JRC Scientific and Technical Reports

The ICT Landscape in Brazil, India, and China

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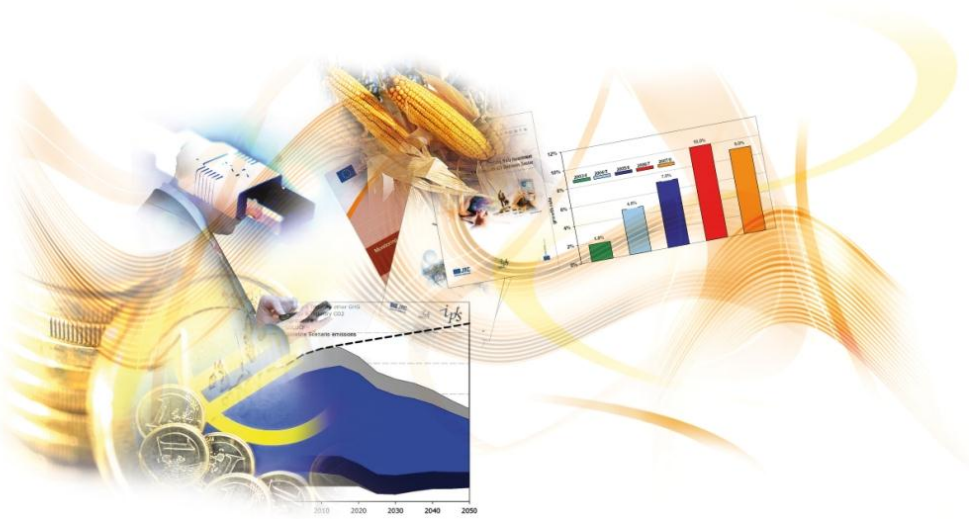

EUR 26923 EN - 2014

JRC EUROPEAN COMMISSION

Institute for Prospective Technological Studies

The mission of the JRC-IPTS is to provide customer-driven support to the EU policy-making process by developing science-based responses to policy challenges that have both a socio-economic as well as a scientific/technological dimension.

This document replaces "The ICT Landscape in BRICS Countries: Brazil, India, China" with ISBN number ISBN 978-92-79-21144-7 and PUBSY request number JRC66110. The corrections made in the new document standardise the way in which China and Taiwan are referred to.

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JRC92241

EUR 26923 EN
ISBN 978-92-79-44013-7
ISSN 1831-9424
doi:10.2791/503714

Luxembourg: Publications Office of the European Union

Printed in Spain

Preface

R&D activity in the Information and Communication Technologies (ICT) industrial sectors is an important factor in boosting the competitiveness of the European economy. The ICT industry and ICT-enabled innovation in non-ICT industries and services is making an increasingly important contribution to economic growth in advanced economies. The ICT sector was highlighted in the EU Lisbon Objectives, and has retained its prominence in the recently proposed **Europe 2020 Strategy**.

The Information Society Unit at IPTS[1] is carrying out a research project on Prospective Insights on R&D in ICT (PREDICT)[2] and has produced a series of annual reports.[3] PREDICT combines, in a unique way, three complementary perspectives: national statistics (covering both private and public R&D expenditures), company data, and technology-based indicators. PREDICT relies on the latest available official statistics delivered by Member States, Eurostat and the OECD.

The first part of each annual PREDICT report gathers the most recent quantitative information on ICT R&D investments in the EU and worldwide. It presents the data by countries, sub-sectors and companies. The second part of each report is dedicated to a specific thematic analysis. In 2009, the thematic analysis focused on patents data analysis. In 2010, it focuses on internationalisation of ICT R&D.

As an extension of these existing research efforts, IPTS launched a tender for research focused on R&D in ICT sectors in India, China and Taiwan, in order to gain a better understanding of major ICT R&D capabilities in those parts of the world. The 2011 PREDICT report offers a country-level approach to ICT R&D internationalisation by analysing the ICT industry in China and India, the two largest emerging economies. It then provides a first synthesis of the research.

This research exercise led to three further reports on China, India and Taiwan, each one including a dataset and a technical annex. Based on these country reports and further research, IPTS prepared this report on ICT in BRIC countries. This first report focuses on Brazil, India and China. A second report will deal with Russia and South Africa.

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1 IPTS (the Institute for Prospective Technological Studies) is one of the 7 research institutes of the European Commission's Joint Research Centre.

2 PREDICT is co-financed by JRC-IPTS and the Information Society & Media Directorate General of the European Commission.

3 Available on our website at: http://is.jrc.es/pages/ISG/PREDICT.html

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Executive summary

An intensive process of redistribution of production across the world is taking place. The BRIC (Brazil, Russia, India, China,) countries are proving to be the major engine of the global growth. They were far less impacted by the financial and economic crisis than developed economies or recovered more quickly. The aim of this report is to take a closer look at the ICTs landscape in Brazil, India and China. It documents the size of the ICT sector for each of the three countries covered and assesses their R&D expenditures.

It is widely acknowledged that the growth rates for these emerging economies have been far above average during the last decade, and have exceeded those of the more advanced countries (EITO 2011). Consequently these four countries are driving most of the world's GDP growth.

Brazil is the world's seventh largest economy by nominal GDP (US$ 2.090 trillion[4]) and the ninth largest by purchasing power parity (US$ 2.172 trillion).[5] China and India are among the fastest growing economies in the world. China's GDP has achieved more rapid growth than most other countries. India is the eleventh largest economy by nominal GDP and the fourth largest by purchasing power parity, having achieved an impressive growth rate over the last two decades. On a purchasing power parity (PPP) basis, China is the second largest economy in the world after the US, representing about 41.56% of total EU27 (World Bank, 2009).

Taking a closer look at BRIC countries allows us to better track the flows between and within regions. Trade, foreign direct investment (FDI) and the off shoring of manufacturing have been highly noticeable in Asia but trade relationships between Asia and Brazil are also worth noting. Brazil now imports for over 60% of IT products from Asia.[6] Exploring the relationships between China and Taiwan and the changing role of R&D also provides a key case study of the formation of global production networks.

1. ICT in Brazil, India, China

In 2010, BRIC countries accounted for 13% of global demand, with spending of about € 328 billion in ICT (EITO, 2011). Therefore, they are becoming major players, not just as plain ICT users/ importers but also as producers of ICT goods and services. China has become the world's largest producer of ICT products (exports of ICT increased fourfold between 2004 and 2008, though many of these are re-exports from other Asian countries).

They are also becoming major players in the entertainment and media markets. According to PricewaterhouseCoopers (Global Entertainment and media outlook, 2011), Brazil, India and China will be the fastest growing leaders with a projected compound annual increase of 11.4%, 13% and 11.6% respectively between 2011 and 2015 (versus US: 4.7%, EMEA: 5.2%).

Table 1 shows ICT spending for selected emerging economies for the period 2000-2007 (OECD 2010): Brazil, Hong Kong, China, Taiwan, India, Russia, and South Africa - for different segments. The growth of the ICT markets in Brazil, India, and China is remarkable. This is likely to continue. In 2009, 46% of Internet users (1.8 billion global Internet users)

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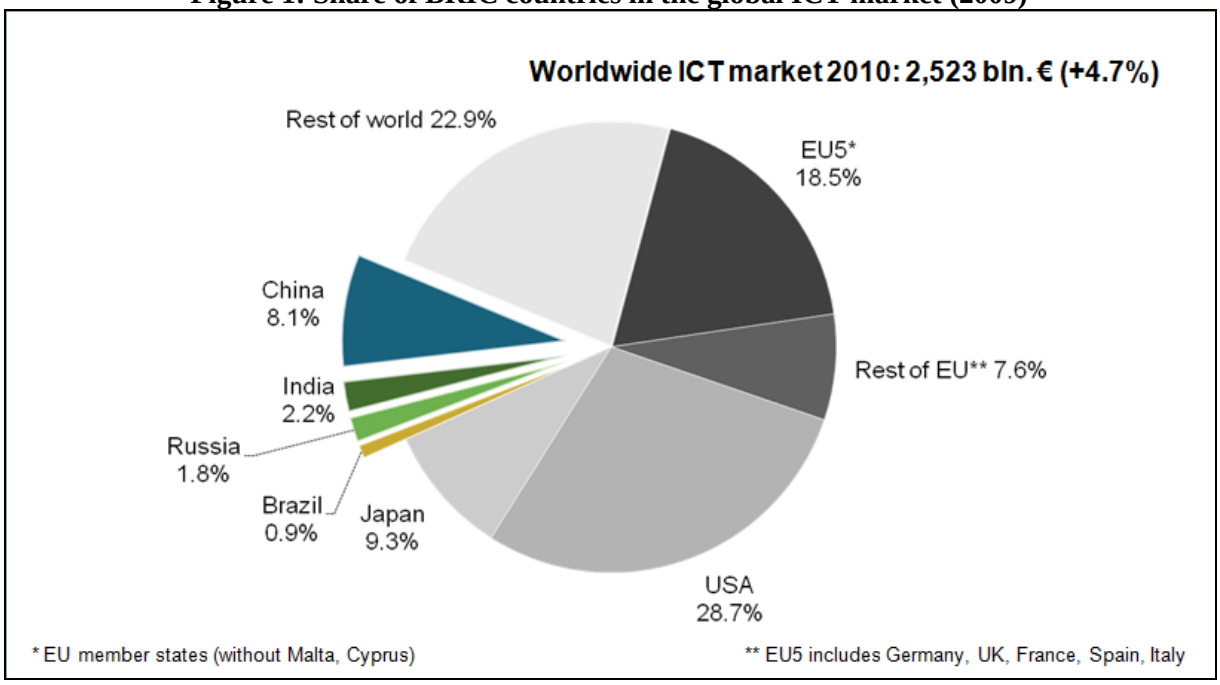
4 2010. Source Wikipedia, last consulted August 2011. US: 10^{12}

5 Estimate 2010. CIA The world fact book, www.cia.gov/library/publications/the-world-factbook/rankorder/2001rank.html, August 2011

6 Source: ABINEE, 2010, http://www.abinee.org.br/abinee/decon/decon10.htm

concentrate in five countries, the top Internet markets: China, USA, Brazil, India, Russia, four are BRIC countries.[7]

Figure 1: Share of BRIC countries in the global ICT market (2009)



Source: EITO in collaboration with IDC, PAC and Idate, published in EITO (2011).

In Brazil, the growth of the ICT market has been impressive. The ICT sector was one of the most affected by the economic opening up process observed in Brazil in the 1990s, when the relative value of the ICT market almost doubled. This growth is expected to continue in the future according to EITO (2011). Brazil's ICT market value is now equivalent to 7% of Brazilian GDP. The largest sub-segments are telecom services (43.14%) and IT services (17.87%). However, the trade balance of the ICT sector is still negative.[8]

As is the case for many other industries in Brazil, the ICT sector is dominated by foreign companies. These foreign firms are leaders in the two main segments (telecom and IT services) of the Brazilian ICT sector. ICT industry production is concentrated in a small number of transnational corporations. The telecom services segment provides a typical example of foreign direct investments. The Mexican firm, Telmex plays a prominent role (it owns 75.16% of Embratel in the fixed market, 100% of America Movil in the mobile market[9]). Large EU companies have also invested in both fixed and mobile markets (Telefonica, Portugal Telecom,[10] Telecom Italia).

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7 Morgan Stanley, Ten Questions Internet Execs Should Ask & Answer, 16 November, 2010 presentation at the Web 2.0 Summit – San Francisco, CA., USA.

8 See Chapter 1: Brazil; Trade deficit ICT, and Table 4.1 "Emerging economies' trade in ICT goods, 1997-2007" in Chapter 4.

9 Statistics and Analysis, Latin American Telecommunications sector 2Q 2009, Business News America, p.6 (mobile), 8 (fixed).

10 Very recently there was a change in the market. Telefonica bought the shares of Portugal Telecom at Vivo (mobile), and PT bought a share of Oi (fixed and mobile).

As stated by the OECD, "*in 2009 OECD countries' share of the ICT world market declined to 76% (from 84% in 2003), as growth in non-OECD economies decoupled from growth in OECD countries. As part of this shift the top 250 ICT firms include more non-OECD firms, among them manufacturing firms in Taiwan, which have partly driven the rise of China as the major exporter of ICT goods, IT services firms from India, and telecommunication services providers from a range of non-OECD economies*."[11]

The Chinese and Indian ICT sectors are certainly representative of the massive changes in their industries and economies. China is the world's largest mobile market. As of January 2011, the number of subscribers reached 853 million.[12] The Chinese ICT market reached a value of € 204.1 billion in 2010 (EITO, 2010:25). China has become the world's largest producer of ICT products (exports of ICT increased fourfold between 2004 and 2008 though many of the exports are re-exports from other Asian countries). Manufacturing dominates China's ICT industry.

Indian telecom operators introduced a major business innovation: the budget or "bottom of the pyramid" (BOP) telecom model. Mobile charges are the lowest in the world. Big numbers require big solutions: hi-tech / low-cost.[13] India is the second-largest market worldwide. **China and India are the fastest growing mobile markets in the world.**

The Indian ICT sector is growing in all domains, but is predominantly driven by software services. Here growth is driven by services – a real "service revolution" with unusual innovations.

In both countries, several electronics firms have become global players: Huawei Technologies, Lenovo, and ZTE in China and Tata, Wipro and Infosys in India. Tencent, Aidu and Alibaba.com (all Chinese companies) now rank now 4th, 6th and 12th among the global top fifteen publicly trading internet companies (by market value, as of 2010). However, these success stories may be misleading in China as very few Chinese corporations are among the main R&D investors (there are scarcely a dozen Chinese corporations among the top 1 000 worldwide). Among these 1 000 top corporations, Chinese and Indian firms account for 1% of R&D expenditures (EU firms for 32%, North America for 40%).

[11] OECD, 2010. p.14.

[12] "The largest, China Mobile, saw its total mobile subscriber base rise to about 589.3 million in January 2011, including 22.6 million 3G subscribers. Number two China Unicom increased to 169.7 million during the month, including 15.5 million 3G subscribers. China Telecom's customer base rose to about 94.1 million, including 13.6 million 3G subscribers". GSMA Mobile Business Briefing, 22 February, 2011.

[13] A view often stressed by several speakers during the JRC-IPTS International Conference "Asian rise in ICT R&D: Looking for evidence", Brussels, 16-17 February, 2011.

Table 1: Emerging economy ICT spending by segment (2000-07, million US$ in current prices)

	2000	2003	2004	2005	2006	2007	Growth (percentage point)
IT Hardware							
China	12507	27027	39057	47927	57813	68303	4.48
Hong Kong	1961	1921	1980	2026	2015	2001	0.02
Taiwan	2767	3605	4148	4391	4550	4871	0.76
India	2257	5013	7204	10264	13630	17910	6.94
Russia	1816	2881	3900	4852	5574	6978	2.35
Brazil	6263	9905	12407	15946	17316	17454	1.79
South Africa	1661	2503	3457	4024	4412	4646	1.8
Software							
China	1085	3344	5295	7940	11376	16328	14.05
Hong Kong	278	373	432	492	558	649	1.33
Taiwan	519	860	1046	1228	1408	1690	2.26
India	358	948	1350	1908	2519	3336	8.32
Russia	343	570	742	923	1056	1182	2.45
Brazil	1602	2469	2877	3566	3828	3803	1.37
South Africa	627	1328	1965	2369	2781	3159	4.04
IT Services							
China	851	3591	6203	10006	15539	24081	27.3
Hong Kong	540	747	903	1071	1266	1532	1.84
Taiwan	788	1226	1478	1731	1973	2358	1.99
India	1120	2859	3876	5243	6607	8356	6.46
Russia	891	1537	2099	2747	3299	3881	3.36
Brazil	4937	7353	9040	11911	13530	14238	1.88
South Africa	1293	2240	3632	4408	5206	5951	3.6
Communications							
China	29917	41437	47102	51759	57586	63668	1.13
Hong Kong	9098	9595	11662	12240	12807	13851	0.52
Taiwan	14200	12570	13247	14367	14949	16305	0.15
India	12841	16873	23734	29023	32549	35978	1.8
Russia	6064	11566	14786	18806	21695	24017	2.96
Brazil	20609	21491	24008	30462	33996	34240	0.66
South Africa	6896	8947	11709	12825	13073	12792	0.85
Total ICT							
China	44359	75400	97658	117362	142313	172380	2.89
Hong Kong	11878	12637	14977	15829	16646	18033	0.52
Taiwan	18274	18262	19920	21718	22879	25223	0.38
India	16575	25692	36164	46438	55304	65580	2.96
Russia	9114	16554	21539	27327	31624	35158	2.86
Brazil	33410	41217	48330	62065	68670	69374	1.09
South Africa	10477	15217	20763	23625	25471	26549	1.53

Source: OECD, 2008, from data published by WITSA, based on research by Global Insight, Inc.

2. R&D expenditures

This impressive growth of the ICT market is translated into R&D expenditures and output, for instance, China's invention output overtook that of both the EU and the US, and comprised more than 44% of all Asian patent applications in 2007. Innovative capability in Asia has grown, the dynamics in terms of catching up are strong. Asian countries are increasingly present in the ICT R&D global landscape.

However, there is still a gap with developed economies and there are local differences. If one takes a look at R&D expenditures (all sectors), these countries are still at the early stages in their investments in R&D. China is closing the gap with the EU27 quicker and had the fastest growth in R&D intensity (i.e. GERD/GDP ratio: annual growth rate of 22.8%) between 2000 and 2008 (Unesco 2010). India, however, is still lagging behind. Korea, Taiwan and Singapore are above the OECD average for R&D gross expenditure (% GDP). Driven essentially by China, India and the Republic of Korea, Asia's world share of GERD rose from 27% to 32% between 2002 and 2007, largely to the detriment of the Triad (European Union, Japan, USA) (Unesco 2010). China plans to raise the GERD/GDP ratio from 1.54% (2008) to 2.5% by 2020 (Unesco 2010).

In 2008, Brazil invested 1.1% of its GDP in R&D and the amount spent by the Government (0.7%) is in line with state investments in other countries. However private investment is lagging. Brazil's R&D intensity (all sectors) progressed more slowly than the economy as a whole (Unesco 2010). Brazil still lags behind the OECD average. Brazil plans to raise R&D expenditure from 1.07% of GDP in 2007 to 1.5% of GDP in 2010 (Unesco 2010).

ICT research is a priority in China and most of its R&D labs are for ICT. China-based R&D increasingly adds value, and is not just cost-oriented. By 2009, there were more than 1 200 foreign R&D centres in China. In spite of this growth, China's level of expenditure remains modest: a mere 2.7% of the total R&D expenditures in 2009.[14] There is still a big difference between China's R&D expenditure as a percentage of GDP and that of the EU (nearly 2.0% in 2006) and the US (over 2.5% in 2006). Indeed, the level of R&D and ICT R&D expenditures remains modest. Still, China's R&D expenditure (GERD) has been growing even faster than GDP, and, as a result, R&D intensity has grown from 0.9% in 2000, to 1.23% in 2004, 1.3% in 2005 and 1.42% in 2006, amounting to some € 30 billion (2006).[15]

The level of investment in ICT R&D is still low in India. Total GERD in India reached some € 3.8 billion in 2004 (around 0.7% of GDP) from 0.58% in 1990-91. It then grew to 0.89% in 2005-06. Consequently, one of the major shortcomings of the Indian ICT sector, repeatedly discussed by existing studies, is the scarcity of R&D expenditures and activities performed by firms in the Indian ICT industry.[16]

FDI-led ICT R&D

As noted, the Brazilian ICT sector is foreign driven.

