indian software offshoring firms have also established subsidiaries in China for the purpose of capturing business in China and servicing the Asia-Pacific market. Meanwhile, the Chinese networking equipment firm, Huawei, employs nearly 800 engineers in India and has announced plans to increase the number of engineers to 2,000 by 2006. Although the outsourcing relationship between China and India remains tiny, given the growth both nations are experiencing, it is possible that they could eventually become significant. The Chinese industry would like to see the Indians outsource their cheaper work to China. This would support the development of management and technical capabilities of the Chinese software industry, while allowing India to focus on higher value-added activities.

Unlike India, where large local firms dominate the software outsourcing market, foreign companies that moved their own software development operations to China are key drivers in China outsourcing market. Whether all of these development centers are performing software outsourcing in the traditional sense is debatable, since their main customer is usually their corporate parent in their home market rather than a third party customer. However, the expertise developed at these centers could be diffused into the Chinese market improving the capabilities of Chinese software outsourcing firms, which foreign companies may make greater use of in the future. Concerning the local players, the Chinese software outsourcing industry is highly fragmented. Instead, the largest Chinese software firms sometimes engage in a wide variety of businesses in addition to software outsourcing, and pure-play outsourcers in China have yet to achieve a proper scale. In many cases, the largest, most well known software groups in China will conduct several (or perhaps all) of the IT business lines along

with software outsourcing, displaying little focus when compared to IT companies in more mature markets. Digital China is a classic example of lacking a clear business focuses, covering hardware distribution, hardware manufacturing, software development and software outsourcing. Other examples include UFSOFT and Kingdee, two of China's largest software companies, focusing originally on accounting and finance software development. Competition in this field has increased significantly in recent years, and both companies are looking to diversify into other areas. Both Kingdee and UFSOFT have recently formed software outsourcing divisions and are targeting US businesses. However, both companies are primarily skilled in product-oriented software development processes, which will not necessarily transition smoothly to service-oriented software outsourcing. While most attention has focused on these big name companies, which have recently diversified into software outsourcing, the largest players in the industry in terms of outsourcing revenues are actually medium-sized pure-plays that are not as well known. These companies tend to be highly focused on outsourcing, often have strategic investment from Japanese firms and a number of key Japanese clients that provide a stable base of business.

3.3 Russia

In terms of offshore software development, Russia is widely defined as a “diamond in the rough”. The size of the software export market in Russia growth from \$546M in 2003 to \$1B in 2005, with the share of software in Russian export increasing from 3% in 2003 to 5% in 2005. It is expected that in the near future the software export industry in Russia will continue its annual growth of 50-100%. According to the Ministry of Information Technologies and Communications, Russian IT exports will grow to \$1 billion by 2005 and \$2 billion by 2006 and Russia's software industry will bring financial gains equal to those by its oil industry within the next 10 years. Estimates for growth through 2010 reaches an amount of software exports of \$6 billion, being expected that in the same period the IT sector will account for 2% of Russia's total economic output (compared with the level of 0.61% in 2003).

Of total software exports, some 30% was products, which typically fall into niches such as text recognition, anti-virus or games-related applications with a strong scientific or technical content. The remainder was software services, typically offshore programming work. It is estimated that the Russian offshoring employed about 15,000 of the 70,000 programmers in Russia. According to the annual market survey undertaken by RUSSOFT and the Outsourcing-Russia.com portal, total software exports (for outsourcing both services and products) for 2005 was expect to growth at a 50% rate from 2004, while 2006 total exports were expected to grow 45%. The export sales is divided as follows: (i) Exports of software development and software engineering services produced by commercial companies and state-owned institutions are estimated as high as \$490mln; (ii) □ Exports of dedicated development centers of international corporations are estimated at up to \$130mln; (iii) □ On-line sales over the Internet (Digital River, SoftKey (Russia)) are estimated at up to \$80mln (\$70mln-\$100mln); (iv) Off-line sales, through direct sells and distribution channels, are estimated at \$50mln (\$40mln-\$55mln).

Concerning the industrial structure of offshore activities, information shows that, after the huge growth faced in the beginning of the decade, when lots of start-ups appeared on the stage, the market has calmed down, which is an indication of the industry's maturation. Companies that specialize in offshore programming began to unite in associations in 1999 (Fort-Ross in St. Petersburg, the national association Russoft, etc). The main goals of these associations are to market Russian outsourcing capabilities in the West and to lobby the Russian government on behalf of software companies. Most players with development centers in Russia have their headquarters based in CIS countries – over 70% in Russia, 10% in other CIS countries. However, about 20% of head offices are located in the USA, Europe and elsewhere. Russia-based companies move their headquarters to target markets to capitalize on the proximity to customers and to be able to move up the value chain, offering more comprehensive

services and placing account management on clients' territory. Luxoft, the Russia's largest custom software firm, was founded in 2000 having already get getting a CMM Level 5. It grew to \$24 million in revenue in 2004, and in 2005 had 1,400 employees. Others important players in the outsourcing market are VDI, Auriga, EPAM Systems and SPIRIT. All these firms are making efforts to get high CMM Levels. In terms of geographical markets distribution, we can observe that USA and Canada top the list, with 65% of the respondents indicating them as their primary target geographies for 2005. Germany, Austria and Switzerland, with their traditional high level of technological development, trail behind, targeted by almost 25% of Russian companies. Scandinavian countries and Finland follow them, being a traditional target for St Petersburg companies. The amount of vendors targeting South-East Asia has dropped to 4% from 5% in 2003, leaving this region a low priority market for the Russian providers, with their traditional affinity to the West. A look at the industries in which customers of Russian providers are engaged shows a fairly typical distribution, with financial services (including banking and insurance), plus the telecoms and government sectors in highest demand. Russian companies also have a remarkable number of clients in education, and manufacturing is at the bottom of the list.