Since 2003, China has become the world's largest recipient of FDI (ICT and non-ICT), overtaking the US. By 2004, supported by these foreign investments, China had become the

[14] Huang Linli, "ICT and R&D in China", China Center for Information Development (CCID), presentation at the Beijing IPTS / IWEP meeting, 3 December, 2010.

[15] In comparison, EU27 GERD was above € 200 billion and US GERD above € 300 billion. EU27 ICT expenditures alone were similar to the total Chinese GERD.

[16] There is no reliable recent data on ICT R&D expenditures, neither on research personnel in the Indian ICT industry. Estimates are pointing at very low numbers.

third most important offshore R&D location after the United States and the United Kingdom, followed by India (sixth) and Singapore (ninth).[17] For some observers, China is expected to become an even more attractive location for future R&D investments than the United States. FDI in China is mainly located in the Eastern coastal areas, such as Guangdong, Zhejiang and the Fujian Provinces.

During the period 1996-2000, R&D investment worth US$ 1.13 billion flowed into India. The US invested most of this (some US$ 860 million) in R&D centres, followed by countries like the UK, Japan and Germany with much smaller amounts.[18] There are many reasons for US dominance: the US is the major consumer of software services originating from India and firms exploring the Indian market for off shoring are from the US.

R&D and innovation in the ICT hardware domain is skewed towards embedded software, especially in the telecom domain. Poor manufacturing capabilities, lack of adequate supportive infrastructure and competitive producers like China, Taiwan and Korea will make the Indian ICT industry pursue a strategy where services dominate in the future.

ICT R&D off-shoring

China is also becoming an important source of outward foreign direct investment (OFDI). These investments are focused mostly on emerging economies including Hong Kong and Macao. Along with overseas investments in Russia and Middle Asia, it accounted for more than 70% of the total OFDI. China has become a leading source of FDI in Africa.

China's OFDI flow and stock now stands as the 4th and 6th largest, respectively, among developing countries, but its OFDI stock accounts for only 0.6% of global OFDI (OECD, 2006). Compared to the large FDI into China, China's OFDI is smaller and is still at an early stage.

Contribution of the Indian ICT sector in outward FDI, measured through values of merger and acquisitions, is significant with the total number of deals involving Indian ICT firms increasing on a regular basis and amounting to significant total investments (US$3.4 billion in 2008 from US$ 2.9 billion in 2007).[19]

Output: patent

Figure 2[20] shows, for Brazil, a very modest growth[21] for patent applications compared with India and above all China. The importance of ICT-related patents remains low.[22]

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17 UNCTAD, 2005.

18 Data from TIFAC report, presented in Banerjee 2009, p.144. Full analysis by the Technology Information Forecasting and Assessment Council (2006). See at: TIFAC.org.in.

19 Nasscom, 2009.

20 Based on JRC-IPTS calculations. See 'The 2011 report on R&D in ICT in the European Union', Chapter 5: Performance of ICT R&D – ICT patenting, at 5.2.2. The report brings new developments include wider coverage of patent databases and refined, more detailed analysis of patent statistics enabled through methodological advances: 59 Patent Offices -versus 29 in the 2010 report were considered. Available at http://ipts.jrc.ec.europa.eu/publications/pub.cfm?id=4399

21 De Brito Cruz. C.H., Chaimovich, H.(Unesco, 2010) report that the Brazilian business sector registered only 103 patents at the United States Patent Office (USPTO) a figure qualified as *"a dismal count"*.

22 See Figure 1.6 "Total and ICT patent application by Brazil-resident inventors", in the Brazil chapter.

Box 1: Methodology for patent data

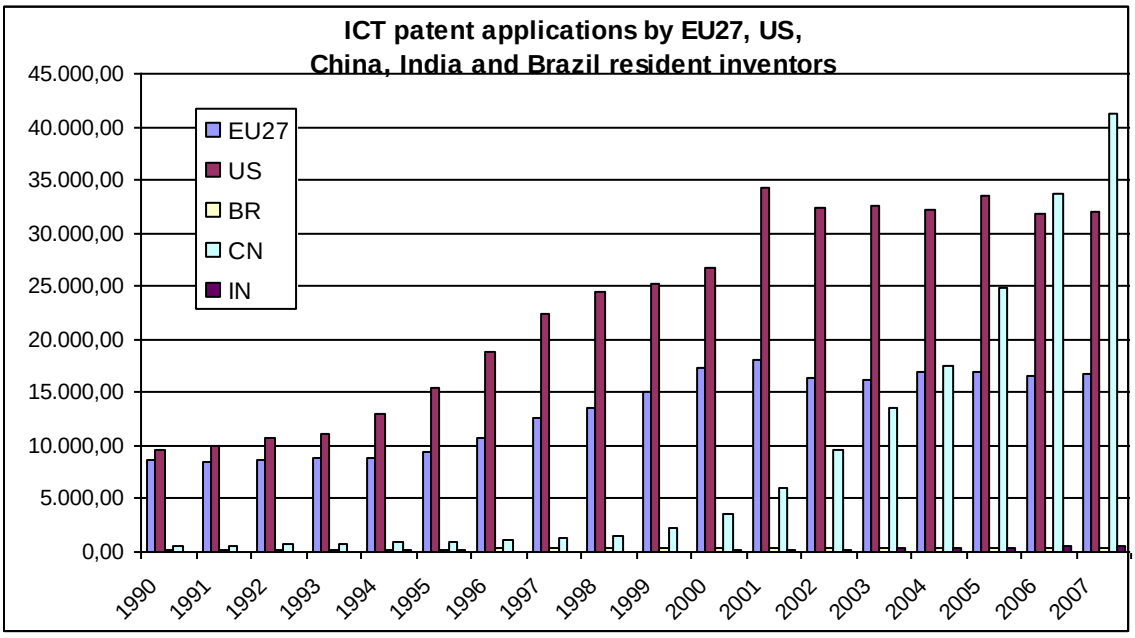
Priority patent applications

A number of steps have to be taken in the process of patenting an invention. When the application is first filed at a patent office by an applicant seeking patent protection, it is assigned a priority date (in the case of a first filing in the world) and a filing date. The filed application could become a granted patent, being then assigned a grant date, if no reasons for refusing the application have been raised during the process of analysis of the subject, novelty, non-obviousness and industrial applicability of the invention.

The indicators proposed in this report aim to provide the best measure of the inventive capability of countries, rather than of the productivity of patent offices. To achieve this objective, patent applications are taken into account, rather than granted patents. The reasons behind this choice are manifold and documented in the scientific literature on patent statistics.

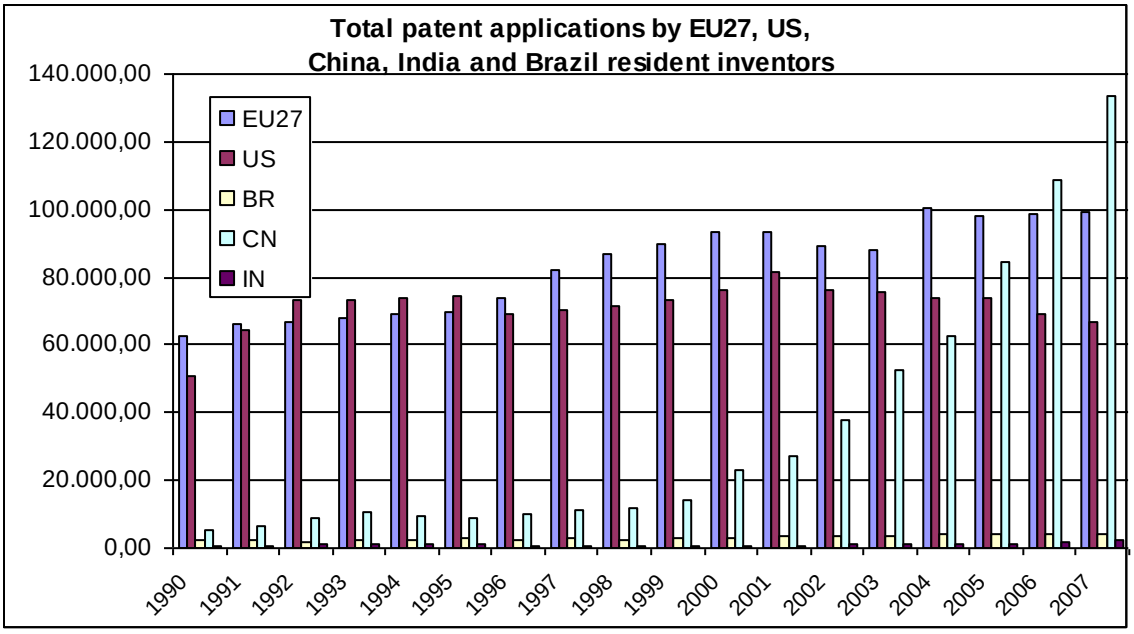
Source: Turlea et al (2011), The 2011 report on R&D in ICT in the European Union, Annex 5.

Figure 2: ICT patent applications by EU 27, US, China, India and Brazil resident inventors



Source: JRC-IPTS calculations based on PATSTAT data (April 2010 release). Priority patent applications to the EPO, the 27 Member States' National Patent Offices, the USPTO, the JPO, and 29 further Patent Offices. Inventor criterion.

Figure 3: Total patent applications by EU 27, US, China, India and Brazil resident inventors



Source: JRC-IPTS calculations based on PATSTAT data (April 2010 release). Priority patent applications to the EPO, the 27 Member States' National Patent Offices, the USPTO, the JPO, and 29 further Patent Offices. Inventor criterion.

Indian patenting activity in the field of ICT grew slowly since 1990 but went through a faster increase during 2002-2007:[23] up from less than a 1000 in 2002, to nearly 2500 in 2007.[24] For both Brazil and India it remains modest as illustrated by Figure 2.

The most striking fact is the impressive entrance China made in ICT patenting activity.[25] China's inventive output increased massively starting in 2000 and overtaking both the EU and US output by the mid-2000s. Figure 2 and 3 clearly show this massive growth. As explained in Predict (2011),[26] data shows that the ICT patent applications filed by China- and Korea-based inventors in 2007 summed up to 91% of the total Asian ICT application output.

New patterns of trade: toward new forms of cooperation?

During the last decade Brazil, India and China went through major transformations that yielded impressive results, especially in the ICT sector. Their share of the global demand will expand, especially taking into consideration their huge opportunities to further grow their respective domestic markets.

These countries play an increasingly important role in international trade as China has become the largest country in the world in international trade of ICT products.

Despite, the achievements of the pioneering firms from India and China which have become global players, the ICT sector is dominated by foreign companies. EU firms operate in Brazil (mostly from the telecom sector: Telefonica, Portugal Telecom, Telecom Italia…), India (Ericson, Telenor, Vodafone, Siemens, Nokia…), China (Alcatel-Lucent, Nokia Siemens Network, Orange FT Group, Sony Ericson, Telefonica…).

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[23] Based on the JRC-IPTS calculations. See 'The 2011 Report on R&D in ICT in the European Union', Chapter 5: Performance of ICT R&D – ICT patenting, at 5.2.2.

[24] See Figure 2.6 "Total and ICT patent application by India-resident inventors" in the India chapter.

[25] See footnote 24.

[26] See footnote 24.

Innovative capability in Asia is growing, the dynamics are strong. Asian countries are increasingly present in the ICT R&D global landscape. This is still not the case for Brazil. However, even if the dynamic is different, the level of investment in ICT R&D is still low in India. Beyond the substantial progress achieved, and the accompanying policies, the level of R&D expenditure remains modest for China. Comparing with developed countries, the technical innovation ability of ICT industry is still weak in the three countries even if uneven.

The economic rise of these countries creates potential possibilities for both domestic and foreign companies. At the same time, the rise of India and other Asian countries creates a challenge to developed countries and their policy making in such aspects as science, R&D, education, industry and international affairs. There is still room to improve the conditions for fruitful collaboration with these emerging economies. Some Asian countries, like China, are learning a lot very quickly from abroad. It remains to be seen if the EU is learning from China and other countries in the same way.

References

Bhattacharya M., Vickery G., (2010), The information and communication technology sector in India. Performance, growth and key challenges, OECD, June 2010.

Chen S.H. (2011), Trends in Public and Private Investments in ICT R&D in Taiwan, JRC-IPTS. Available at: http://ipts.jrc.ec.europa.eu/publications/pub.cfm?id=4240

EITO Special Report, (2011),BRIC countries' ICT markets, 2007-2011, 3 January.

Kubota L.C, Nogueira Milani D., (2009), Relatório Setorial: Industria de tecnologia da informação e comunicação, Agência Brasileira de desenvolvimento industrial, Belo Horizonte, April 2009.

Ling W., Shiguo L., (2011), Trends in Public and Private Investments in ICT R&D in China. JRC Technical Note - JRC 64578. Institute for Prospective Technological Studies, Joint Research Centre, European Commission. Forthcoming.

Malik P., Vigneswara Ilavarasan P., (2011), Trends in Public and Private Investments in ICT R&D in India. JRC Technical Note - JRC 63993. Institute for Prospective Technological Studies, Joint Research Centre, European Commission. Available at: http://ipts.jrc.ec.europa.eu/publications/pub.cfm?id=4240

Organization for Economic Cooperation & Development (OECD), 2006, China will become world's second highest investor in R&D by end of 2006, finds OECD. http://www.oecd.org/document/26/0,2340,en_2649_201185_37770522_1_1_1_1,00.html (accessed 2 August, 2008).

Pascall S., (2010), EU-China Cooperation of Information and Communication Technologies in RTD. Status and way ahead, DG INFSO, February 2010.

PricewaterhouseCoopers, (2011), Global Entertainment and media outlook.

Turlea G., Nepelski D., de Prato G., Simon J.P., Sabadash A., Stancik J., Szewczyk W., Desruelle P., Bogdanowicz M., (2011),The 2011 report on R&D in ICT in the European Union, available at: http://ipts.jrc.ec.europa.eu/publications/pub.cfm?id=4399

United Nations, (2005), Core ICT Indicators: Partnership on Measuring ICT for Development. Available at: http://new.unctad.org/upload/docs/Core%20ICT%20Indicators_Eng.pdf.

Unesco, (2010), Unesco Science Report 2010.

Introduction

This first report focuses on Brazil, India and China. A second report will deal with Russia as well as South Africa, two additional countries which, with the former, are often named under the banner "BRICS".

This report is a synthesis of a set of reports[27] on the ICT industry and its R&D in emerging economies. The data provided here is based on specific research complemented by desk research, expert workshops[28] and interviews. The analysed countries are not members of the OECD, therefore it is probably needless to state that the data, when available, are heterogeneous, little comparable and usually based on non-governmental statistics. The author tried as much as possible to make the figures as valid and consistent as possible.

This research takes part of the PREDICT project,[29] a research line started some five years ago at JRC-IPTS and aiming at describing the dynamics of the ICT industry and its R&D worldwide. In 2011, the PREDICT report series offered a country-level approach to ICT R&D internationalisation by analysing the ICT industry in China and India, the two largest emerging economies. This report complements these 2011 PREDICT reports but from a somewhat larger perspective, including Brazil in the analysis and considerations about the structure of the markets, their regulation as well as trade aspects.

Each national chapter, after a quick introduction to the country economy, assesses the size of the ICT sector. The chapter moves then to a presentation of the R&D expenditures, R&D output (patents), and stresses the role of foreign direct investment (FDI) and R&D offshoring, followed by a description of the major ICT players. Case studies of some of these major companies are presented to close the chapter.

In addition, Chapter 1 on Brazil offers some more detailed view of the Brazilian telecom market and of its regulatory framework. Some trade aspects are emphasized. Chapter 2 on India, also offers a focus on telecom services highlighting the unusual innovation that took place in the telecom subsector. Chapter 3 on China follows a somewhat more standard outline, focusing on the description of the industry and its R&D. Chapter 4 is offering some conclusion while reviewing the case of Taiwan and introducing the news patterns of trade linked to the role of emerging economies.

Each chapter, after a quick introduction of the country economy, assesses the size of their ICT sector. The chapter moves then to a presentation of their R&D expenditures, R&D output (patents), and stresses the role of foreign direct investment (FDI) and R&D offshoring, followed by a description of the major ICT players. Case studies of some of these major companies are presented to close the chapter.

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[27] In 2005, and again in 2008, IPTS launched several tenders for research focused on R&D in ICT sectors in Asia (2005) and particularly in India, China and Taiwan (2008), in order to gain a better understanding of major ICT R&D capabilities in these countries.

[28] Workshops were held in 2009 and 2011. In addition at the IPTS conference "Asian rise in ICT R&D – Looking for evidence: Debating collaboration strategies, threats and opportunities", 16 - 17 February 2011, Brussels, Belgium. 22 experts from academia, research institutes, industry and public administrations were invited to speak. 13 of these experts are working in Asia. Presentations, proceedings and accompanying documentation available at: http://is.jrc.ec.europa.eu/pages/ISG/PREDICT/AsiaICT.html

[29] PREDICT: More at http://is.jrc.ec.europa.eu/pages/ISG/PREDICT.html

1 Brazil[30]

Source: Jean Paul Simon

Brazil is the largest country in South America. It is the world's fifth largest country, both by geographical area (8 514 877 km^2) and by population (estimate of 2010: 193 005 000). Brazil is the world's seventh largest economy by nominal GDP (US$ 2.090 trillion[31]) and the ninth largest by purchasing power parity (US$ 2.172 trillion).[32] The growth of Brazil over the last few years has been hailed as spectacular, even considering the economic downturn from which Brazil emerged as one of the champions of recovery (EU Brasil, 2010).

[30] We would like to thank the following people for their valuable help: Renato Cotrim (Microsoft), Luis Claudio Kubota (IPEA), Gabriel Laender (Telecommunication Advisor to the Chief of Staff at the Executive Office of the President of Brazil and technical coordinator of regulation at the National Broadband Plan Task Force), Simone H. C. Scholze (Anatel), Jose Rogério Vargens (Oi), and Marcio Wohlers de Almeida (IPEA).