Concerning the annual salaries paid in offshore activities, evidences show that they are among USD 4.000 for researchers and USD 9.000 for software developers in Russia, compared with salaries between 65.000-80.000 in US and Western Europe. According to RUSOFT, the programmer wage levels in 2004 were similar to India and the Philippines, with annual salaries topping out at about \$9,000, compared to top levels of \$36,000 in Ireland and \$20,000 in Singapore. These numbers seem to include a myriad of small, local Russian companies. More established Russian firms with international offices and clients pay average programmer salaries more in the range of \$14,000, with managers or senior architects receiving considerably higher compensation, which is also true in India. Wages in Moscow were higher than these scales. Nonetheless, many U.S. and European companies, including Intel, Microsoft, Motorola, Sun Microsystems, Alcatel, Siemens, and Borland, already have set up facilities in Russia to take advantage of relatively inexpensive, highly trained people.

Russia constitutes an offshore destination that can offer the scale required by many clients and cultural/geographical proximity with European countries. In this sense, there are some distinctive advantages of outsourcing to Russia compared with Asia or the Pacific Rim. First, the Russian business hours are in better synchrony with the U.S. and Europe. Second, Russia is physically closer to the U.S. than Asia or Pacific Rim making more face-to-face interaction possible across management and development teams - Moscow is only three hours away from London and 40 percent closer to New York than Bombay, India for example. Russia has also closer cultural affinity with both the European and American worlds. Finally, Russian developers also have direct access to scientists and researchers from different scientific disciplines, thus combining commercial programming knowledge with world-class scientific knowledge. Russia's strengths appear to be a number of technically sophisticated engineers capable of doing cutting-edge research. They may be good – even excellent – technically, but English language skills are limited and there is poor knowledge of Western business practices. Outsourcing contracts are also stuck in 'programming prison': limited experience and few skills with software project management or quality control are preventing any generalized move up the value chain. In terms of international linkages, we can see that relationships with individual clients are deepening, but this is not true of the Russian software industry more generally. Widespread piracy (arguably a legacy of the pre-1991 "all property is theft" mentality), a weak legal system, perceptions of widespread corruption plus heavy-handed bureaucracy have restricted the development of trust within the potential Western client base.

4 - Geographical distribution of software activities

4.1 - Brazil

Reproducing a pattern that can also be observed in other developing countries, there is also a spatial concentration of software industry in Brazil. In fact, according to micro data from PAS-IBGE presented by Roselino (2006), more than 60% of the employments in informatics activities (including software) are concentrated in the southeast of the country. Moreover, the same source demonstrate that almost 80% of the sales revenues in informatics activities come from southeast, while more than 70% of informatics firms are located in this region. Beyond that, those firms have a high level of labour productivity calculated as a *proxis* by the amount of sales revenues divided by the number of employees. The middle west region follow that region in terms of sales revenues and workers. This trend can be explained by the presence of large firms oriented to heavy bureaucratic dataprocessing services, due to the presence of the central government in Brasília. Because of this, middle west companies have sales revenues and number of workers expressively higher than the general means of the country. The regional distribution of employment is strongly concentrated in most heavily industrialized core of the country, including the states of São Paulo, Rio de Janeiro and Minas Gerais (see Table 19). Aggregated with the Brasília Federal District, those states are responsible for more than 87% sales revenues and for 70% of the jobs generated in the informatics activities. São Paulo alone is responsible for almost an half of firms and sales generated by software activities. The south of the country accounts for 17% of formal employment, mostly concentrated in the states Rio Grande do Sul and Santa Catarina. Concerning an index of labor productivity calculated by the amount of sales revenues divided by the number of employees, high levels can be found in the states of Rio de Janeiro and São Paulo.

Considering the thirty spatial agglomerations with more than 0,3% of the total employment generated by software sector in 2004, some trends might be stressed First, it is observed that, as expected, most of those agglomerations were located in the most developed areas of the country. In fact, eleven agglomerations were located in São Paulo state. Second, we can observe strong differences between the patterns of software specialization to the different agglomerations selected. Comprising the specialization index, we can point out seven agglomerations where that index is higher than three indicating a strong specialization in software activities: Brasília, Blumenau, Campo Grande, Aracatuba, Osasco, Belo Horizonte and Joinville. The analysis of the salaries paid by the firms in the agglomerations selected also points out strong differences between them. In fact, only four agglomerations paid more than USD 8.000 per employee in 2004: Sao Paulo; Osasco; Brasília; Montenegro. On the other hand, eleven agglomerations paid salaries that were inferior to USD 5.000 per employee in 2004. These salaries were particularly low in agglomerations located in some micro-regions such as Serrana, Limeira, Araçatuba, Fortaleza and Campo Grande. According to those data, the general argument that the salaries paid in Brazilian software are relatively high – when compared with the level of firms´ competitiveness – might be qualified.

The creation of stimulus to the consolidation of technological poles oriented to the development of software activities were widely adopted as a tool to accelerate the process of local competences building. Policies oriented to the software sector in Brazil also have incorporated a focus on spatial decentralization. SOFTEX, for instance, had change its focus in the middle of the 90´s in order to support autonomous and geographically dispersed nuclei of software activities, fostering ties with local authorities and clients, in order to permit software development and the built of exporting capabilities. These independent nuclei would promote the sponsoring of local software labs, incubators and software training, including training on business issues and responding to local needs. In order to promote a decentralized growth the program created 20 regional nuclei throughout Brazil. These nuclei were responsible for coordinating and assisting company activities that associate to this program, trying to take advantage of the potential of each region. Today, it has a network of regional agents established in 22 cities in 12 States, with 37% of the software development firms in Brazil as its associates.