[31] 2010. Source Wikipedia, last consulted August 2011. US: $10^{12.}$

[32] Estimate 2010. CIA The world factbook, www.cia.gov/library/publications/the-world-factbook/rankorder/2001rank.html, August 2011

Source: http://www.worldmapnow.com/images/2011/01/Brazil-Map.gif

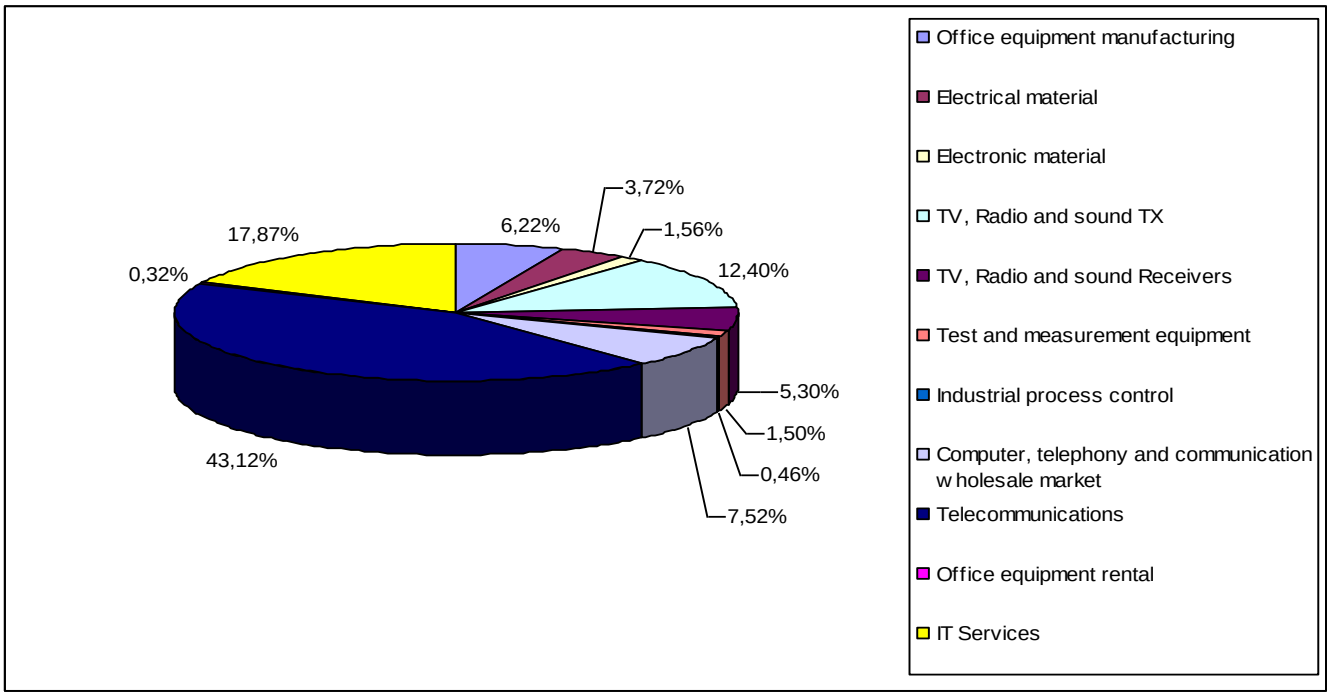
The prospects for investment and growth in Latin America were generally seen as positive for 2010-11, as most of the countries were not as severely affected by the financial crisis as developed economies. The penetration ratio of ICT equipment still provides a lot of room for further growth. Telecom operators appeared to be "*more concerned with dealing with the inherent evolution of the sector*" (ongoing mobile substitution, increasing competition from other players such as cable companies).[33] Even in Mexico, the worst case, "*the telecom sector grew 12.6% in the first nine months of 2009*".[34] Players are likely to still invest to improve their broadband offerings (fixed and mobile). According to Telecom Intelligence Series, Brazil is likely to "*take the lion's share of region wide capex*".[35]

1.1 The size of the ICT market

The growth of the Brazilian ICT market has been impressive. The ICT sector was one of the most affected by the economic opening process observed in Brazil in the 1990's. The relative value of the ICT market almost doubled over the decade. The growth is expected to continue in the future according to EITO (2011).The value is now equivalent to 7% of the Brazilian GDP. The largest sub-segments are telecom services (43.14%) and IT services (17.87%) as illustrated in Figure 1.1 (market shares) and Table 1.1 (value).

[33] "Latin America telecoms investment in 2010", Telecom Intelligence Series, Business News America, February 2010, p.2.
[34] Id, p. 2.
[35] Id, p. 6.

Figure 1.1: ICT market, segments by market share



Source: Anatel, 2010.

Table 1.1: ICT market by segment (2000-07, million US$ in current prices)

	2000	2003	2004	2005	2006	2007	Growth % (percentage point)[36]
IT HARDWARE	6 263	9 905	12 407	15 946	17 316	17 454	1.79
SOFTWARE	1 602	2 469	2 877	3 566	3 828	3 803	1.37
IT SERVICES	4 937	7 353	9 040	11 911	13 530	14 238	1.88
COMMUNICATIONS	20 609	21 491	24 006	30 642	33 996	34 240	0.66
TOTAL ICT	33 410	41 217	48 330	62 065	68 670	69 734	1.09

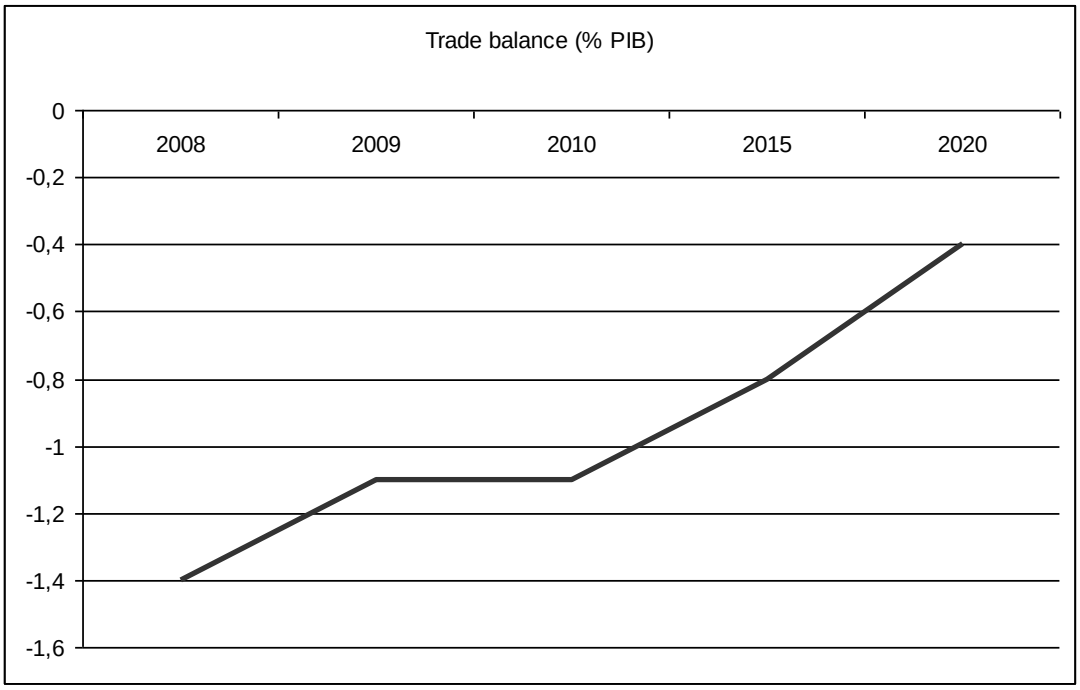
Source: OECD, 2008, from data published by WITSA, based on research by Global Insight, Inc.

However, the trade balance of the ICT sector is still negative and deteriorating: - US$ 27.3 million in 2010 and - US$ 33.4 million projected for 2011.[37] For the middleware part of the ICT industry, measures may have to be taken, otherwise the trade deficit is likely to further deteriorate: from -1.4% of the GDP in 2008 (US$ 22.8 billion) to over -1.9% in 2020 (see Graph 1.1).

[36] Ratio: 2007-2000/2000. For other BRIC countries the ratio (total ICT) was: China 2.89, India 2.96, Russia 2.86. Source: OECD, 2008.

[37] http://www.abinee.org.br/abinee/decon/decon15.htm, last accessed 22 July, 2011.

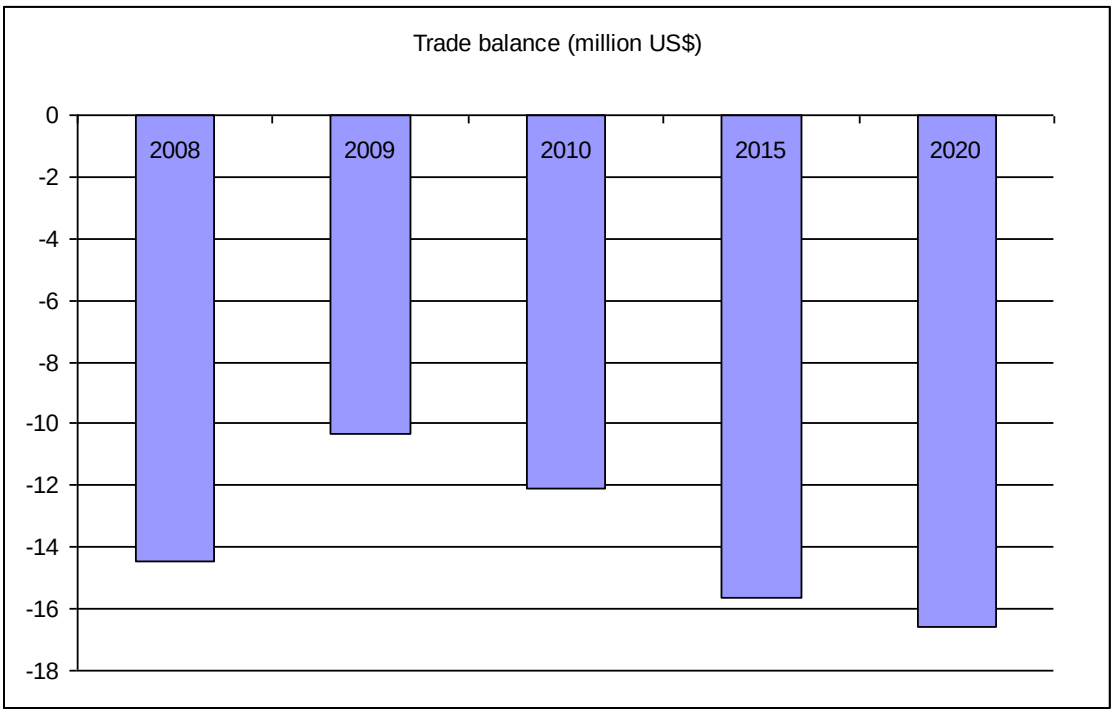
Graph 1.1: Trade deficit ICT



Source: ABINEE (2009).

The component sub-sector is in the worst situation but the telecom trade balance was also negative in January 2010.[38]

Figure 1.2: Trade deficit "component"

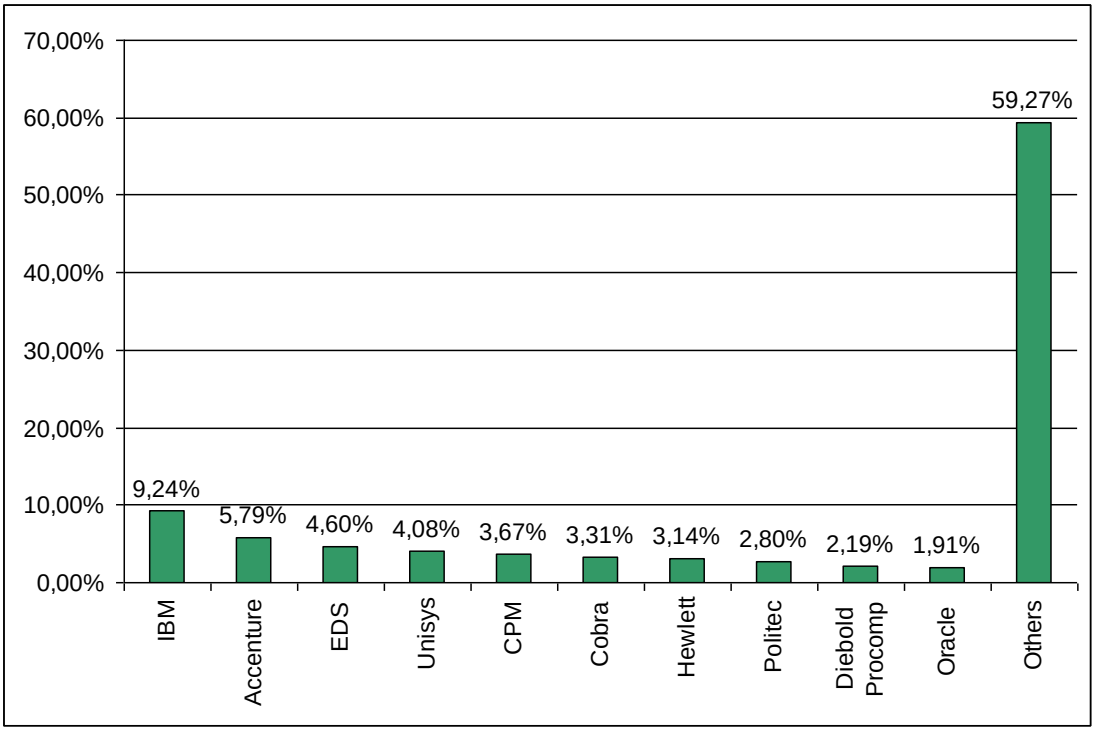


Source: ABINEE (2009).

[38] Teleco, Intelligence in Telecommunications, 12/04/2010.

According to the Brazilian government agency, Instituto de Pesquisa Economica Aplicada (IPEA) the characteristics of the ICT sector are two-pronged.[39] On the one hand, the level of innovation is higher than the average industrial sector. On the other hand, it has two interrelated structural weaknesses: it is highly dependent on the import of electronic components (a rising part of the value added), and Brazilian firms are kept out of standard setting, done mostly through alliances between large international corporations. ICT industry production is concentrated in a small number of transnational corporations: they account for over 16% of the firms but over 70% of revenues:[40] US$32.8 million dollars out of 46.1 million (see Figure 1.3 for IT firms). To substantiate further the concern of IPEA about a two-pronged market, foreign firms are leaders in the two main segments of the ICT sector (telecom services and IT services). In the IT markets, Figure 1.3 shows that the leading IT firms, accounting for 40% of the market, are indeed foreign firms.

Figure 1.3: Revenues of the top-10 IT firms by percentage



Source: IPEA based on IDC/IT Data

Looking at trade flows, for China, between 1998 and 2007, the share of total purchases increased from 2.65% to 33.43% with a corresponding increase of the external payments to China of US$ 146.86 million in 1998 to US$ 3.5 billion in 2007. During the period, the volume of imports grew at an "exorbitant" four digit rate (over 2000%), with an average annual increase of 46.60%. In the case of other Southeast Asian countries[41] it jumped from 16.13% to 27.93%. In other words Asia stands for over 63% of the imports much to the detriment of other regions as illustrated by Table 1.2 in 2010. The US peaked in 2000, then

[39] Luis Claudio Kubota and Daniele Nogueira Milani, Relatório Setorial: Industria de tecnologia da informação e comunicação, Agência Brasileira de Desenvolvimento Industrial, Belo Horizonte, April 2009, p.2.

[40] Luis Claudio Kubota, p.64.

[41] Brunei, Camboja, Filipinas, Indonésia, Laos, Malásia, Mianmar, Cingapura, Tailândia, Timor-Leste, Vietnã, Taiwan.

fell with China overtaking in 2004, leaving the US far behind. In 2010, 55.0% of imports of housewares and 44.6% of IT goods came from China.[42,43]

Table 1.2: Sources of import (2008- 2010, million US$)

Region	2008	2009	2010
US	4.055	3.162	3.963
Aladi[44] (Total)	1.138	814	1.135
- Argentina	319	234	307
- Other Aladi	819	580	829
EU	5.727	4.754	6.043
South Asia (Total)	20.030	15.149	22.143
- China	9.809	7.841	12.104
- Other South Asia	10.221	7.309	10.039
Other	1.084	1.074	1.598
Total	32.035	24.953	34.882

Source: ABINEE, 2011.[45]

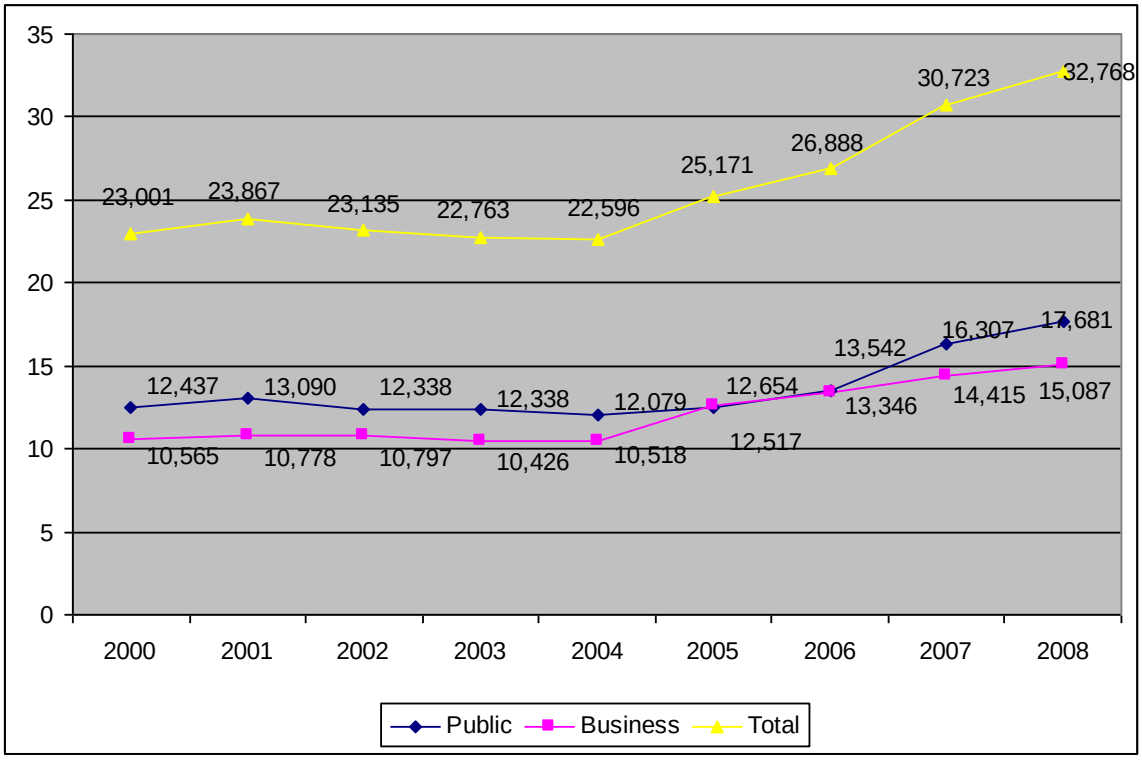
During the same period, imports from the United States plummeted from 36.8% to 5.58 of the total.[46] On the export side, during the same period, the fall is less impressive: from 24.18% to 13.31% but volume went up a sound 65.94%.[47] However, the main commercial partners are now the ALADI (Associação Latino-Americana de Integração) countries: from 29.42 to 36.69. Then if exports to Argentina are added (from US$ 261.13 million to US$ 1.02437 billion between 1998 and 2007, an increase in the volume 292.28% higher than the average of other ALADI countries) the American continent is clearly the main commercial partner. By contrast, exports for the EU went down from 11.61% to 6.56%. Imports fell even more drastically: from 14.59% to 4.31%.

1.1.1. R&D expenditures in the ICT sector

Total R&D expenditures went through a 50% increase between 2004 and 2008. The total ratio to GDP was, as of 2008, 1.09% (0.59 public expenditures, 0.50 private expenditures) (Figure 1.5). However private investment is nevertheless perceived to be lagging, Figure 1.4 shows that the level of private investments remained under the level of the public investments for the period 2000-2008. By the same token, the Unesco 2010 report notes that Brazil's R&D intensity (all sectors) progressed more slowly than the economy as a whole (de Brito Cruz C. H., Chaimovich H., Unesco 2010). The same report states that if its intensity exceeds Latin American standards, nevertheless it lags behind the OECD average.