The use of incubators to strengthen local competences in the software sector has also been a strategy disseminated in Brazil. According from data collected by Anprotec (Brazilian Association of Technological Incubators) approximately 25% of the 283 incubators identified in Brazilian economy are involved with software and informatics activities in 2004. An emphasis on this kind of support can be seemed not only in SOFTEX strategy but also in a lot of actions formatted by government agencies, such as Finep and CNPq. As a consequence, spatially dispersed nuclei of software poles were created during in the last decades. Some of these nuclei seem to be particularly dynamics in terms of the process of competences building, such as Parqtec (São Carlos), SOFTEX Recife, Blusoft (Blumenau-SC), SOFTEX Campinas and Petrópolis – Tecnópolis. Some of these poles seem particularly dynamic. The Recife Digital Port, for instance, has 86 firms in its infrastructure which generate annual sales of approximately R\$ 250 millions, most of them already involved in an export effort.

4.2 China

The growing disparity in the business environments in different regions of China is a striking aspect of the economic transition. While the country has always been diverse, the decentralization of government authority and increased administrative autonomy of city and provincial governments has resulted in substantial differences in resources, regulations, and performance across China. The uneven geographic distribution of the software industry reflects these differences. China's software industry is geographically concentrated on the Southeast coast area – including Beijing, Shanghai, Shenzhen and Dalian - where the economy is much more developed than in the rest of the country. The software activities reproduce this pattern, with firms and employment in the being heavily clustered around Beijing, Shanghai and Guangdong regions along the eastern coast of China. In China, software firms and employment in the software industry is heavily clustered around Beijing, Shanghai and Guangdong regions along the eastern coast of China. These three urban areas account for the majority of the large software firms in China due to the clustering of human capital and the presence of the central government in these three locations, especially Beijing. The eastern coast of China also boasts most of the leading research institutions and universities in China, which further concentrates human capital for the software industry. The leading research institutes and elite universities in China are also located in urban areas on the Eastern coast. This contributes to the disproportionate concentration of technical skill and research. Beijing, for example, is the home of 68 universities, 260 research institutes, and one-third of the employees of the Chinese Academy of Science. State funding for R&D goes overwhelmingly to five coastal provinces: Beijing, Shanghai, Jiangsu, Guangdong and Shandong provinces

Beijing and Shenzhen also have the largest workforce employed in software industries (91,882 and 70,000 respectively), with more than double the number of people employed in these industries in Shanghai, Guangdong, Zhejiang or Shandong. Significantly, both Beijing and Shenzhen boast around 12,000 software researchers, with the other four localities having from around 1600 to 4300 researchers each (CSIA, 2003). While these numbers for the geographical concentration of software human resources may change as other localities train more people, the agglomeration effects of the current concentration is likely to continue for some time. Statistics available for R&D expenditure in the software industries reveal a slightly different pattern of concentration. The three top spending localities are Beijing (2.17 billion yuan), Shenzhen (4.15 billion yuan), and Shanghai (2.12 billion yuan), with most other software centers spending significantly less than 1 billion yuan. The importance of Shenzhen in terms of R&D expenditure is significant and may be related to the existence of research-intensive telecommunication software industries and outsourcing of R&D from Hong Kong.

The importance of Beijing as a geographical center for software industries is most likely the result of three factors: first, the concentration of research organizations and universities in Beijing; second, the early experience of “plunging into the sea” (*xiahai*) entrepreneurship by scientists and

engineers from research institutes and universities, and the particularly favorable policies adopted by the local government (Segal, 2003); third, the continued importance of the central government organizations for research funding and as a market for software and services. Shenzhen's supremacy as a geographical center is also associated with its early status as a venue for entrepreneurial talent but, in addition, a highly significant factor is foreign investment and relocation of software development to Shenzhen from both domestic high-tech enterprises and overseas (particularly Hong Kong and Taiwan) firms. In addition, both localities have benefited from foreign investment and international linkages – which have been critically important in the case of Shenzhen.

The total R&D investment in the 53 National High Tech Industry Development Zones grew dramatically in the 1990s, from RMB 15.2 million in 1992 to RMB 230.8 million in 1999. These parks, however, include all businesses qualified as high technology. The Chinese government has also developed 19 software parks around the country under the high tech development plan entitled the "Torch Plan". They accounted over 80% of China's total software sales, involving 2100 companies located within the 19 software parks established under the Torch Plan. Software research took place in a variety of institutes or universities in diverse localities in China, and since new software firms have often emerged as spin-off from these types of organizations, the geographical concentration of the Chinese software industry to a few locations tends to become less prominent. The successes of companies like EUSoft based in Shenyang and the Top Group based in Chengdu indicate that there are ample possibilities for agglomeration of software talent outside the main centers in the coastal areas of China. Nevertheless, Beijing with its Zhongguancun "Silicon Valley" district remains dominant, particularly in sales of software and system integration services. Guangdong and Shenzhen are very important centers for embedded software and software exports. On the other hand, although Shanghai remains one of the advanced centers for high technology industries in China, and in spite of the ambitious goals that the Shanghai government has pursued in promoting software industries, this region has not yet been able to overtake Beijing and Guangdong/Shenzhen. Other provinces such as Shanxi, Shandong and Liaoning (home of Neusoft) have successful software firms that are closely linked to local universities and/or research institutes. The concentration of technical skill, research, and university connections in these coastal cities contributes to external economies and a self-reinforcing process of increasing returns, as software firms benefit from the pooling of managerial and technical skill and know-how as well as the benefits of connections to universities or research labs.