[42] Source: http://www.abinee.org.br/abinee/decon/decon10.htm. "55.0% das importações de Utilidades Domésticas e 44,6% dos bens de Informática vieram da China".
[43] China and Brazil are also developing space technology together under the China-Brazil Resources Satellites (CBERS), (Unesco 2010: 118).
[44] ALADI: Associação Latino-Americana de Integração.
[45] http://www.abinee.org.br/abinee/decon/decon15.htm, last accessed 22 July, 2011.
[46] Kubota, pp.15-16.
[47] Kubota, pp 11-12.

Figure 1.4: ICT R&D expenditures (2000-08, million RS 2008)



Source: Anatel, 2011.

There are more employees with higher education in ICT sectors, especially in the sectors of communications: 7.4% of all employees in R & D. While the industry's total national percentage of employed people in research and development activities that have at least an undergraduate education is 67.21%, in the ICT industry as a whole, it is 79.91%. Among the different subsectors of the ICT industry, the telecom sub-sector is the one that employs more manpower in R&D accounting for 59.99% of all people employed for R&D in the sector.[48]

According to the IPEA study, the highest number of innovative firms is concentrated in the states of Sao Paulo[49] (53.4%), followed by Amazon (13.8%), Paraná (11.7%) and Minas Gerais (9.6%).[50] Campinas (100 km from São Paulo, State of Sao Paulo) seems to play the role of an R&D cluster for high tech firms with already a legacy of industrial R&D. The Sao Paulo area received 86% of the funds from the telecom fund of Funttel (Fundo Nacional de Telecomunicações).[51]

The high degree of internationalization of the Brazilian market is seen by IPEA as a negative parameter for R&D as international firms tend to reduce they local R&D efforts.[52] Taking into account the profile of the Brazilian firms, they are most likely to invest on the D side rather than in the R one. To mitigate this tendency, Anatel, the regulatory body, is using the mergers processes and subsequent authorisations to mandate some obligations on R&D spending. For instance, the agreement on the purchase of the Brazil Telecom by Oi came with specific conditions also to encourage competition. This trend may also alleviate the concern of IPEA about the dominance of foreign firms as firms must tailor their offer to the domestic market

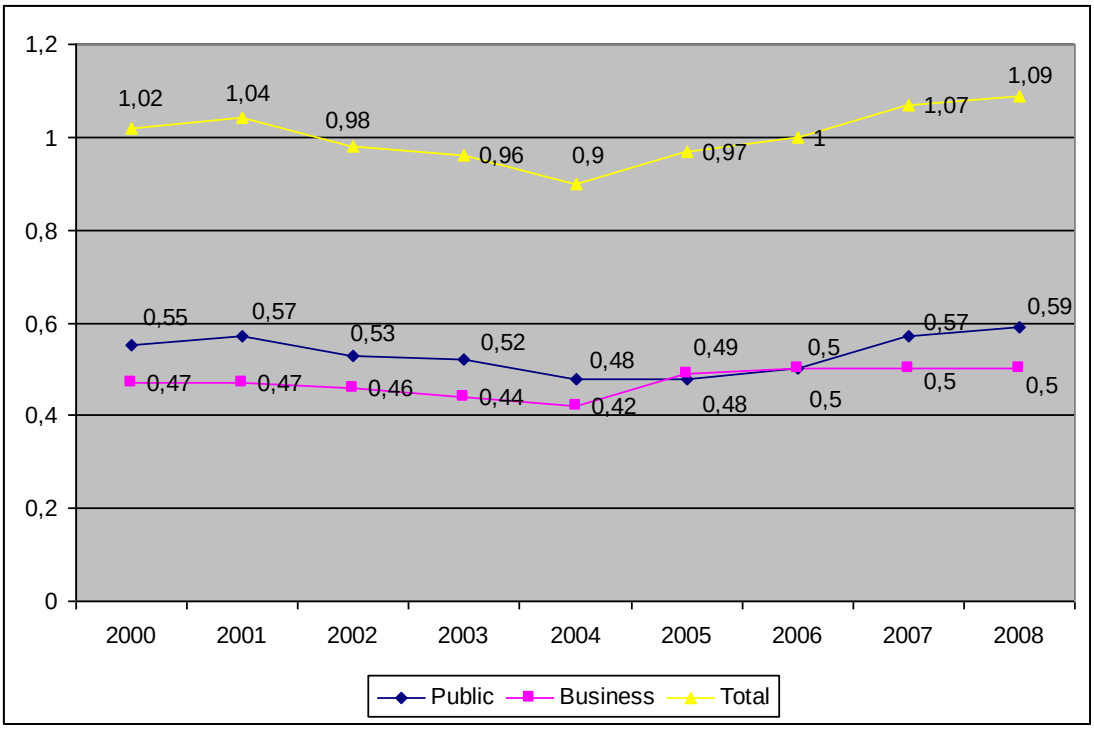
[48] Luis Claudio Kubota, p. 47.
[49] This State generates 34% of Brazilian GDP according to Unesco (2010).
[50] Luis Claudio Kubota, p. 48.
[51] Source: IPEA.
[52] Luis Claudio Kubota, p. 6.

and invest to that end. However, according to the same institute, a great percentage of the investments in R&D of the foreign firms come from fiscal incentives enabled by the Informatics Law ("Lei de Informática") and the real contributions to local technological development are unclear.

The telecom services sub-sector is a typical example of foreign direct investments with the prominent role of the Mexican company Telmex (owning 75.16% of Embratel in the fixed market, 100% of America Movil in the mobile market[53]), and of large EU companies in both fixed and mobile markets (Telefonica,[54] Portugal Telecom,[55] Telecom Italia).

If we take a closer look at the distribution of R&D expenditures among its various segments, it clearly appears that the telecom and radio equipment segment is leading with $ 427.61 million (56.94% of the total), of which less than 1% (or $ 2.89 million) corresponds to public financing.[56] The computers and office machinery segment[57] is coming next with 23% of the total but with the highest share of public funding 4.2%. Then comes "radio and television, sound and video" with resources for R & D that are equivalent to 16.66% of the total invested in the ICT industry. It is also the sector that shows the maximum level of self-funding: 99.91%. The last segment identified in the report (basic electronic material[58]) only accounts for the remaining 3.55% of the total.

Figure 1.5: ICTs R&D expenditures to GDP (%, 2000-2008)



Source: Anatel, 2011.

[53] Statistics and Analysis, Latin American Telecommunications sector 2Q 2009, Business News America, p.6 (mobile), 8 (fixed).

[54] One quarter of total revenues of the Telefonica group come from Brazil; source: EU Brasil 2010.

[55] In 2010, there was a change in the market. Telefonica bought the shares of Portugal Telecom at Vivo (mobile), and PT bought a share of Oi (fixed and mobile).

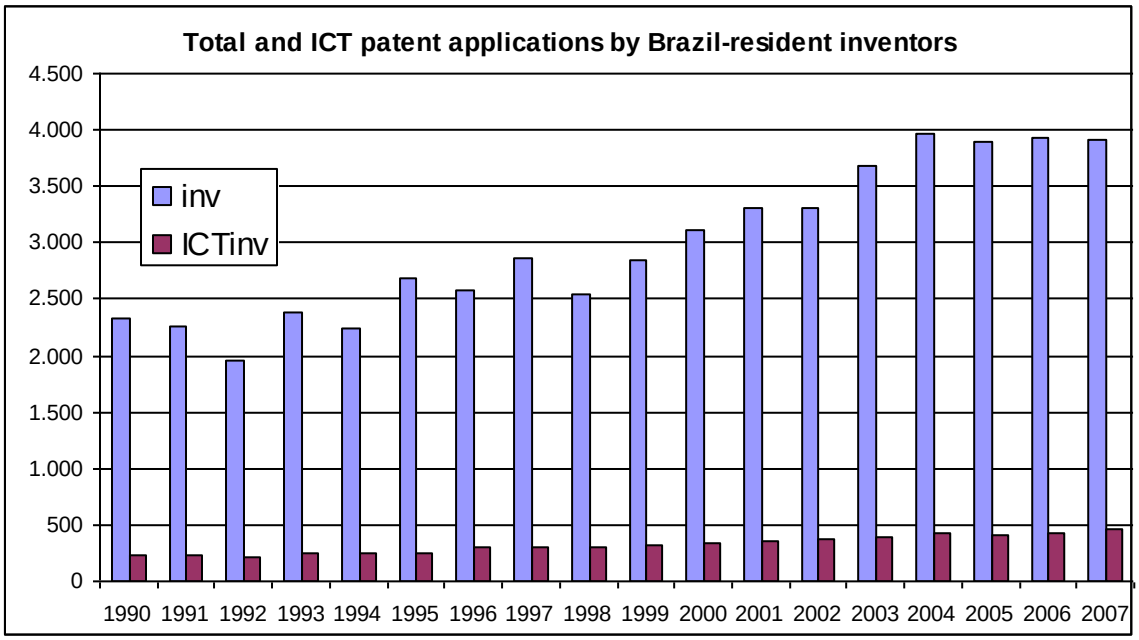
[56] "Equipamentos de telefonia e transmissores de rádio e TV", Kubota p. 71. Using data from Pesquisa de Inovação Tecnológica (PINTEC). See appendix 2 for the classification used by this report.

[57] "Máquinas para escritório e equipamentos de informática" Kubota, p. 72.

[58] "Material eletrônico básico", Kubota p. 72.

In terms of average annual growth rates of ICT-related patent applications to the European Patent Office (EPO), Brazil ranks rather well with a growth rate of 20.7 (as an average for the period 1995-2003).[59] Based on JRC-IPTS calculations,[60] Figure 1.6 shows a modest growth.[61,62] It also reveals a low relative importance of ICT-related patents.

Figure 1.6: Total and ICT patent application by Brazil-resident inventors



Source: JRC-IPTS calculations based on PATSTAT data (April 2010 release). Priority patent applications to the EPO, the 27 Member States' National Patent Offices, the USPTO, the JPO, and 29 further Patent Offices. Inventor criterion.

1.2. A focus on the Brazilian telecom markets

1.2.1 A growing industry

At the end of the first quarter of 2011, there were 2 891 telecom service providers: 6 franchise holders for fixed switched telephony, 137 authorised providers of fixed switched services, 31 holders of mobile authorisations, 2 553 IAP (registered as multimedia communication services), and 161 active Pay TV operators. The market value of telecom (fixed and mobile) and Pay TV reached R$ 149.5 billion (around € 57 billion) at the end of the first quarter of 2011.[63]

[59] *Source*: OECD, Patent Database, 2007.

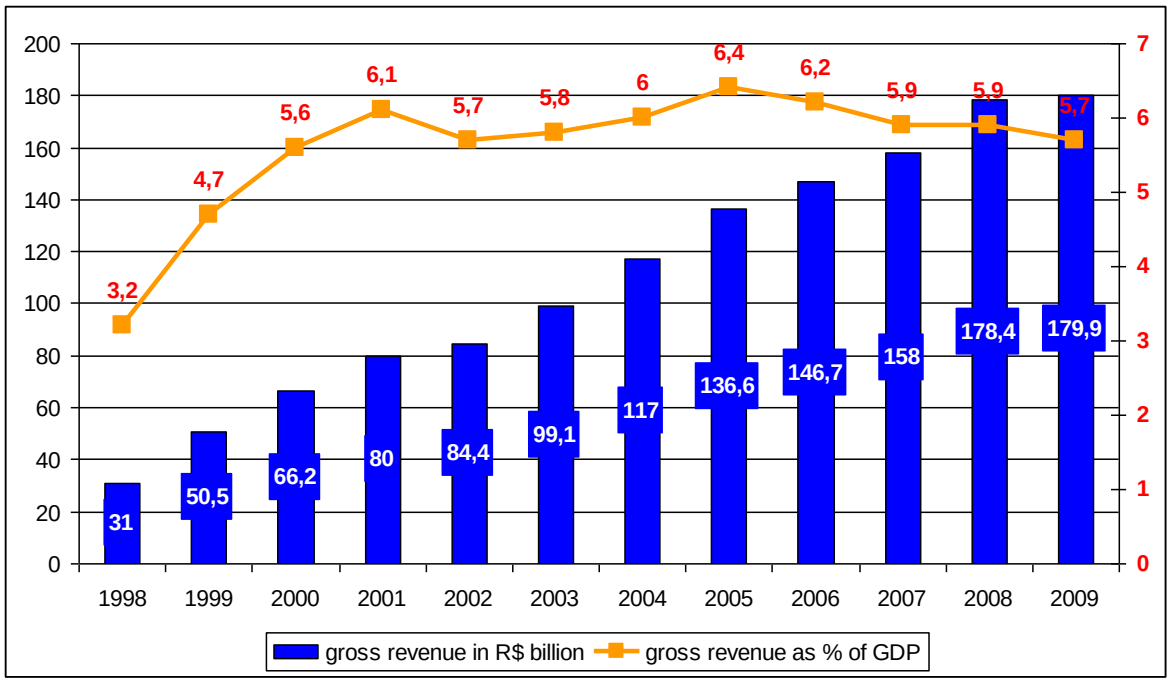
[60] Turlea et al., (2011) The 2011 report on R&D in ICT in the European Union. Chapter 5: Performance of ICT R&D – ICT patenting, Section 5.2.2.

[61] De Brito Cruz C.H., Chaimovich H. (2010) report that the Brazilian business sector registered only 103 patents at the United States Patent Office (USPTO). They present it as "a dismal count" for a country the size of Brazil.

[62] Compared with India and above all China, see the following chapters.

[63] Source: Anatel. As of 2010, the market value was € 55.1 billion without Pay TV (EITO 2011).

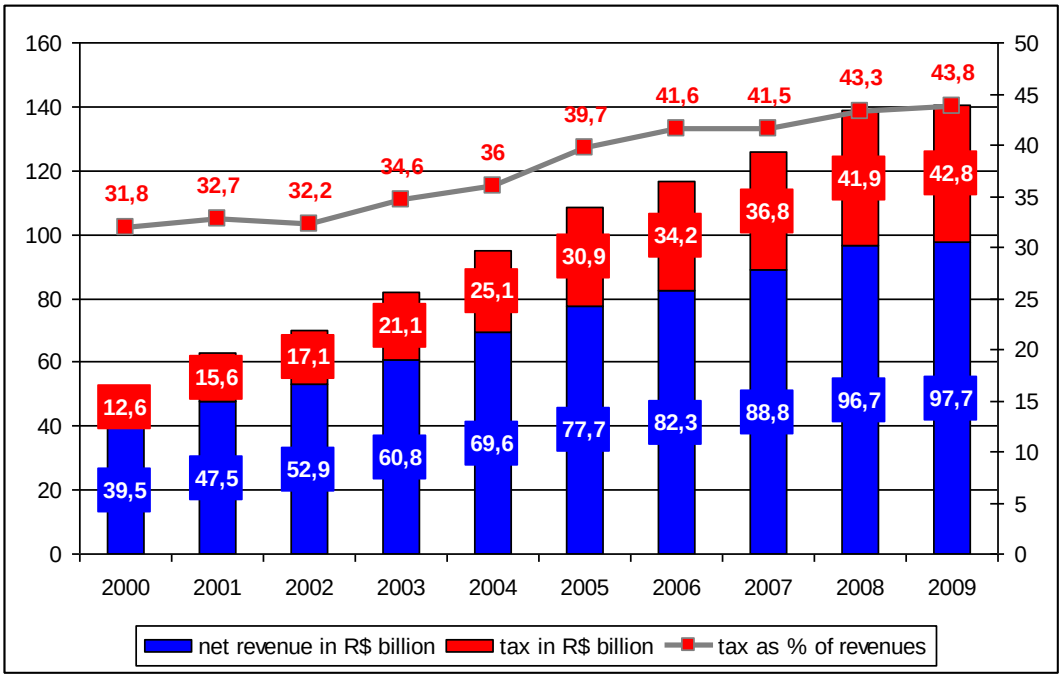
Figure 1.7: Brazilian telecom sector gross revenue in R$ billion[64]and as % of GDP:



Source: ABINEE (2009).

The workforce attained 392 700 employees: 26 700 in the manufacturing industry, 138 000 in the telecom services (out of which 31 100 in the fixed provision, 30 200 in the mobile, 16 100 for cable and 56 000 in other services such as broadcasting and the internet services), 177 400 in call centres.

Figure 1.8: Brazilian mobile and fixed telephony net revenue in R$ billion, tax in R$ billion and tax as % of revenues

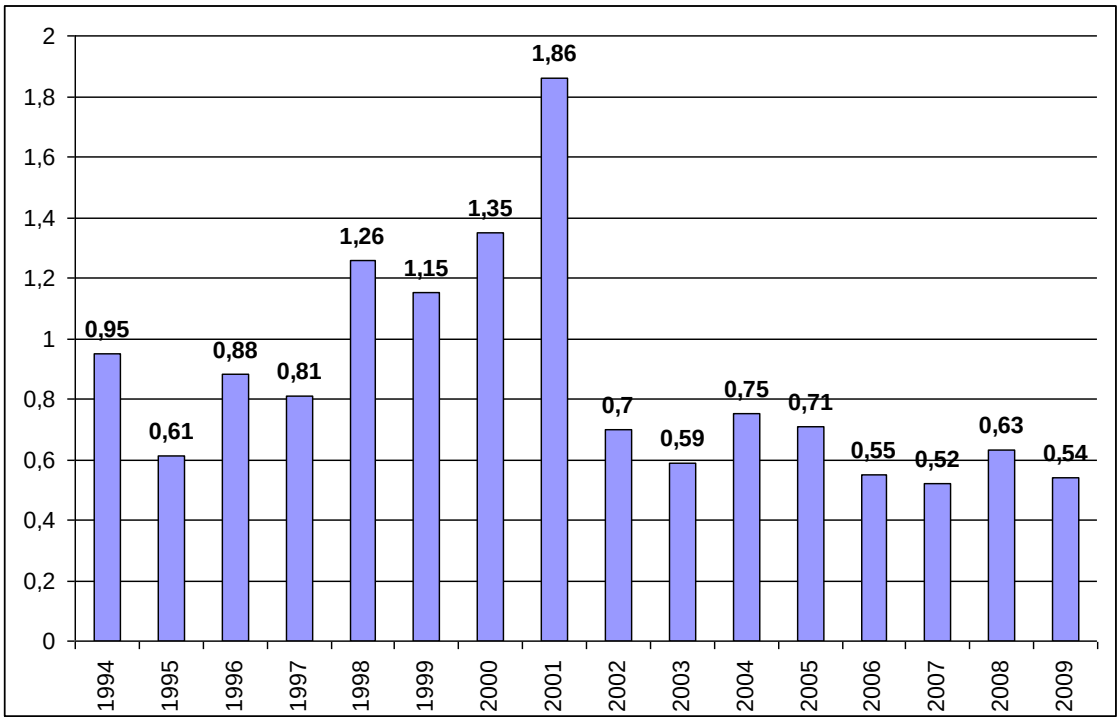


Source: ABINEE (2009).

[64] €1 = R$ 2.62 (as of August 2010). Gross revenues in 2009: € 68.66 billion.

Investments look somewhat erratic but remain in a 0.5 - 1.5% bracket of the Brazilian GDP. The market value is erratic too but it is a common feature of stock markets. The market value of fixed telephony firms went from R$ 2.8 billion in 1998 up to 13 in 2007 and down to R$ 8.4 billion in 2010. However the decline in the value of mobile companies between 2006 and 2008 is more surprising as the prospect for growth seemed more on the mobile side especially with the deployment of wireless broadband.[65] The value grew again in 2009 and 2010.

Figure 1.9: Brazilian telecom investment as % of GDP.



Source: ABINEE (2009).

As of 2009, the broadband penetration was reaching 22 million access lines (13 fixed[66] and 9 mobile) but is expected to grow steadily to reach 160 million at the end of the next decade (see growth of the number of terminal, Figure 1.10). "*Broadband penetration in Brazil by mid-2009 was approximately the same as the OECD average by mid-2003*".[67] Recent growth rates for Brazil as a whole are comparable to average growth rates in the OECD for 2005 and 2006. "*Brazilian broadband penetration growth rates in 2008 and 2009 whereas the average OECD rates were much higher, 54.72% and 42.02%, respectively*".[68] OECD rates in 2003 and 2004, when penetration rates were similar to Brazil's, were much higher, 54.72% and 42.02%, respectively. Brazil does not fare too well compared to countries with similar per capita income (with Slovak Republic, Hungary, and Turkey ranking ahead). A. Rossi concluded:

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65 Source: http://www.telebrasil.org.br/saiba-mais/O_Desempenho_do_Setor_de_Telecom_-_Series_Temporais_1T11_F.pdf , June 2010, Last accessed July 20, 2011.

66 Cisco estimates Brazil could reach 15 in 2010. Cisco Broadband Barometer quoted "2010 Telecom Outlook," Business News America, December 2009, p.17.EITO forecasts 16.4 million in 2011.

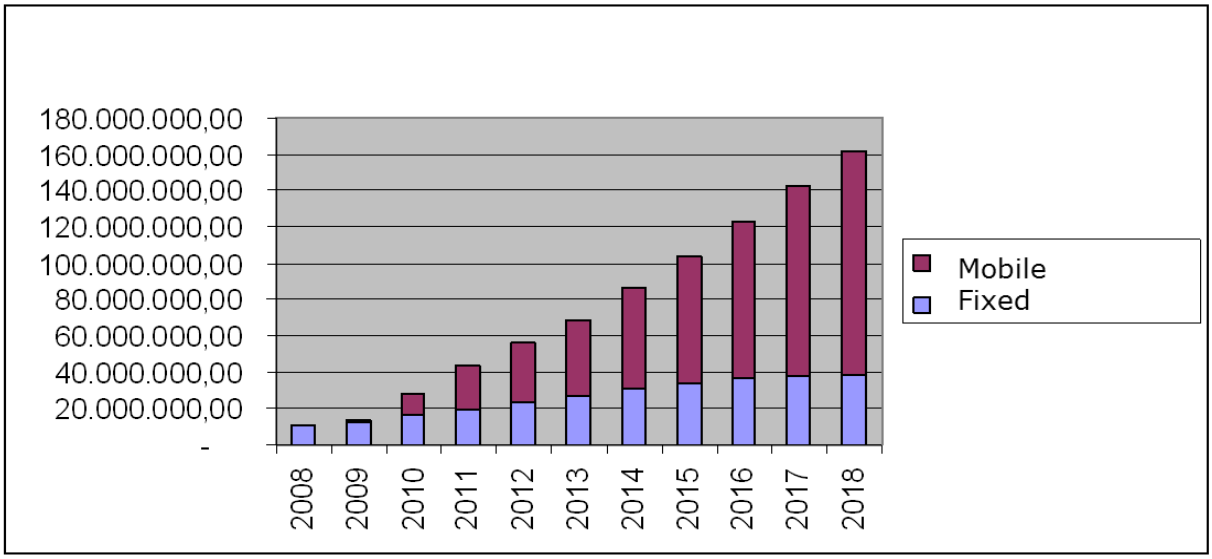
67 The author follows the presentation of A. Rossi at the Americas Communication Research Network (ACORN) conference, Brasilia, May 14-15, 2009. Andre Rossi Oliveira, Paulo Cesar Coutinho, "Broadband expansion in Brazil: An empirical study", p.5.
Available at http://www.acorn-redecom.org/papers/acornredecom2010oliveira.pdf.

68 Id p.6.

"*This adds to the evidence that the Brazilian broadband market is not developing fast enough*"[69] but this is related to the low penetration of computers.

The newly adopted five-year project (National broadband plan) will improve this situation, as the planned investments reaches R$ 15 billion per year (a total of 75 billion out of which 35 are supposed to come from private investors).[70] It is projected that wireless broadband will play a major role and overtake the fixed provision. There were already 19 320 million 3G subscribers as of 2010 (EITO 2011), an increase of 40.7% over 2009. EITO forecasts an increase of 352.4% 2010/2011.

Figure 1.10: Broadband terminal evolution



Source: Anatel, 2011.

Brazil ranked 63rd among 163 countries in price levels. However, the price of broadband basket in Brazil fell from 47.3 to 28 (in US$) and from 56.5 to 34.1 (in PPP$) from 2008 to 2009, a drop of around 40%. There is still a lot of room for prices to decrease before broadband in Brazil becomes as affordable as in top ranking countries.

For PC penetration, Brazil is lagging behind OECD countries. However, the number of computers increased after the launch of the "computer for all" plan in 2005[71] which brought down the prices from R$ 1000 to R$ 500. In 2006, PC sales increased by 46% and notebook by 111%.[72] The increase went on reaching a total of 12 million in 2008, until sales collapsed in 2009.[73]

"*The CETIC's survey has shown that the number of households that have a computer has increased by more than 10 percentage points in the last four years, and that the number of households with access to the Internet has increased by 7 percentage points, according to the table below*"[74] (See Table 1.3).

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69 Id at 6.
70 Id, p. 6. This amount from Cisco may be overstated.
71 Law No. 11.196, of 2005, so-called "*Lei do Bem*".
72 "Indice Brazil para convergencia digital", May 2007, www.ibcd.org.br.
73 Source: Telebrasil.
74 Jaime Barreiro Wagner, " Heading towards IT as a service", Survey on the Use of Information and Communication Technologies in Brazil ICT Households and ICT Enterprises 2008, Brazilian Network Information Center, São Paulo, 2009, 463 p, pp. 61-66.

Table 1.3: Penetration of computer and Internet

Penetration in households

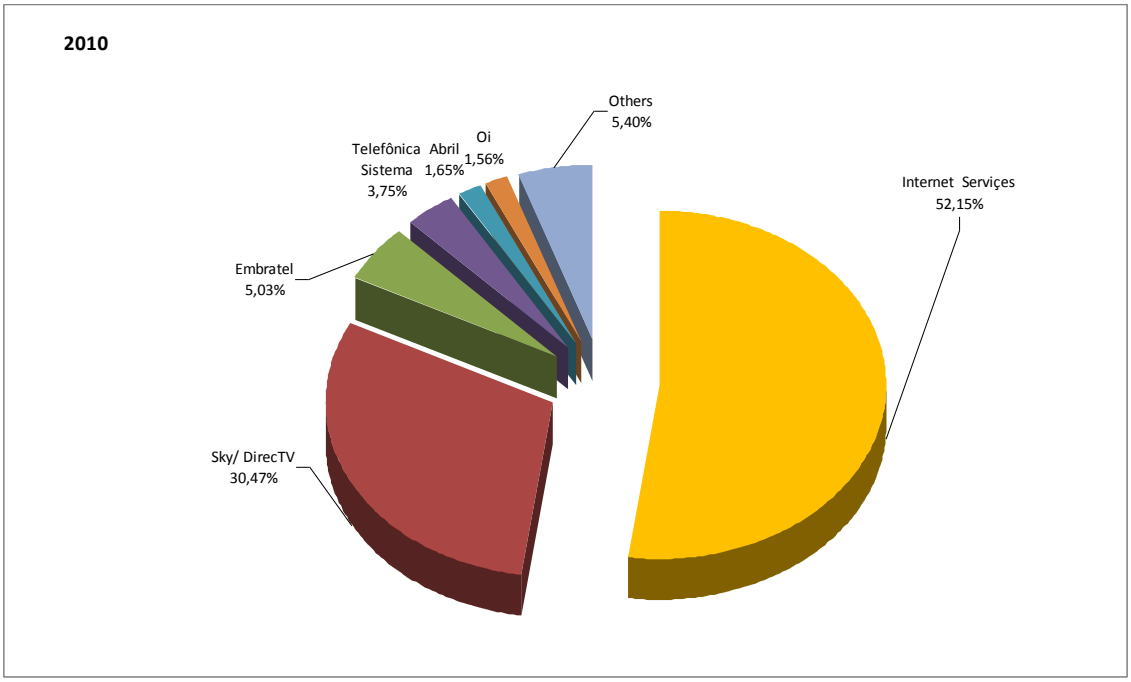
	2005	2006	2007	2008
Computer	17%	20%	24%	28%
Internet	13%	14%	17%	20%

Growth rate

	2005	2006	2007	2008
Computer	-	19%	25%	20%
Internet	-	14%	19%	23%

The pay TV market is relatively small[75] for the size of the country with a penetration of 7.5 million subscribers in 2009 (from 2.8 a decade ago), a ratio of 3.61% (connections per 100 inhabitants)[76] but growing, although unevenly (between 2009 and 2010, the growth rate was 11% for cable TV, 32.9% for satellite TV subscription and 28.9% for digital TV) (EITO 2011) with the exception of MMDS.[77] Figure 1.11 shows the distribution of market shares and access between companies.

Figure 1.11: Pay TV market (net revenues and access)

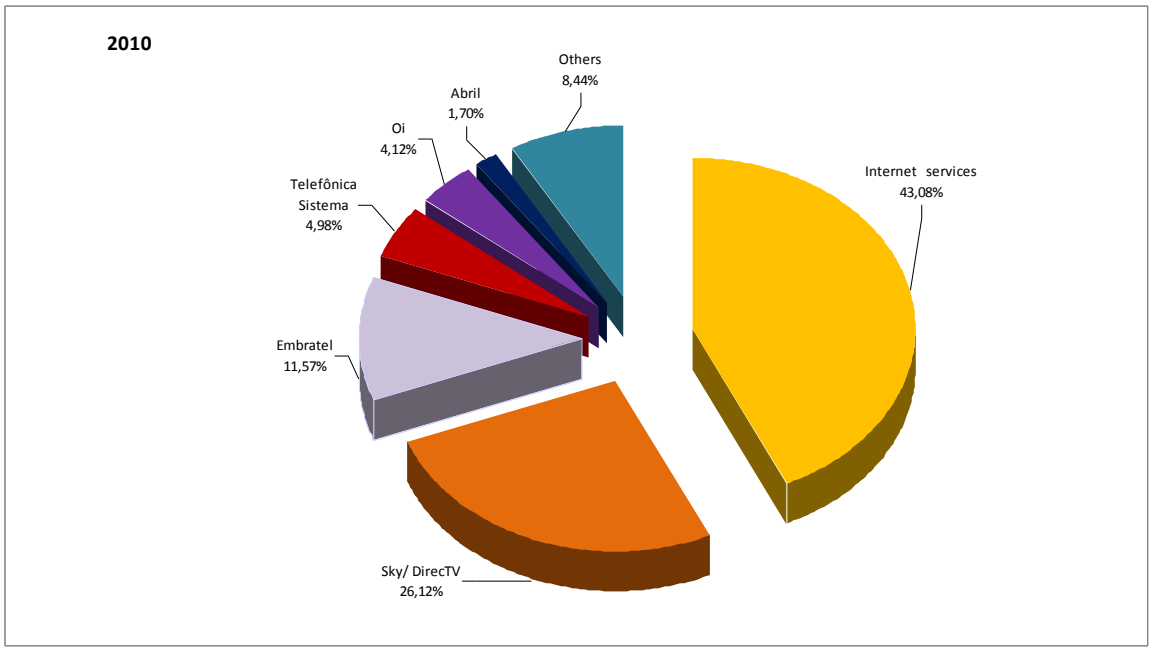


a. Net Revenue of Pay TV - 2010

[75] However, according to PricewaterhouseCoopers (2011) the entertainment and media market was one of the fastest growing globally in 2010 with 15.3 % increase and a double digit growth projected over 2015.

[76] Statistics and Analysis, Latin American Telecommunications sector 2Q 2009, Business News America, p.14. Serving 7% of the households, see appendix.

[77] MMDS: multichannel multipoint distribution system, the so-called wireless cable, most commonly used in sparsely populated rural areas. It is a rather declining distribution technology and the introduction of WIMAX may make it even more obsolete.



b. Pay TV Access - 2010

Source: Anatel, 2011.

1.2.2 The regulatory background

Just like in Mexico and Argentina, some of the existing regulations are seen an obstacle to growth and to an increased competition in the pay TV market. Telcos are under some heavier restrictions for the provision of TV services than cable companies for the provision of telecommunications services according to the 2010 Telecom Outlook.[78] However, a bill is pending that may authorize telcos to offer full TV services and not just video on demand. If the bill was adopted it will also have a positive impact on the deployment of broadband.

The Brazilian telecom market was liberalised in 1998 and its regulatory agency (Anatel) set up in 1997 with a statutory jurisdiction enshrined in the Brazilian constitution (article 174: one of the few agencies with such a legal status), thereby granting a strong legitimacy to Anatel. At that time the fixed line penetration was under 17 million.[79] It reaches now 42 million[80] (40% of the total number of the households as of 2008),[81] but above all mobile penetration grew from 4.6 million to 175 (76% of the households as of 2008).[82,83] The heavy investments mandated on foreign investors during privatization enabled this strong growth.

The huge Brazilian territory is divided in four regions for the fixed telephony with one incumbent operator in each geographical area, one additional operator and many other authorized operators. The market is characterised by a low competition on the local access but

78 Statistics and Analysis, P.13: "Pay TV".

79 Data are from Anatel unless otherwise specified. Anatel, "The Brazilian regulatory framework for electronic communication services and TICs", presentation of May 10, 2010. "2009 Relatorio", Anatel/ Ministerio das Commicacoes, 2010.

80 Around a 21.6% penetration (total lines/100 inhabitants), Statistics and Analysis, Latin American Telecommunications sector 2Q 2009, Business News America, p.5.

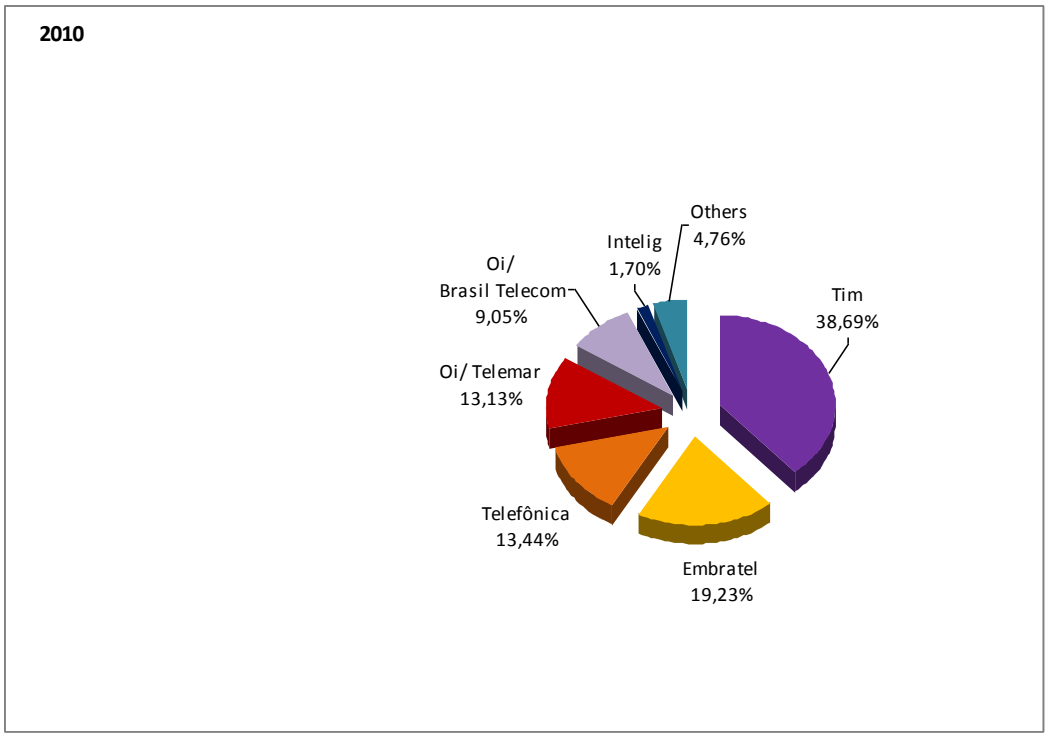
81 Survey on the Use of Information and Communication Technologies in Brazil ICT Households and ICT Enterprises 2008, Brazilian Network Information Center, São Paulo, at 207, see Appendix 1.

82 Id.

83 177 792 as of 2010 according to EITO (2011), a 15% increase.

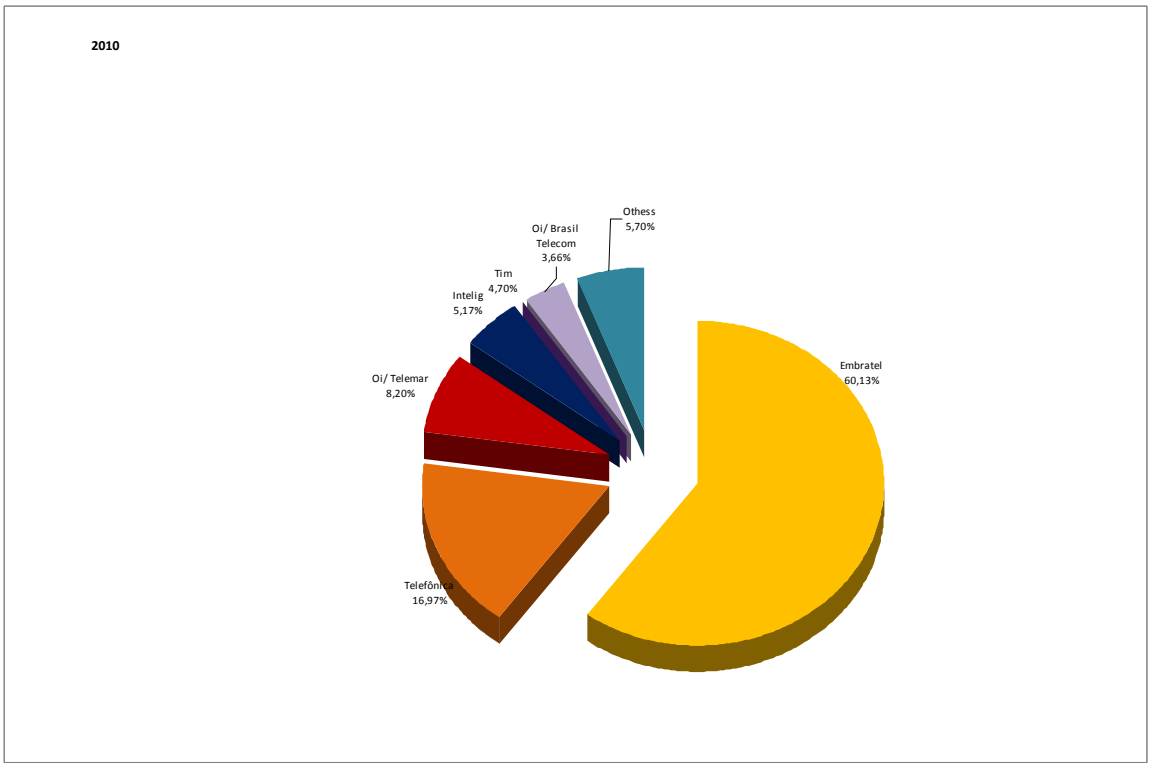
a high competition on the long distance market (Embratel, Telmex, Oi, Telefonica…) (Figure 1.12).