With the development of the hinterland in the recent years, software industry in Xi'an, Chendu, Chongqing, Wuhan, Changsha is rising too. The perspective is that, with the advance of the Government's Western Exploitation Plan, the software industry in the Western area will grow quickly. Northeast China and East China can also become important drivers of the China software outsourcing market in the next few years. On the other hand, the South of China currently has a smaller market size but is rich in resources and software talent, becoming a region where a rapid growth of software industry can occur.

Concerning the spatial distribution of software exports, it can be observed that the export of software services to Japanese clients has grown rapidly in Beijing, making the city an important center for software exports. Shenzhen is also a leading center for software exports, capitalizing to a considerable extent on its geographical proximity to Hong Kong and relationship with Taiwanese producers. Shanghai has formulated aggressive plans to attract foreign clients and investments in its software industry, setting up extensive facilities in the Pudong Software Park; nevertheless, software exports only accounted for less than 9% of the production value of software industry in Shanghai. Critics have argued that the lack of interest in developing overseas markets, lack of skilled software project managers, lack of innovative products, and especially lack of internationally acknowledged certification for quality of management and products – such as license under the Capability Maturity Model, CMM – is holding back the export potential of Shanghai firms.

4.3 Russia

Within Russia, Moscow and St. Petersburg continue to be the two most popular locations for software development. Apart from these two cities' obvious leadership in size and recognition levels, they offer the best infrastructure, ease of access for visiting customers, and numerous universities conducive to high availability of local talent for hire. Some data about the distribution of software and IT activities stress the spatial concentration of them. Concerning the Internet, Moscow is responsible for 37% of the users base, followed by 10% of St. Petersburg and Leningrad region, with other regions being responsible for 53% of those base. St-Petersburg is considered a good location for multinational IT companies and investments in IT and Telecom, as demonstrated by the installation of Motorola, Lucent, LG, Borland, TeliaSonera bases in the region. Approximately 200 companies involved with software development are located in the region, with more than 6.000 engineers. From that base, approximately 30 companies are active players on the International market in IT outsourcing and software development. Data related to the spatial distribution of software developers and IT students also can be used to demonstrate this tendency. Central Region (including Moscow) is responsible for 28 % of software developers and for 33 % of software students. In the Volga Region these shares are respectively 20 % and 20%, while in the North-West Region (including St. Petersburg) they reach 14 % and 14 %. Other regions that can be mentioned are the Ural Region (with 13 % of software developers and 6 % of software students), Siberia Region (13 % and 12 % respectively), the South Region (10 % and 18 %) and the Far East Region (5 % and 4 %)

Because of its roots in technical education institutes and pre-existing R&D facilities, Russia's software industry has tended to be geographically cluster. 'Silicon cities' are particularly located in St Petersburg, Moscow and Novosibirsk, clustering around the local state universities and featuring local marketing consortia. Apart from Moscow State University, IT bachelors degrees are offered at St Petersburg and Nizhny Novgorod universities and three engineering institutes — St Petersburg State Electrical Engineering University (LETI), the Tsiolkovsky State University of Technology and the Moscow State Institute of Electronics and Mathematics. Other institutes will join them in the next couple of years. In order to decentralize the spatial concentration of software activities, the creation of IT-parks have been supported. The geography of IT-parks projects in Russia involves the Silicon Belt of St Petersburg, the State University in Petrodvorets (in the South), the University of ITMO (in the Center), the first Private IT-park carried by RUSSOFT in the North, the University of Communication (in the East), the IT-parks in the Moscow area (Troitsk, Dubna, Chernogolovka), the park locate in Novosibirsk, the two projects in Nizhniy Novgorod (Intel in Sarov and Telma and State University), as well two new projects in Tomsk and Ekaterinburg.

5 - Human resources

5.1 - Brazil

When the government removed the protection of the IT hardware sector, in 1991, many specialized workers, who had been trained on hardware issues, or who were working in that field, turned to software development. By this period, we could already found a competent software development core working on operational system issues, but not much of a software industry, except that related to data processing bureaus. So, a lot of new companies oriented to software development have started up during the nineties. By 1995, software development companies were employing almost five thousands staff, half of them with university degrees and no more to 15 with PhD degrees. With the turn of the century the software industry has maintained its capacity of generating new jobs. Information extracted from PAS show that software segments employed around 60 thousand workers in 2003, which corresponds to 41% of total workers in the informatics sector. According to information

collected by PAS firms in the package segment have a mean of 60 employees per firm, contrasting with a mean of 150 employees per firm in the custom made segment. According to information collected by PAS-IBGE, the firms in the software segment spent around US\$ 15.000 with each one of its workers in 2003, from which approximately US\$ 9.600 was directly spent with salaries. The salaries paid in segments oriented to the development of software are usually higher than the salaries paid in informatics sector as a whole, being particularly higher in the package segment, compared with the custom made segment. Compared with other economic activities in Brazil, the software industry can be seen as an elite sector in terms of the qualification of its manpower. In fact, the level of schooling in software companies is substantially higher than the national average: a full 93% of the labor force of software companies has at least a complete secondary education (eleven full years of schooling) in 2005 while only 53% of Brazilian employed labor shows a comparable level of schooling. Further, the share of labor with at least a university degree is almost the triple of the comparable average share for Brazil. Compared with other segments of informatics sector, the shares of employees with complete and incomplete university education is higher in the segments oriented the development of software, especially in the custom made segment.