Figure 1.12: Distribution of market shares and access for the fixed market (a. national long distance, b. international, c. access), 2010.

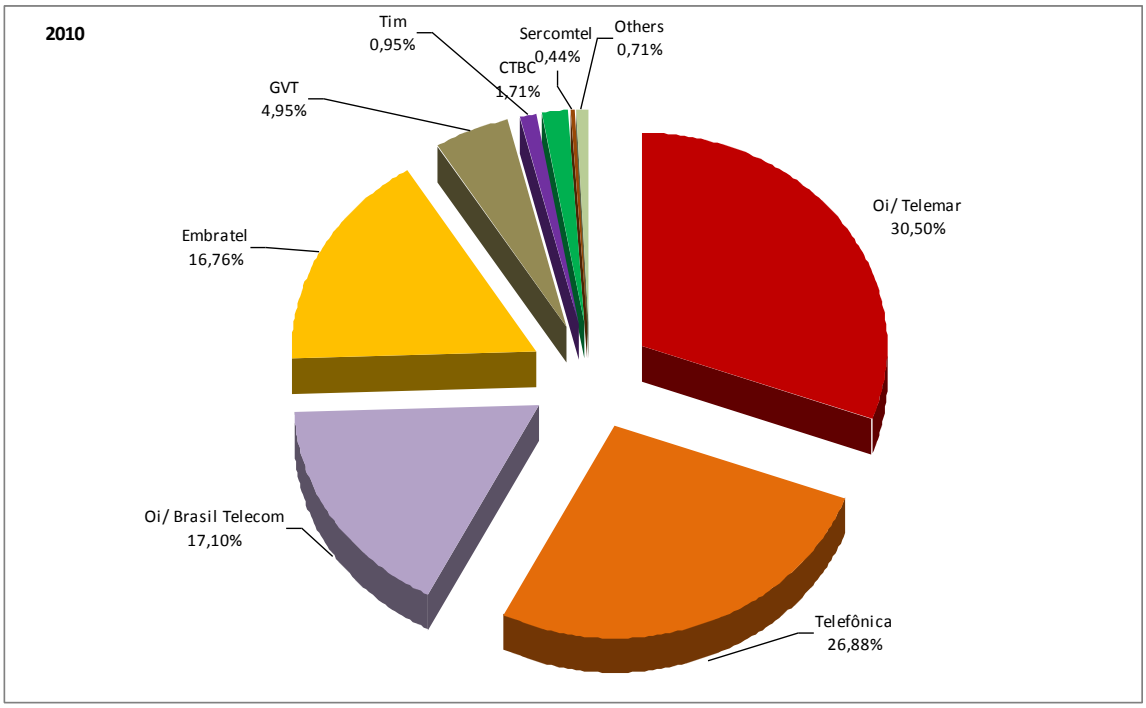


a. National long distance

Source: Anatel, 2011.



b. International long distance

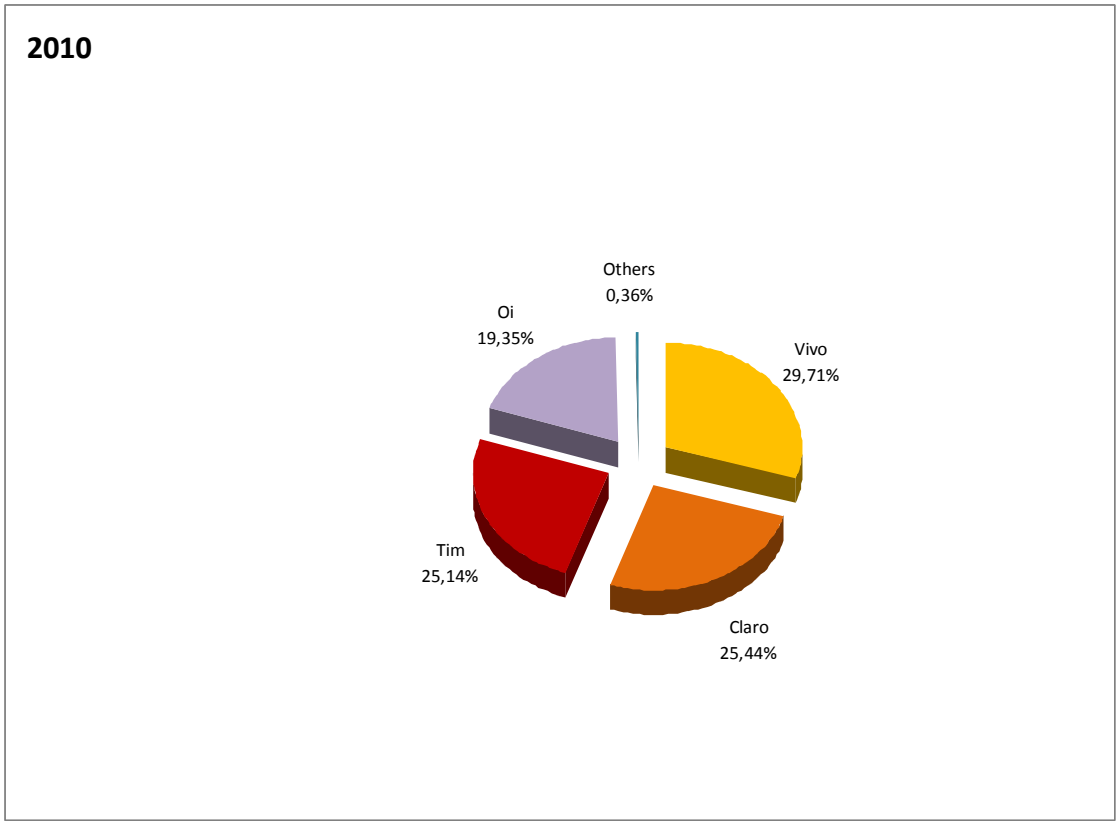


c. access

Source: Anatel, 2011.

Only three regions were defined for mobile telephony with four main national operators (Oi, Claro, Tim and Vivo) deploying their own networks (including 3G) in each geographical area. These operators have similar market shares and the market is competitive.

Figure 1.13: Distribution of market shares for the mobile market (2010).



1.2.3. Assessing the policies

Anatel was founded under two major principles: competitiveness and universal access. Anatel focused on availability: social, geographical and physical (handicaps). To that end a fund was created: Fust (*Fundo de Universalização das Telecomunicações*). The resources from Fust accrue from a rate of 1% over gross operating revenues resulting from the provision of telecommunication services, excluding value-added taxes and other taxes. Despite having been raised more than R$ 8 billion to Fust in a decade, only R$ 7 million were invested to improve universal services.[84]

Besides Fust, Funttel (*Fundo para o Desenvolvimento Tecnológico das Telecomunicações*) was also created. This is a fund aimed at stimulating technological innovation, encourage capacity building, fostering job creation and promote access by small and medium enterprises to financial resources in order to increase the competitiveness of Brazilian telecommunications industry. This fund is composed of a 0.5% tax rate over revenues of telecommunication companies. Between 2001 and 2009, more than $ 2 billion were collected to Funttel. These resources have been applied mainly in projects related to Brazilian Digital TV System.

It is now acknowledged that if it did provide eventually a "consistent framework", it was initially designed for a fixed line environment. Therefore a new plan was designed and adopted (2008) to introduce a vision of the future and of the coming challenges for the next decade: Plano Geral de Atualização da Regulamentação de Telecomunicações (PGR). This plan defines the role of regulation during this transition period.[85]

A national broadband plan[86] (Plano Nacional de Banda Larga: PNBL) was adopted in May 2010 with ambitious targets on coverage, prices and speed: tripling the number of accesses, decreasing the price from around R$ 49-96 to R$ 15, and increasing the capacity from 256 kbps to over 512 by 2014.[87] The PNBL focuses on the deployment of networks, on increasing competition, on stimulating the national telecom equipment industry, and on fostering innovation. It is proposed to rebuild the prior state company Telebras (with a capitalisation of R$ 3.22 billion, € 1.22 billion) so as to act as a broadband infrastructure provider competing with the existing private companies but offering retail broadband access to users in "underserved areas" and wholesale access services on non-discriminatory terms. Funttel will be allocated R$ 1.75 billion (€ 0.667 billion) for R&D.

The agency is in charge of over 23 projects involving broadband (for instance reviewing the spectrum allocation plan). It is a geographically segmented approach, in developed areas platform based competition will be encourage, while other tools will be used to stimulate deployment of low cost broadband services in isolated areas.

The Brazilian policies may appear to be torn between "*desire and reality*",[88] between plans and implementation. The situation is characterised by a lack of planning and coordination

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84 The original focus of the Brazilian efforts towards universal services was placed on the expansion of fixed lines.

85 Among the goals set in the PGR, regulatory measures are being elaborated in order to encourage research, development and production of domestic technology by telecommunications industry.

86 Other Latam countries have adopted similar broadband plan: Chile, Mexico, Peru.

87 Source: presentation "Plano Nacional de Banda Larga", Brasilia, 5 May, 2010. http://www4.planalto.gov.br/brasilconectado

88 The author is following the presentation "*Do Desejo e da Realidade*" of Mario Dias Ripper, a consultant also adviser to the Brazilian presidency, at the Americas Communication Research Network (ACORN) conference, Brasilia, 14-15 May, 2009. Available at: http://www.acorn-redecom.org/papers/program2010.pdf.

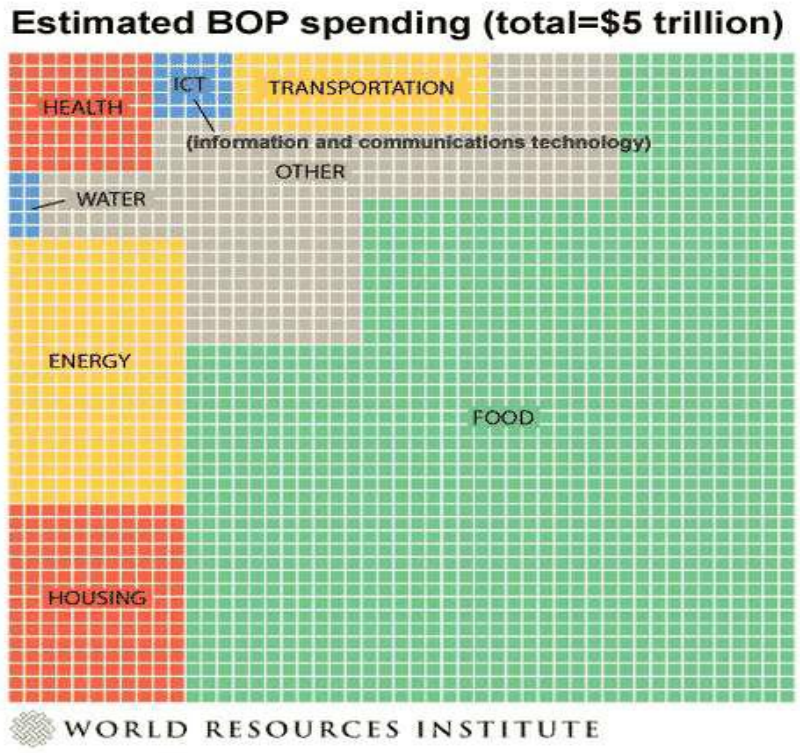
which is linked to the very nature of Brazil: diversity, lack of integration. The features are obviously making it difficult to intervene or to regulate. Furthermore there is no long term vision and no "structural awareness". There is still a blatant "*need to continue constructing national ICT agendas in the region*" covering infrastructure, middleware, applications/ contents and services.

Nevertheless, some attempts to come up with coordination plans are under way:

- "Livro Verde da Sociedade da Informação", MCT 2000,
- "Brasil em Alta Velocidade", Minicom 2010.

For the PNBL, the ability to implement may turn out to be an issue as well as the way to transition from broadband to ultra-high broadband especially taking into account the huge differences between regions. For 12.5% of the population living in great urban centre it should not be a problem as opposed to the 15% living in rural, low density areas. For those low income customers, the Asian experience of the so-called bottom of the pyramid (BOP) communication model may offer some lessons.[89] The plan will be monitored by a specific committee for digital inclusion (Comitê Gestor do Programa de Inclusão Digital – CGPID) and a new body bringing together all the stakeholders (private companies, public sector and citizen) was created (Forum Brazil Digital in June).

Figure 1.14: Bottom of the pyramid (BOP) spending.



The industry seems to have real concerns about what some are describing as a "ridiculous"[90] level of taxes: 50% of the revenues. This is a huge tax burden on telcos.[91] Taxes on services are hampering the deployment of services. As R. Katz sums up: "*Fiscal policies that apply a special tax to the telecommunications sector are inefficient and cause distortions that "crowd*

[89] See Chapter 2: India of this report.
[90] M. D. Ripper at the Acorn Conference.
[91] As illustrated with Figure 1. This is also the conclusion of a cross-comparison between Latam countries achieved by Raul Katz (Columbia Business School: CITI).

out" private spending and in the end diminish welfare".[92] According to his computation: "*For every dollar that taxes are reduced over the 5 year period ending in 2014, 4.4 to 91.4 dollars will be created in additional GDP*".[93]

Among other things, such a fiscal policy accounts for the difficult relationships between the administration and the private sector. The debate has been going since the privatisation of Telebras in 1998. This is a possible explanation of the lag of private investments and the impact on R&D is likely to be negative. The result is a loss-loss situation for the ICT sector. Recently, the government granted a tax waiver for the deployment of broadband but only to serve low income population. However, it does not appear to be flexible enough for the operators and may end up being underused. This is what happened to the universal service fund (Fundtel): 70% of the resources are not allocated.

For innovation policies,[94] the traditional approach of the Brazilian government has been an industrial policy based on import substitution and foreign direct investment (FDI) but the link with innovation and entrepreneurship was missing. To that end, an agency (FINEP) was set up to support the entire value chain of knowledge based creation. According to IPEA, however, even though there are clear advances in the scientific production, the participation of private companies in innovation processes is still relatively low.

1.3 Conclusion

The ICT sector was one of the most affected by the economic opening process observed in Brazil in the 1990s. During the 1990s, due to successive economic crises, public policies on science and technology in Brazil sought to focus on the consolidation of R&D infrastructure and on the modernization of the respective legislation, particularly intellectual property laws and tax incentives.[95]

Like it is the case for many other industries in the country, the ICT sector is dominated by foreign companies. It is characterised by a great heterogeneity as well as by disparities between foreign and domestic firms. Among the 382 companies, identified by the IPEA survey,[96] operating in Brazil, 62 (16.23%) are foreign. Although this percentage is relatively low, one should bear in mind that these companies account for over 70% of the net revenues; it clearly delineates the major role of foreign investments.

The total funding for ICT R&D, between 2003 and 2005 for firms with 30 or more employees, was of R$ 1 377 million (€ 525 557 million), most of it, R$ 1 349 million

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92 In a study for the GSMA trade association, Raul L. Katz, Ernesto Flores-Roux, Judith Mariscal, "The Impact of Taxation on the Development of the Mobile Broadband Sector", Telecom Advisory Services LLC, cf. Abstract.

93 Id at 6. " *The effect of lowering taxes on Total Cost of Mobile Ownership from the current 43.3% to 42.3 % will have the following cumulative effects:*
- Additional penetration: 0.3 %-0.5 %, representing 2.1 %-4.2 % additional subscribers (or 520,000-1,050,000)
- Wealth creation (accumulated GDP): $0.7-$3.4 billion (0.1-0.7% additional GDP by 2014),
- Gain in tax collection: $115 million-$1.27 billion".

94 The author is following here the intervention of L. M. Rebelo Fernandes, chairman of the Brazilian innovation agency at the Policy makers' forum, Concorde 2010 Conference, "Corporate R&D. An engine for growth, a challenge for European policy", Sevilla, 4 March 2010.

95 Law of Informatics (Law 8.248/1991); Industrial and Technological Development Programmes (Laws 8.661/1993 and 9.532/1997); Tax Exemption for Imports of Research Equipment (Laws 8.010/1990 and 8.032/1990).

96 Kubota, p. 80.

(97.95%) funded by the firms. The rest of the investments in R&D came from public source (1.52%) and the rest from other private agents (0.5%).

The prospects for growth and the deployment of new technologies appear rather good. Most of the ICT markets do not appear to be mature; the penetration ratio of ICT equipment provides sufficient space for a sustained growth. However the willingness of companies to invest is also highly dependent on the consistency of the policies. The fiscal policy may be in contradiction with a policy to promote innovation and the balance between the short run gains for the government and the long run benefit for the general welfare does not seem to be appropriate.

The last but highly striking feature of the Brazilian ICT markets is the amazingly growing role of Asia and especially of China as a trade partner.[97] By the same token the regional trade seem to be now more tilted toward the Latin American region much to the detriment of the EU or the US.

[97] Asia is now the first trade partner for both exports accounting for 27.3% of the total in 2010 and imports (30.6%). Source: Balança Commercial Brasileira, www.mdic.gov.br.

1.4 Appendix 1

PROPORTION OF HOUSEHOLDS THAT HAVE ICT EQUIPMENT
Percentage over the total number of households[1]

Percentage (%)	*Television*	*Satellite Dish*	*Paid TV*	*Radio*	*Landline Phone*	*Mobile Phone2*
TOTAL	**98**	**19**	**7**	**87**	**40**	**76**
REGION						
Southeast	98	17	11	89	51	78
Northeast	97	19	1	83	21	67
South	98	20	6	94	40	79
North	96	25	2	70	25	73
Center-West	96	27	7	83	41	89
Family *INCOME*						
< R$ 415,00	93	13	1	75	11	46
R$ 416,00 - R$ 830,00	98	17	2	85	24	68
R$ 831,00 - R$ 1.245,00	99	20	6	89	44	82
R$ 1.246,00 - R$ 2.075,00	99	21	11	91	57	91
R$ 2.076,00 - R$ 4.150,00	99	24	21	92	76	95
R$ 4.151,00 +	98	25	38	95	85	98
SOCIAL CLASS						
A	100	31	54	99	91	97
B	100	26	20	96	76	94
C	99	19	6	90	42	82
DE	94	15	1	76	15	56

Percentage (%)	*Mobile Phone with Internet access (Base: owns a mobile phone)2*	*Game console (Videogame, etc.)*	*Desktop Computer (Desktop, PC)*	*Portable Computer (laptop, notebook)*	*Palm Computer (palmtop, pocket PC)*
TOTAL	**23**	**15**	**27**	**3**	**-**
REGION					
Southeast	26	20	33	3	-
Northeast	15	5	13	1	-
South	26	14	31	3	-
North	20	9	16	3	-
Center-West	28	17	31	6	-
FAMILY *INCOME*					
< R$ 415,00	7	2	2	-	-
R$ 416,00 - R$ 830,00	15	7	11	-	-
R$ 831,00 - R$ 1.245,00	23	16	25	1	-
R$ 1.246,00 - R$ 2.075,00	35	23	44	3	-
R$ 2.076,00 - R$ 4.150,00	41	31	65	12	1
R$ 4.151,00 +	56	47	82	26	-
SOCIAL CLASS					
A	57	59	91	31	-
B	41	32	67	11	-
C	24	15	25	1	-
DE	10	3	4	-	-

1 Base: 16 808 households interviewed in urban areas. Multiple and stimulated answers. 22 Considering that at least one member of the household owns a mobile phone. *Source*: Survey on the Use of Information and Communication Technologies in Brazil ICT Households and ICT Enterprises 2008, at 207, 208.