Human capital formation has a reasonable history in Brazil, and the country has in general a widespread infrastructure capable of educating and training professionals to the various IT technology areas. Since the period of protectionism a significant amount of resources were ploughed into higher education and training. The number of universities and course offerings increased and this has been maintained in the recent period. The university system annually provide approximately 30.000 IT bachelors, most of them qualified people with proper technical skills, creativity and ability for identifying problems and conceiving solutions for sophisticated software and services solutions. The basis for the generation of qualified people came from around 875 Graduation Courses in the areas of computer sciences, systems' management and correlated disciplines, comprising 159,984 enrolled students in 2001. At the same time, IT technical education has been increasingly provided at secondary or non-university levels and this has raised the effective supply of labor to the software sector, albeit at the lower end of the skill spectrum. The picture at postgraduate education is more problematic. In fact, we can also note an impressive growth of post-graduated basis in the last period. Concerning software activities we can found 29 Mastering Courses in 2002, with 2467 enrolled students and 847 dissertations defended. We can also found 11 Doctoral Courses, with 2467 enrolled students and 80 PhD thesis approved. However, we can also note a relatively low exposure to education abroad and a weaker science orientation, compared with countries like India or China, which has limited the availability of high end skills for the sector. As an evidence of this process we can note that in the area of computer sciences the share of scientific articles of Brazilian residents published in indexed international scientific periodic seems to be quite inferior to the share of other scientific areas such as agronomy, natural sciences and physics. In addition, while Brazilian universities – rather than firms - have tended to produce the major stream of R&D, much of this work has had limited market application while serious legal difficulties in assigning patent rules for work done in universities has also had adverse consequences for incentives.

5.2 China

According to the Chinese Software Industry Association, there are 300,000 workers employed in over 6,000 firms, of which approximately 160,000 are software professionals, approximately 25 per firm (Tschang and Xue 2005). China has a resource of 200,000 IT professionals, with approximately 50,000 new entrants each year. In addition, an estimated 450,000 people were engaged in research, teaching, or applications related to software in a range of other industries or organizations in society (CSIA, 2003). The average Chinese IT programmers salary is approximately USD \$5,850 annually. With the growth of the domestic IT market, there has been growing demand for skilled labor. It is

expected that as the software services industry matures, Chinese programmer will upgrade their skill and wages will increase. However, the country has a limited reserve of project managers who are experienced in large software project management and even fewer professionals that are able to combine technologies with industry experience.

In fact, China has also taken initiatives to train more software engineers, programmers, and other professionals in related fields such as information science, geographical information systems (GIS), automation, network engineering, etc. In 2002, there were about 720,000 students studying computer science and software technology and 480,000 students studying software-linked subjects (such as automation, network engineering, information security, information engineering etc.) in 1396 universities and institutes. The 248,603 registered graduates that had completed software related education in 2002 included 336 people (0.14%) with a PhD degree, 3491 people (1.4%) with a Masters degree, plus 91,666 persons (36.9%) with a regular undergraduate degree and 153,110 persons (61.56%) with a degree from vocational training institutes (CSIS, 2003). The various higher education institutions play a major role in training people for the software industry. The importance of research organizations and universities as breeding ground for software entrepreneurs is revealed in statistics pertaining to the background of employees in software industries surveyed in 2002. As much as 71 per cent of employees have entered software firms from universities or research organizations, while 17 per cent came from various vocational training institutes or on-the-job training programs. The remaining 12 per cent were students who had returned from overseas. This latter category represents the crucially important “brain circulation” identified by Saxenian (2003), and has recently been recognized as vital to new entrepreneurship in software parks and high tech zones in China.

Most of the major universities, including general universities such as Beijing University, Tsinghua University, Nanjing University, are currently recruiting around 800 students in software related subjects every year. Thus, the fact that around 77 per cent of software professionals are graduates from university and college education indicates an important structural problem in the system of training for software professionals. Compared with other software producers such as India, China has lacked training schemes for basic level technicians and there has been a tendency to employ people with relatively high levels of education for basic programming tasks in many Chinese software firms. Moreover, major software firms in China have launched large-scale training facilities to meet the requirements from their own business. It is expected that the expansion of private training facilities for programmers will help China achieve a more balanced framework for development of software manpower, and at the same time support the expansion of manpower resources as the domestic industry matures. At the same time, the Chinese software industry has suffered from a shortage of personnel with training and experience in management of development projects, systems analysis and specification, and other advanced software development skills. Currently, many people receive such skills while working for foreign-owned software firms or joint ventures; the technological spill-over that occurs with mobility of human resources between foreign and domestic firms is one element of the Chinese strategy to upgrade its software sector. Nevertheless, problems have also appeared because the location of software industries is not fully aligned with availability of manpower, and the mobility of trained software engineers remains constrained by institutional and regulatory frameworks.

When the Chinese economy opened to overseas investment, the earlier investment in elementary and secondary education provided a pool of literate and capable factory workers. For those seeking further education, national examinations identified the most capable students, and these students were allowed to continue for massively subsidized post-secondary education. The result has been enough educated people in the general populace, together with a well-educated elite, to provide an adequate supply of trained engineers and scientists for the country. After the opening to the West in the 1980s, the final element of the Chinese education system was put in place: going abroad, preferably to the United States, for post-secondary education. Graduates in engineering or the sciences from elite universities, such as Peking or Tsinghua, are nearly certain to be able to secure admission and financial

support to a foreign university. Since the educational reforms of the 1980s, Chinese universities and research institutions have developed an unusual mode of interacting with industry. Chinese URI personnel have established firms that are, in effect, university subsidiaries. This general pattern of university/industry interaction is true for the software industry as it is for other industries. Although there had been earlier interest in hardware engineering, Chinese universities largely neglected software studies as an academic discipline until 2001.