1.5 Appendix 2: classification used in the IPEA report

10.1. ESCOPO DO TRABALHO
30 FABRICAÇÃO DE MÁQUINAS PARA ESCRITÓRIO E EQUIPAMENTOS DE INFORMÁTICA
30.1 FABRICAÇÃO DE MÁQUINAS PARA ESCRITÓRIO
30.11-2 Fabricação de máquinas de escrever e calcular, copiadoras e outros equipamentos não-eletrônicos para escritório
30.12-0 Fabricação de máquinas de escrever e calcular, copiadoras e outros equipamentos eletrônicos destinados à automação gerencial e comercial
30.2 FABRICAÇÃO DE MÁQUINAS E EQUIPAMENTOS DE SISTEMAS ELETRÔNICOS PARA PROCESSAMENTO DE DADOS
30.21-0 Fabricação de computadores
30.22-8 Fabricação de equipamentos periféricos para máquinas eletrônicas para tratamento de informações
32 FABRICAÇÃO DE MATERIAL ELETRÔNICO E DE APARELHOS E EQUIPAMENTOS DE COMUNICAÇÕES
32.1 FABRICAÇÃO DE MATERIAL ELETRÔNICO BÁSICO
32.10-7 Fabricação de material eletrônico básico
32.2 FABRICAÇÃO DE APARELHOS E EQUIPAMENTOS DE TELEFONIA E RADIOTELEFONIA E DE TRANSMISSORES DE TELEVISÃO E RÁDIO
32.21-2 Fabricação de equipamentos transmissores de rádio e televisão e de equipamentos para estações telefônicas, para radiotelefonia e radiotelegrafia -inclusive de microondas e repetidoras
32.22-0 Fabricação de aparelhos telefônicos, sistemas de intercomunicação e semelhantes
88
32.3 FABRICAÇÃO DE APARELHOS RECEPTORES DE RÁDIO E TELEVISÃO E DE REPRODUÇÃO, GRAVAÇÃO OU AMPLIFICAÇÃO DE SOM E VÍDEO
Fabricação de aparelhos receptores de rádio e televisão e de reprodução, gravação ou amplificação de som e vídeo
329 MANUTENÇAO E REPARAÇAO DE APARELHOS E EQUIPAMENTOS DE TELEFONIA E RADIOTELEFONIA E DE TRANSMISSORES DE TELEVISAO E RADIO - EXCETO TELEFONES
3290-5/01 Manutenção de equipamentos transmissores de rádio e televisão e de equipamentos para estações telefônicas, para radiotelefonia e radiotelegrafia – inclusive de micro-ondas e repetidoras
3290-5/02 Manutenção e reparação de sistemas de intercomunicação e semelhantes – exceto telefones

L. C. Kubota, at 87-88.

This CNAE classification corresponds to the ISIC. The latest Innovation Survey (Pintec) available is the 2005 one (the 2007 edition will be released in 2010). Therefore, the classification used followed the equivalent to the Rev.3.

1.6 References

References for the ICT market in Brazil:

For the size of the ICT sector and subsectors (weight within the economy: % of GDP): www.teleco.com.br; www.telebrasil.org.br; www.ibcd.org.br, www.anatel.gov.br; www.ibge.gov.br, www.abinee.org.br/ , Associação Brasileira da Indústria Elétrica e Eletrônica

For trade balance, main ICT exports/ imports: www.mdic.gov.br

Size of ICT R&D broken down also in segments, ratio private/ public expenditures: www.mct.gov.br

Leaders of the markets (for each segment): www.teleco.com.br; www.telebrasil.org.br; www.ibcd.org.br,

Regional aspect: CPQD (Centro de Pesquisa e Desenvolvimento), www.cpqd.org.br.

Main ICT public policy priority: www.ipea.gov.br, The National Broadband Plan. http://www4.planalto.gov.br/brasilconectado

FINEC and IBGE publish an innovation survey PINTEC (Pesquisa de Inovação Tecnológica), the last 2005 data was released in 2007, and the next one is forthcoming.

Brazilian Internet Steering Committee, www.cgi.br

Brazilian Innovation Agency: www.finep.gov.br

Movement for Business innovation (National Confederation of industry): www.cni.org.br/inovacao/

Science and Technology Indicators, Ministry of Science and Technology: www.mct.gov.br/index.php/content/view/73236.html

Other useful websites:

- http://www.teleco.com.br/en/
- http://www.teletime.com.br/
- http://www.tiinside.com.br/
- http://www.telaviva.com.br/
- http://www.paytv.com.br/
- http://www.anatel.gov.br/Portal/exibirPortalInternet.do
- http://member.bnamericas.com/en/brazil

Bibliography:

ABINEE (Associação Brasileira da Indústria Elétrica e Eletrônica), (2009), A Indústria Elétrica e Eletrônica em 2020.

Uma Estratégia de Desenvolvimento

BRASIL. Agência Nacional de Telecomunicações.

BRASIL. Ministry of Communications.

Portaria nº 71: Plano de Contas Padrão para Serviços Públicos de Telecomunicações. Brasília, 1985.

Exposição de Motivos nº 231: Documento de Encaminhamento da Lei Geral deTelecomunicações. Brasília, 1996.

Lei 9.472: Lei Geral de Telecomunicações. Brasília, 1997. Available at: <http://www.planalto.gov.br/ccivil_03/Leis/L9472.htm>.

Lei nº 9.998: Fundo de Universalização dos Serviços de Telecomunicações (Fust). Brasília, 2000. Available at: <http://www.planalto.gov.br/ccivil_03/Leis/L9998.htm>.

Decreto nº 4.733: Políticas públicas de telecomunicações. Brasília, 2003. Available at: <http://www.planalto.gov.br/ccivil_03/decreto/2003/D4733.htm>.

"2009 Relatorio", Anatel/ Ministerio das Commicacoes, 2010.

EITO Special Report, BRIC countries' ICT markets, 2007-2011, 3 January, 2011, Brazil, pp.6-11.

EU Brasil (2010), EU Brasil follow-up report on the ICT dialogue between Brazil and the EU, December 2010, available from http://www.cullen-international.com/cullen/cipublic/eubrazil_report.pdf

IDC Brasil, Barômetro Cisco Banda Larga Brasil 2005-2010, IDC Brasil, São Paulo, 2009.

"Latin America telecoms investment in 2010", Telecom Intelligence Series, Business News America, February 2010.

"O Desempenho do Setor de Telecomunicações no Brasil", Séries Temporais, Novembro de 2009. A TELEBRASIL – Associação Brasileira de Telecomunicações.

Statistics and Analysis, Latin American Telecommunications sector 2Q 2009, Business News America, 2010.

Survey on the Use of Information and Communication Technologies in Brazil ICT Households and ICT Enterprises 2008, Brazilian Network Information Center, São Paulo, 2009, 463 p.. Brazilian Internet Steering Committee, www.cgi.br.

Raul L. Katz, Ernesto Flores-Roux, Judith Mariscal, "The Impact of Taxation on the Development of the Mobile Broadband Sector", Telecom Advisory Services LLC.

Luis Claudio Kubota and Daniele Nogueira Milani, Relatório Setorial: Industria de tecnologia da informação e comunicação, Agência Brasileira de Desenvolvimento Industrial, Belo Horizonte, April 2009.

Ramires A., Posseti D., Santos J. A., Vargens J. R., Viana L., Viotti L. E., Padua M. H., Souza R. G., Teixeira R. Brasil Telecom: a case on telecom regulation in emerging markets. Brasilia, Brazil: Brasil Telecom and PricewaterhouseCoopers, special edition, 2008. Available at: brtnapontadolapis@brasiltelecom.com.br and marketing@br.pwc.com

PricewaterhouseCoopers, (2011), Global Entertainment and media outlook.

Unesco Science Report 2010, see Carlos Henrique de Brito Cruz, Hernan Chaimovich, pp. 103-122.

Wagner J.B. (2009), "Heading towards IT as a service", Survey on the Use of Information and Communication Technologies in Brazil ICT Households and ICT Enterprises 2008, Brazilian Network Information Center, São Paulo.

2 India

Source: Jean Paul Simon

India is the seventh-largest country by geographical area, the second-most populous country with over 1.18 billion people. India is a federal constitutional republic with a parliamentary democracy consisting of 28 states and seven union territories.

The Indian economy is the world's eleventh largest economy by nominal GDP and **the fourth[98] largest by purchasing power parity**. The growth rate has been impressive for the last two decades with 9.1% in fiscal year 2007-2008[99] and is forecast to grow by 8% in 2010.[100,101] It is greatly placed to meet the global market demand with 64% of the population in the working age group (15-60 years). Contribution of agriculture to the national economy is declining slowly (2009: 17.5% of the national income[102]) with rise in service and manufacturing sector. Since the introduction of market-based economic reforms in 1991, **India has become one of the fastest growing major economies in the world.**

98 5th according to the World Bank, quoted by the Unesco Science Report, p.363.

99 These sections are mostly based of the report commissioned by IPTS by Malik P., Vigneswara Ilavarasan P., (2011), Trends in Public and Private Investments in ICT R&D in India. JRC Technical Note - JRC 64578. (JRC-IPTS Indian Report hereafter). The report is also inspired by Mita Bhattacharya, Monash University, Australia and Graham Vickery, OECD, The information and communication technology sector in India. Performance, growth and key challenges, OECD, June 2010.

100 OECD (2010), p. 4.

101 GDP growth in 2011 is expected to reach 8.2% and 8.5% in 2010, EITO (2011).

102 National Income in Gross domestic product at factor cost. Source: India in Figures 2009, p.55.

Source: worldmapnow.com/images [103]

2.1. The size of the ICT sector

The Indian ICT industry is contributing to the national economic development in many ways and almost all states in India are targeting ICT sector as a vehicle for economic development. As summarized by the Nobel Laureate Professor Amartya Sen[104] *"… [it] is not that the IT industry should do something for the country at large, for that it does anyway. It makes enormous contributions: it generates significant income for many Indians; it has encouraged attention to technical excellence as a general requirement across the board; it has established exacting standards of economic success in the country; it has encouraged many bright students to go technical rather than merely contemplative; and it has inspired Indian industrialists to face the world economy as a potentially big participant, not a tiny little bit-player. …, rather, is that it can do even more, indeed in some ways much more. This is because the reach of information is so wide and all-inclusive, but also because the prosperity and commanding stature of the IT leaders and activists give them voice, power and ability to help the direction of Indian economic and social development*".[105]

The Indian ICT sector has evolved in three phases: up to 1984, 1984–1990 and post-1990. In the first phase, apart from trying to establish its own technological trajectories, the state attempted to run the industry which resulted in the absence of a commercial sector. During this phase, there was no great differentiation between software and hardware. In the second

[103] Available at http://www.worldmapnow.com/images/2009/11/india-map.gif
[104] Quoted in OECD (2010), pp 4-5.
[105] See Amartya Sen "I.T. and India" at http://www.nasscom.in/upload/51245/Amartya_Sen.pdf

phase, the government realized that software was a viable option for income generation and technological capability enhancement. In the third phase, the software export industry blossomed, strongly promoted by both national and sub-national governments. Consequently, the export-driven growth model ignored the hardware sector and domestic markets, despite their huge potential. Though the ICT sector is growing in all domains, **it is predominantly driven by export-oriented software services**.

Until 1990s, the Indian economy was typically run under state control and there was less incentive to invest in R&D by the private industry. The science and technology system in the country was mostly driven by the state run research institutes and research laboratories without any pressure of competing with international standards. Sea of changes happened after liberalization of the economy in post 1900s. Domestic players faced the global competition in the home turf from the multinational companies (MNCs) and need to invest in R&D was tremendous. State run research institutes and laboratories were asked to generate their share of revenues through commercialization and showcase their capabilities through patents as well.

The National Association of Software and Services Companies (Nasscom) stressed: "*Timely government policies and increased public-private participation have played a key role in developing an enabling business environment for the Indian IT-BPO*[106] *industry. The Government's focus on education has helped create the large talent base from where the industry draws its workforce. The Government's proactive approach towards the IT-BPO industry was further highlighted in 2008 through actions such as the IT Act Amendment, extension of tax incentives by a year, removal of the SEZ*[107] *Act anomalies and the introduction of progressive telecom policies that focus on work from home".*[108]

According to Nasscom,[109] the IT-BPO (Business process outsourcing) sector overview is the following:

- Total IT-BPO industry to reach aggregate revenues of US$ 73.1 billion in 2010, with the IT software and services industry accounting for US$ 63.7 billion of revenues. As a proportion of national GDP, the sector revenues have grown from 1.2% in 1998 to an estimated 6.1% in 2010.
- Its share of total Indian exports (merchandise plus services) increased from less than 4% in 1998 to almost 26% in FY2010.[110]
- During this period, direct employment is expected to reach nearly 2.3 million, while indirect job creation is estimated at 8.2 million. Most of the indirect employment absorbs the unemployed who are school pass-outs or drop outs. Revenue generated by the industry is also a driving factor for many other sectors in the country, especially the real estate and retail. Apart from direct employment, the ICT sector is credited with booming of first generation of entrepreneurs and growth of venture capital industry in India.

[106] BPO: business process outsourcing.
[107] SEZ: Special Economic Zones.
[108] National Association of Software and Services Companies (Nasscom), Nasscom Industry Trends, 2008 data, accessed September 2010.
[109] Nasscom Industry Trends, 2008 data, accessed September 2010. Data for fiscal year (FY).
[110] Nasscom Strategic Review 2010, last accessed October 2010.

According to the latest available official data at national level,[111] the contribution of the ICT sector to GDP is more modest than the one claimed by NASSCOM,[112] with 3.42% in 2004 (see Table 2.1):

Table 2.1: Indian ICT Industry economic profile (2004)

GDP	€ 555.4 Billion
ICT VA	€ 19 Billion
ICT VA/GDP	3.42%
ICT Manufacturing VA	€ 1 Billion
ICT Services VA	€ 18 Billion
ICT Employment in CSS[113] sub sector (2004)	830 000 persons
ICT employment in CSS sub sector (2007)	1 630 000 persons

Source: Adapted from data in: Malik P., Vigneswara Ilavarasan P., 2011. Employment data from NASSCOM, quoted by Mita Bhattacharya, Graham Vickery, (2010).

Information on Indian ICT industry is abundant, but surprisingly access to data firm level data is difficult,[114] while aggregated economy-wide data is scarce. The industry is dominated by the larger players with the top two hundred firms contributing 86% of the total revenues. Manufacturing and Services divisions of the Indian ICT sector have two contrasting plots. Services sector, composed of computer related services and telecommunications has been growing at a steady rate when compared to manufacturing sector. India is then often presented as having a 'walking on one leg' strategy in ICT sector (Malik 2011), concentrating more on the services exports than the manufacturing.

Box 2.1: Performance of IT services firms in India

Demand for IT and business process outsourcing (BPO) continued during the crisis, with firms taking further advantage of (offshore) outsourcing to reduce their costs. Indian IT services firms have benefited from this trend. However, decreasing total contract value (in 2009 it was the lowest since 2001) and increasing competition from other offshore locations such as Brazil, China and the Philippines have put the revenue growth of Indian IT services providers under pressure.

The Indian IT services industry (including IT services, BPO, and software and engineering) has grown at two-digit rates year on year since the late 1990s. Only in 2010 has year-on-year revenue growth slowed to one digit (6%). Between 2000 and 2010, annual revenue in the industry grew at 27% a year to reach almost US$ 64 billion in March 2010

The top 10 Indian IT services firms generated almost US$ 23 billion in annual revenue in 2009. This is almost 36% of the overall revenue of the Indian IT services industry. Tata Consulting Services (TCS), Wipro and Infosys Technologies are the biggest firms, accounting respectively for 27%, 24% and 21% of the top 10 revenues in 2009. Quarterly revenues of the top 10 Indian IT services firms have been increasing year on year (33% on average), since the 3% year-on-year decline in the first quarter of 2001. In the first quarter of 2009, however, quarterly revenue growth turned negative (around –5%) and remained slightly below zero in the following quarters of 2009

Source: OECD, 2010. IT Outlook, p.32.

[111] Barnjee, 2009, p.138. "The latest available report by the Department of Scientific and Industrial research (…) captures industrial R&D expenditure data up to 2002-03."

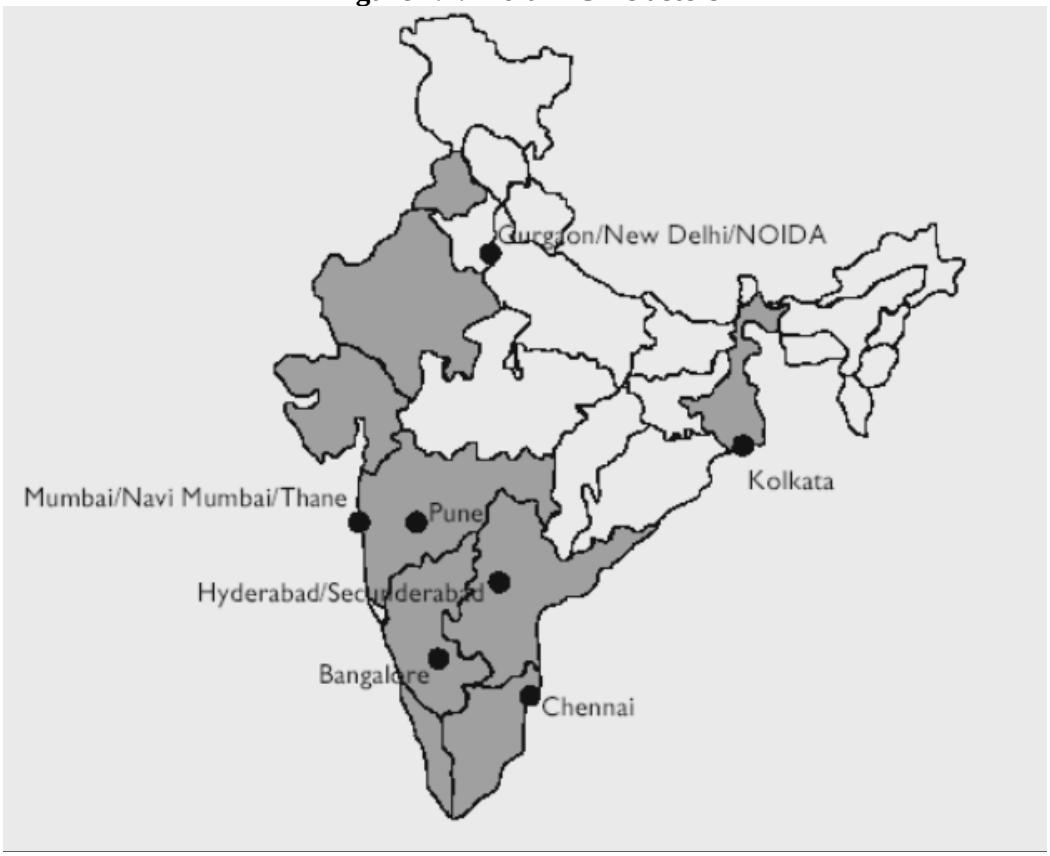
[112] As it is calculated in official statistics on value added and not on revenues contribution to GDP, in line with international statistical standards.