At the end of the 1990s, the Chinese government recognized that it had a shortage of trained software personnel. The Tenth Five-Year Plan called for a dramatic improvement in Chinese software capabilities. The State Department of Education in 2001 authorized the launch of 35 model university-based Software Institutes, with financing from China's banks and domestic as well as foreign companies. The first six software institutes in Beijing are associated with the elite universities such as Peking University, Beijing University of Aeronautics and Astronautics, and Tsinghua University. They admitted approximately 5,000 students in 2002. These institutes have developed are using international textbooks and a corporate management model. They are also free to offer courses and hire faculty based on market demand--unlike China's traditional, government controlled educational institutions. This is an example of the ability of the Chinese government to redirect resources quickly and on a large scale. At the beginning of 2001, 51 Chinese universities have established Masters Degrees in software engineering. Another is the substantial increase during the 1990s in the number of post-graduate degrees granted in Science and Engineering fields. Between 1995 and 2000 the number of S&E doctorates granted in China increased 240% from 518 to 1247. While these degrees were historically oriented toward traditional engineering fields, the field of Computer Science is gaining faculty and students fast.

Even though Chinese universities have become interested in software training only recently, the Chinese software industry has benefited from URI and government spinoffs in the formation of some of the more recent software firms. Although the shortage of software professionals is starting to be addressed, problems remain in educating these professionals to be creative and innovative. Chinese programmers tend to be proficient in low-level coding and maintenance of existing programs, but there is a real shortage of high-level system architects, designers and project managers. One of the problems is that university engineering programs continue to emphasize traditional engineering fields rather than computer science. As a result, Chinese programmers lack technical capabilities required for systematic analysis and design of software. This limits the presence of Chinese firms in the international software outsourcing business, in spite of relatively low wages. Most Chinese technology start-ups appear to be "me-too" firms that clone a Western business model for the Chinese market or use fairly unoriginal technology. In this sense, given the rapid growth in the economy, the shortage of qualified and innovative software engineer tend to be reinforced.

However, brain drain is still a serious problem for China's software and the IT industries. While accurate data on the number of Chinese students returning after graduation is difficult to find, most sources estimate very limited rates of return, particularly among those studying the United States (the dominant destination for Chinese postgraduate students.) Between 1978 and 1999, for example, one scholar calculates a 14.1% return rate from the US. Similarly an NSF study in the late 1990s found that 88% of Chinese S&T doctorates in the US reported that they planned to stay abroad. In this sense, Chinese policymakers have devoted substantial resources to promoting technical and business exchanges that involve overseas Chinese students. Such activities are designed to involve scientists and researchers, business people, and policy makers in cross-regional exchanges of know-how and information. They also provide opportunities for overseas mainland professionals to build relationships with their domestic counterparts. In the late 1990s, Chinese policymakers, academic institutions and technology companies increased their commitment to improving external communications with the overseas Chinese. They sponsored an increasing number of events and programs in the US, while also inviting overseas Chinese academics and industry representatives to China to attend conferences and

other events. In addition, the Ministry of Education established the “Chunhui Program” to finance short-term trips to China by overseas Chinese who were trained abroad to participate in Chinese provincial and central governments, recognizing the severity of the loss of human capital have meanwhile developed a range of programs that aggressively court talented returnees.

5,3 Russia

Compared with developing countries, the educational infrastructure of Russia seems quite impressive. The country has 1,097 universities, with 364,000 professors, and 6.8 million students. The literacy rate among the population with more than 15 years get 99.4%, with 16% of total population and 23% of working population having higher education. Approximately 650 universities are teaching software developers. The World Bank estimates that Russia has more than 1 million technically trained personnel, more than the U.S., China or Japan, and three times as many as India. The ratio of researchers to the number of total inhabitants in Russia was 3,801 per million, just less than Japan (4,909), but greater than the United States (3698), Europe (2476), China (454), and India (151). And Russia ranks third in the world in terms of number of scientists and engineers per capita.

Moreover, Russia has seen a deterioration of its intellectual base due to emigration as well as a marked decline in funding for R&D generally. One of the events that demonstrate the potential of Russian technological influence is the impact resulting from the mass immigration of Russians to Israel between 1989 and 1991. However, Russia not only retains vast pools of untapped technical resources, but also continues to produce large numbers of highly skilled graduates educated in the proud academic tradition preserved from Soviet times. Thousands of Ph.D.s or other highly trained researchers with extensive backgrounds in mathematics and physics were put work building defense-related military and communications systems by the Soviet government, consolidating a remarkably talented pool of people who understand how to solve complex "system" problems.

Forty percent of university degrees are awarded in technology and science, with Russian universities producing more than 45,000 IT engineering graduates in the 2003/2004 academic years, including more than 22,000 math and physics graduates. Concerning Science and IT, we can find 125,000 software developers, and 330,000 IT professional in Russia. Approximately 35 % of Russian developers are working in export segment of Russian software development industry (mostly software outsourcing). According to surveys by Microsoft Research, within the last seven years, 1.3 million people graduated from Russian universities with the skills to work in the IT industry. But only 70,000 actually work in IT companies in Russia, and only 8,000-10,000 are working within the offshore software industry. Outsourcing-Russia reports that the total number of IT-related specialists who graduate each year from Moscow universities alone is approximately 5,000-5,500 and that Moscow universities produce an additional 16,000-18,000 annual graduates in various engineering fields that are also available for employment as programmers. The Russian R&D pool involves approximately 950,000 top-level scientists and researchers with leading edge domain knowledge and/or fundamental science skills, from which 50 % could easily learn how to program in a few weeks/months.

An emphasis on math forms a strong foundation, helping Russian graduates to deal with new problem domains and technically challenging tasks. Mastery in quantitative disciplines coupled with English proficiency has resulted in a skill set that has enabled the country to take advantage of the current international demand for IT. Practically, every Russian programmer holds at least a master’s degree in computer science, applied mathematics, mathematics, electrical engineering or physics. According to consulting and research group Market-Visio/EDC, 77.4% of Russian software companies employ PhDs, while in 45.8% of those companies PhDs make up 10% or more of their staff. In this sense, Russian programmers are well suited for complex projects Russian computer specialists have walso on numerous top honors at international programming competitions. At the 2004 ACM International Collegiate Programming Competition, the best-known event of its kind, the winning team

was from the St. Petersburg Institute of Fine Mechanics and Optics. Teams from St. Petersburg State University won the ACM Programming Competition in 2000 and 2001, and in 2003 three Russian teams made it into the competition's top ten – Moscow State University received second place, the St. Petersburg Institute of Fine Mechanics and Optics took third, while Saratov State University took seventh. This pool of scientific talent has attracted numerous Western companies to open wholly owned offshore development centers in Russia.

However, specialists mention that Russia is currently utilizing only 10% of its software development potential. In fact, only 40,000 programmers are involved in products development, while approximately 100,000 are doing either outsourcing or in-house software development. This could be partially attributed to piracy (which is going down) and to lack of management and entrepreneurial skills. Another problem is that Russia tends to compete in the wrong component of IT market – its biggest potential is not in services (India), not in hardware (China), but in software products development. Concerning the competence building process, Cusumano (2003) argues that Russia will have great difficulty to escape from the paradigm of treating software primarily as a science. Russian programmers are specialized in the development of sophisticated algorithmic underpinnings. But they can hardly build "good-enough" products or invent technologies that come to market quickly.

In this sense, a critical issue is related to management capabilities. The technical competence and the creativity of Russian does not always compensate the poor management capabilities to develop those projects, particularly in terms of quality management practices. The lack of management skills is a traditional challenge since Soviet times, which is reinforced by the fact that Russian education system is mostly technical-oriented and geared toward fundamental sciences, generating a lack of middle managers in IT industry which is mentioned as one of "institutional problems" in "Conception of developing IT market in Russia" published by Ministry of IT and Telecommunications in 2005. The current situation in the education system might lead to a loss of competitive advantage in Russia in the future. One of the problems is the fact that the wages of lecturers and professors in state universities are far from competitive in relation to wages in industry and in some private universities. Many software companies are supporting the teaching process at universities by encouraging employees to take part in it, establishing close relationships with universities and supporting them financially. The market for training and continuing education is also developing quickly, including certified training courses coordinated by software companies such as Microsoft, Sun and Oracle. Although technical certification is very popular in Russia (there are more than 10,000 specialists with official Microsoft certification, for instance), the number of certified IT managers in Russia remains below 100, illustrating one of the key problems that must be resolved if the industry is to grow further. In 2002, the Education Ministry initiated training to bachelor and master-degree levels according to international IT standard, including disciplines such as bioinformatics, software engineering, network technologies, research automation, etc. In 2003, Russia joined the European education system's Bologna Process, and by 2010 will fully meet European educational standards. Russian government has approved a concept for IT development until 2010 that stipulates construction of hi-tech parks on the Indian pattern. The computing, mathematics and cybernetics department has already developed and is implementing a project to create a Russian national IT education system. Under the Electronic Russia program a bachelor's degree takes four years and involves a serious mathematical background and a series of specialized practical sessions to develop the skills to deal with modern software to international standards.

6 - Conclusive remarks: the building of technological competences

In the context of a "knowledge economy" the software industry seems particularly relevant not only due to the embodiment of knowledge into products, systems and services but also because it provides the tools to adapt the characteristics of systems, channels, nets and organizations, accelerating

the diffusion of new information and telecommunication technologies. The construction of local capabilities in software activities is also an important component of national competitiveness. Starting from those hypotheses, the analysis developed focus on the complexity, heterogeneity and sophistication of the software industry in Brazil, China and Russia. In fact, despite the huge problems and challenges imposed by the trajectory these countries have faced in the last twenty years, software remains a very dynamic with potential to amplify its economic impact and to stimulate the adoption of innovations, contributing decisively to the growth of productivity and to the deepening of learning and competence building processes in virtually all the economic activities. Throughout this trajectory, these countries have invested significantly in the accumulation of technological capabilities and important backward and forward linkages were developed. A policy regime which emphasized human capital formation, infrastructure building and support to new ventures appear to be a common aspect of the development of software activities in those countries.

We can also point out some characteristics of the software industry in each one of those countries that reveal an important set of strengths, weaknesses and opportunities. Brazilian companies, for instance, comprise a dynamic industry, capable of innovation, but very much fragmented, which tend to restrict the possibilities of investing in formal R&D activities and in more aggressive outsourcing strategies. An important shortcoming was the inadequate and insufficient technological learning by local firms. The adoption of more aggressive technological strategies has been restricted by the absence of conglomerates in the Brazilian economy that could provide the financial means for a long run strategy. Besides the amplitude of the internal market, the basis of the industry's strength can be associated with the flexibility and creativity of companies and technical personnel, with the sophistication and attractiveness of some of its target markets and to the capacity of generating satisfactory technical solutions for a wide range of economic activities. Among the weaknesses faced by the industry, we can highlight the fragmentation of industrial structure and the presence of policy issues that create some troubles to improve a strategy of effective internalization based on the construction of a well known image abroad. The small amount of exports by Brazilian companies emerges from these characteristics. Despite these problems, we can also identify a lot of opportunities that can be exploited to maintain and enlarges the dynamism of Brazilian software industry. These opportunities include not only segments where Brazilian firms had also consolidated a strong position – such as in the financial sector, ERPs, e-business, telecommunications applicative, e-government, agribusiness and retail - but also new attractive segments – such as those related to complex integration outsourcing, to free software and to the development of digital games, virtual reality software and broadcasting solutions.

In China, the domestic software seem to be very dynamic, but it remains relatively immature. In this sense, some problems might be stressed: piracy of software remains strong, local manufacturers have not installed the complex software systems and most Chinese programmer focus on low level programming work such as software maintenance or porting. This lack of maturity hampers the development of the outsource software services sector because it deprives companies experience in developing and maintaining complex software systems for large organizations. This lack of domestic experience in designing complex software systems, directly leads to a lack experience in undertaking large international software outsourcing projects from international companies. Although some specialized small new ventures may have a considerable competence and may be expected to expand their capabilities quickly in growing domestic markets, many observers have stressed the weak technological status and capabilities of the greater part of small software firms in China. The problems related to the limited capabilities of the vast population of relatively small Chinese software firms, which primarily rely on craft-based approaches to software development, is compounded by the fact that they often compete in a few popular domains with virtually identical products. The industry thus appears not very well prepared for competition with large foreign software vendors, once these enter the most popular market segments such as ERP or network management with more mature and

sophisticated products and services that have been localized for the Chinese context. Despite these problems, the emergence and rapid growth of the software industry in the last decade has clearly been happening under a new institutional regime that encourages entrepreneurship, with the growth and dynamism of the sector reflecting new approaches to management and ownership patterns that are increasingly gaining ground in the Chinese economy. The problems mentioned tend also to be mitigated by the dynamism of the market. Given the relative paucity of data, it is difficult to predict when China will become one of the largest software markets in the world, but given the number of Internet and cell phone users, the rapid roll out of broadband networks, and the gadget orientation of Chinese consumers, it might happen quickly.

In Russia, the skill level of local programmers is quite high quality and they are considered to be good problem solvers. Although there was a brain-drain to the West that started in the 1980s and continued through the 1990s, there are still plenty of IT developers in Russia. On the other hand, project management skills are viewed as not so strong. This may change over time as Russian firms become more experienced and hire IT managers returning from abroad. In addition, programmers with adequate English-language capabilities are in short supply, bandwidth costs are higher than in most of the other contracting nations, and the general legal environment in Russia is also quite uncertain. Based on the magnitude of untapped talent, the array of specialized expertise, high levels of productivity, and high quality development output, Russia is well positioned to establish itself within the second-generation sourcing network as the premiere source for advanced development services and specialized technical innovation. However, concerning Russian IT and software development capabilities, the opinions of specialists tend to be polarized. Some analysts claim that Russians are the best in the world when it comes to software, particularly when it involves complex computer programs. Other sources, like A.T. Kearney in its famous report, position Russia very low on a scale among the countries with potential for software outsourcing. Despite this evaluation, the general picture shows that, in terms of cost, quality, and volume, Russia is an attractive destination for offshored work. There are a considerable number of capable, low-cost personnel available in Russia; however, the stability of the business environment and the capabilities of management preclude the type of massive growth seen in India or even China. The evidences also show that the independent Russian software firms are still too small to tackle the largest and most sophisticated projects.

In this context, some common challenges concerning might be stressed to the countries surveyed. One of the main challenges that might be faced by local companies refer, basically, to the construction of an image of technological reputation, as well as to the improvement of the quality of services provided. Among the aspects that should be improved at the firm level, we can mention the search for quality in all service delivery phases, the concern about competitive cost/benefit solutions and about on-time delivery, and the consolidation of a perspective of supplier continuity in market relations. The continuity of investments in innovation to domain new technological platforms is also extremely important. At the infrastructural level, the availability of an agile, trustable and cost-competitive telecom infrastructure seems to be very important. The availability of human resources is also key element to provide the industry with competitive conditions to follow the market evolution, keeping the original quality and evolving as new technologies and new requirements arrive. The increase of inter-firm and firm-government cooperation is also a prerequisite to reinforce the international competitiveness of software industry in those countries.

Some challenges concerning policy measures might be stressed to those countries. Confronted with the heterogeneity of software industrial structure and to the complexity of its technological dynamics, the policy measures might be flexible and properly adapted to the focus they target. The formulation of a software policy should consider the intrinsic characteristics of the different software activities in each context to elaborate their programs and to construct institutional arrangements. However, the policy also has to consider some important integrated instruments and some general conditions that might be attended to consolidate a sustained growth trajectory. Countries like Brazil,

China and Russia, where the socio-economic contrasts are still strong, these policies might also pursue a trajectory based on the reduction of social and spatial disparities.

This perspective also implies a focus on the creation of incentives that widen the possibilities of learning, innovating and competence building for the whole industry. Specifically, there are a lot of evidences that the contacts, interactions and exchange of information and knowledge developed through a local base constitutes an important root to the improvement of innovative competences in the software industry. Moreover, the strengthening of industrial competitiveness might also be articulated with local conditions that improve the potential of learning, innovation and competence building processes. In the software industry, the complex and tacit character of the knowledge required to generate innovations reinforces the importance of the construction of proper channels of contact and communication between providers and users, in order to allow a systematic interchange of information that permits the adaptation of customized solutions according to their needs. The capacity to develop these solutions in a local base permits the accumulation of capabilities that make possible the expansion to more sophisticated markets, including international ones. Considering the territorial heterogeneity of software industry in those countries, policy measures should try to be well informed and well adapted to the characteristics of the local productive systems in which software activities are embedded. Finally, it can be reinforced that both the 'digital divide' and the 'learning divide' might be bypasses in those countries. So, policies initiatives might also be compromised with the achieving of a wider socio-economic development, making the necessary improvements in infrastructure building (and particularly in the educational and vocational system) to effectively include the society in the trajectory of software development.

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