[113] CSS: Computer services and software.

[114] The major source is the National Associational for Software and Services Companies (NASSCOM). Firm level data in the NASSCOM annual directories are not available beyond 2003. NASSCOM provides only aggregate data and a limited break up details.

While in the rest of the world small high technology firms are adaptive to market conditions and have spurred overall sectoral innovation, in India, the absence of small firms will be felt rather than presence. Small firms serve as training ground for entry level programmers before they migrate to larger firms but the linkage between small firms and large firms is weak in India. Small firms are present in technological collaboration in terms of cross licensing.

Figure 2.1: Indian ICT clusters



S*ource*: Indo-Italian Chamber of Commerce and Industry (2006), 'ICT Industry in India', OECD.

ICT firms are prominently located in major six clusters, Bangalore (Karanataka), Mumbai & Pune (Maharastra), Chennai (Tamil Nadu), Hyderabad (Andra Pradesh), and the National Capital Region which composes of New Delhi (Delhi), Noida (Uttar Pradesh) and Gurgaon (Haryana). Almost 97% of the revenue comes from these regions in exports.[115] Similar generalizations can be made for overall industry revenues as well. All these regions show a strong presence of foreign firms.

A comparison of the major ICT clusters shows that Bangalore cluster presents a more mature ecosystem for the ICT industry when compared to other ones. Due to its historical lead advantages, it has a deep labour market, proximity of reputable research institutes, government research labs, access to venture capital, healthy mix of large domestic firms, multinationals and other supplementary firms.

Both state and central governments have been trying to expand the presence of Indian ICT sector beyond the established six clusters. An array of tools were used to stimulate exports

[115] However, there is no direct data available on the region wise revenue distribution of the industry. According to Nasscom, seven Indian cities account for 95% of export revenues, there is now a focus on developing 43 new locations to emerge as IT-BPO hubs.

among others special economic zones, Export Oriented Units (EOUs) within Export Processing Zones, (EPZ), Electronic Hardware Technology Parks (EHTP), and Software Technology Parks (STP).[116]

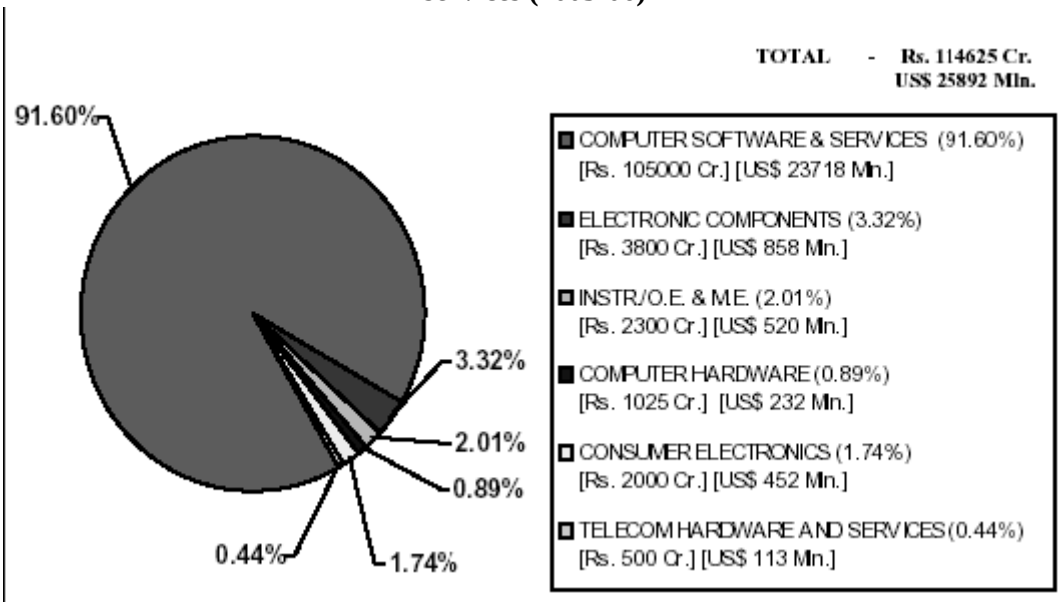
Though efforts are impressive, sustainability of the industry is dependent on many soft infrastructure factors like availability of high end labour pool, competitive pool of suppliers, access to power centres of policy making, venture capital accessibility, and opportunities for interaction that enhances innovation etc. Given the lack of soft infrastructure, sustainability of the industrial sector in tier II cities will be difficult.

2.1.1 The sub sectors

The ICT industry has been growing steadily in India, with revenues growing from US$ 21.6 billion in 2004 to US$ 31.9 billion in 2007. The ICT sector is centred around IT service exports with revenues growing from US$ 8.3 billion in 2004 to US$ 23.2 billion in 2008 (Figure 2) with the percentage of the domestic sector decreasing. Within the domestic industry focus has been more on the hardware side which has increased from US$ 5.1 billion in 2005 to US$ 11.5 billion in 2008. The growth of software services has been slow from US$ 4.5 billion in 2005 to US$ 7.9 billion in 2007. The growth of the domestic industry is attributed to increase in IT spending by the domestic industrial sectors and the outsourcing of software services.

Exports of service and software are the major contributors to the total revenues, generating US$ 31.3 billion in 2007[117] as illustrated by Figure 7.

Figure 2.2: Sector contribution in exports of electronic hardware, computer software and services (2005-06)



Source: Statistical Year Book 2005-06, Electronics and Computer Software Export Promotion Council, Government of India, OR at 13.

Nasscom put forward that "*The IT Services segment aggregated export revenues of US$ 27.3 billion, accounting for 55% of total exports. Indian IT service offerings have*

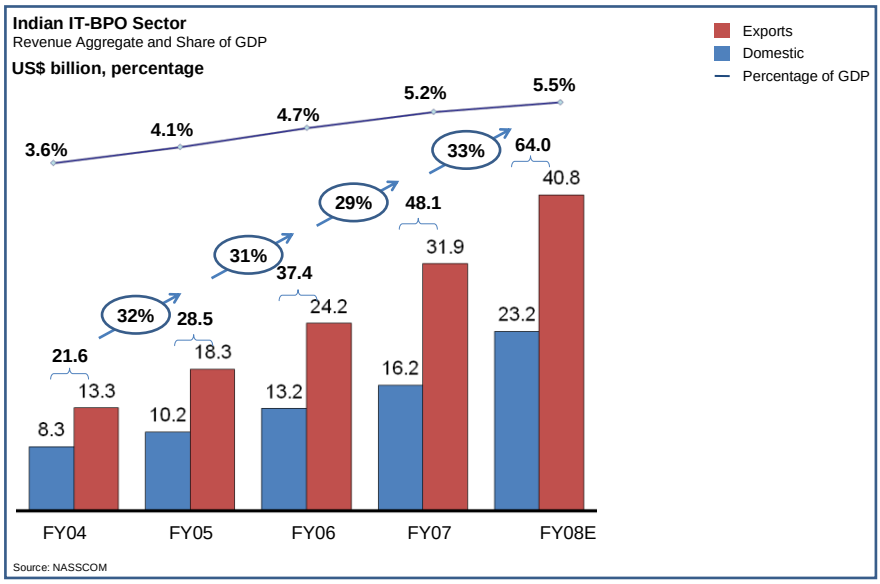
[116] OECD (2010), p. 36.
[117] Id, p. 24.

evolved from application development and maintenance, to emerge as full service players providing testing services, infrastructure services, consulting and system integration".[118]

"*Indian IT exports are predominantly based on services. In recent years electronics goods exports have increased…The United States and European countries together registered nearly 52% of electronic hardware and around 85% of computer software exports. Exports to North America during this period are estimated to be US$ 15 334 million, up from US$ 11 546 million in 2004-05 registering a growth of 33% in US$. Exports to EU countries grew by 42% in US$ terms during the same period. In value terms, exports of Electronics and Computer Software / Services to EU Countries increased from an estimated US$ 4 671 million in 2004-05 to US$ 6 627 million in 2005-06. Singapore, Hong Kong, China and other South Asian countries attracted around 23% of total electronics exports for the same period. In recent times, besides traditional exporting countries, Indian firms are extending into the Middle-East, North Africa and Latin American countries*".[119]

The Indian ICT contribution to GDP (ICT revenue as a proportion of the GDP) has been growing from 1.2% in 1998 to 5.2% in 2007, and 5.8% in 2008 (Nasscom 2009). The Indian ICT manufacturing sector is small when compared to the services, in 2004, manufacturing contributed to only 0.217% of GDP (ICT value-added as a proportion of GDP) (Malik et al, 2011) when compared to the 3.611% of services. India shifted focus to software in mid 1990s from hardware.

Figure 2.3: Growth and contribution of Indian ICT industry



Source: NASSCOM, 2009.

2.1.2 The ICT services

The services component of ICT is composed of telecommunications and computer related services.

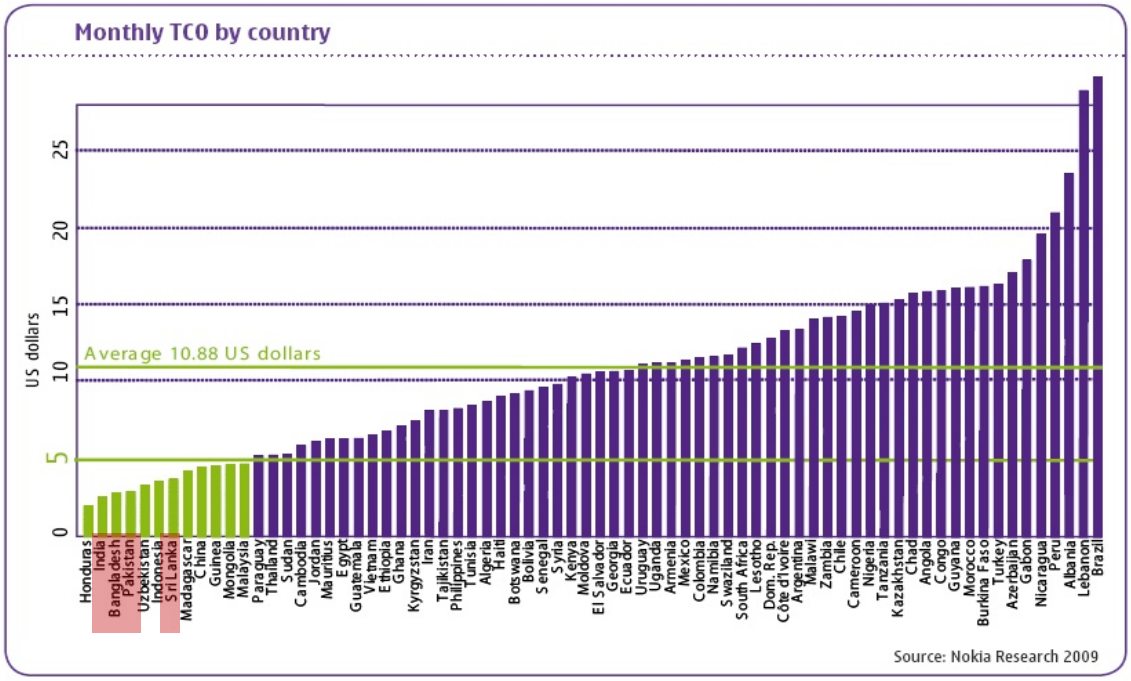
[118] Nasscom Report 2009, Executive Summary, p. 6.
[119] OECD, (2010), p. 15.

2.1.3 Telecommunications services

The results of liberalization[120] in the late 90s have been impressive. Teledensity has increased from merely 2% or so in 1999 to 37% in 2009, 52.74% in 2010[121] Table 2.2) and almost 8-10 million mobile subscribers are added every month. Wireless has been the principal engine for telecom growth in the country. The wireless subscriber base has grown from 0.88 million in 1999 to 391.67 million in 2009,[122] to nearly 722 in 2010.[123] The mobile sector grew at the Compound Annual Growth Rate (CAGR) of 84.01% in the last decade. "*India is the second-largest (after China) and one of the fastest growing mobile markets in the world*".[124]

Figure 2.4:

Total cost of mobile ownership in 77 emerging economies



Source: Rohan Samarajiva (CEO, LirneAsia).[125]

[120] Liberalization started in fact in 1984, but the Indian government set up the Telecom Regulatory Authority of India (TRAI) in 1997.
[121] Rekha Jain presentation at the Telecom Policy Research Conference (TPRC) 2010.
[122] OECD (2010), p. 33.
[123] EITO (2011), 869 predicted for 2011.
[124] OECD (2010), p. 33.
[125] Rohan Samarajiva, Founding Chair and CEO, intervention at the Americas Communication Research Network (ACORN) Conference, Brasilia, 14-15 May, 2010.

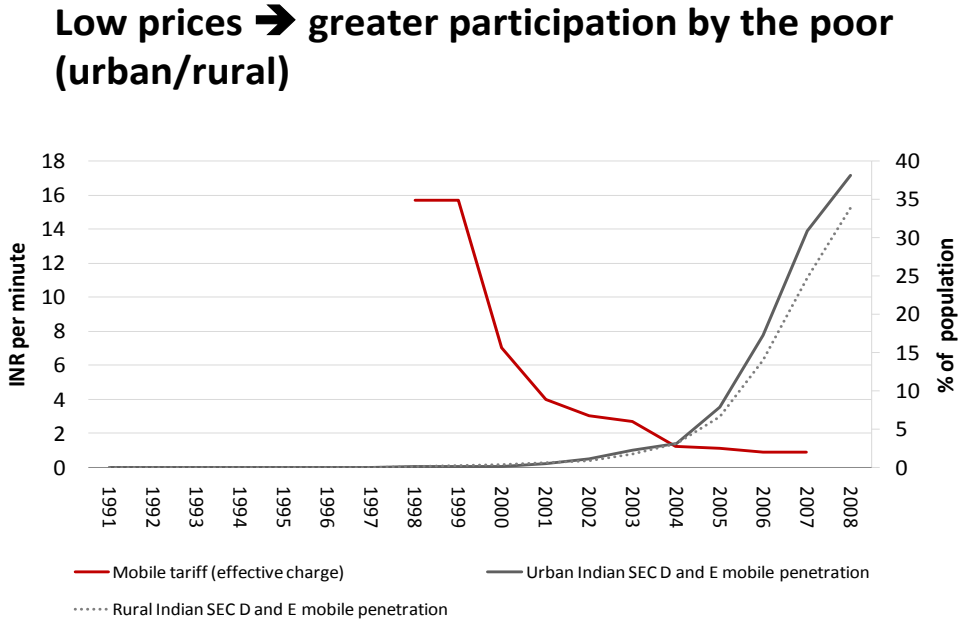
Table 2.2: Teledensity (2000-10)

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Subscriber Base	28.55	36.29	44.87	54.48	76.53	98.41	140.32	165.11	300.49	429.72	621.28
Teledensity	2.81	3.52	4.28	5.1	7.04	9.11	12.8	18.23	26.22	36.98	52.74

Source: Rekha Jain, Indian Institute of Management, Ahmedabad.[126] Compiled from various editions of "Voice and Data", New Delhi, India.

The Indian case provides an interesting case study of innovation with the budget telecom model or "bottom of the pyramid" (BOP) model. Growth is driven by services – a real "service revolution" with unusual innovations.[127] The low prices and high use of the telecom network in India point to the core explanation for the success of connecting billions of people in the past decade. It is the discovery and application of an entirely new business model in South Asia, the "budget telecom network model," akin to the budget airline model implemented by the likes of Air Asia and Ryan Air.[128] The model is based on pre-paid and fitted to meet the demand of the poorest segment of customers. This model achieved impressive outputs**: the lowest mobile rates in the world**.

Figure 2.5



Source: Rohan Samarajiva[129] Indian Rupee (INR) on the left.

The budget telecom network business model is an innovation, driven by intense competition and in response to the hard regulatory environments and low purchasing power of the countries like India. If not for competition, the innovation would not have happened. Once

[126] Presentation at the TPRC 2010.
[127] Rohan Samarajiva, Founding Chair and CEO, presentation at the IPTS conference "Asian rise in ICT R&D".
[128] Nokia (2008a). Affordability key in bringing digital inclusion. Expanding Horizons, 1, 12-13; Nokia (2008b). A roadmap to affordable mobility in emerging markets. Expanding Horizons, 4, pp. 4-7.
[129] Intervention at the Americas Communication Research Network (ACORN) Conference, Brasilia, 14-15 May, 2010.

competition was established, which was a necessary condition for the growth of the sector, the market took over. New entrants eager to expand their market shares by increasing their share of the market and not just by eating each other's market shares offered alternatives to standard services.

The model was based on the following features:

1. Low installation charges.
2. Low rentals: virtually zero rental for service in the form of lifetime validity offers.
3. Means allowing the consumer to control expenses: micro prepaid where a low income consumer could buy talk time for very small denominations as low as R$ 10 ([130]€0.165, US$ 0.25).[131]
4. Permitting the consumer to make small, frequent and regular payments.

Box 2.2: The budget telecom model: market innovations that meet consumer's ability to pay

- Low ARPUs of US$: 2 –5
- Mostly (over 80%) prepaid
  - – low cost of serving (no bills, electronic re-load, minimal 1-800 customer care)
  - – low customer acquisition cost (~US$ 3.5)
  - – low/no credit risk (pre-paid and cash)
- Infrastructure sharing and managed networks
- Leapfrogging: Install newer (cheaper) technologies without legacy investment issues
- Regional negotiations for equipment (many regional operators)
- Formula: Drop prices to encourage VERY high minutes of use, load up network
- Low(er) Quality/ necessary feature in early stages with an "acceptable" call drop rates x 2 of US/EU

Source: Helani Galpaya, LirneAsia.[132]

One major barrier to ownership was the cost of a handset. Reliance Infocomm, for the first time in India, offered handsets free of charge, along with the service. This free handset offer was managed in three ways. Firstly, the pioneer offer had a built-in contract of three years for every customer. This guaranteed cash flows and minimized churn allowing them to discount the cost of the phone. Secondly, Reliance Infocomm entered into exclusive agreements with handset vendors like LG and Samsung. For a guaranteed purchase of huge volumes (between 1 million and 8 million phones) the prices were negotiated down to rock bottom. Thirdly, Reliance Infocomm reduced the choice available to the customer to just two models per brand, thus ensuring mass production and further reduction in prices. Internal estimates say that the handset model which was available on the open market at a price of R$10 500 (US$ 233) was procured at a price of R$ 800 (US$ 17.8) by Reliance Infocomm.[133] Indian operators are currently operating at very low average revenue per user per month (ARPU) of US$ 6, but they are still making profits as revealed by their EBITDA.

[130] 1 INR = €0.0165519.

[131] Hutch (now known as Vodafone) aligned the products to the rural market. One of their innovations is the now popular "chota" recharge, what is called a micro recharge. When the industry had a minimum norm of Rs.200 (€3.3, US$ 5) as a minimum recharge, they went down to R$ 10.

[132] Intervention at the EuroCPR, Brussels, 30 March, 2010, Examples from Emerging Asia. Information Society Policies: What worked and did not work.

[133] JRC-IPTS India Report, p. 37.

Table 2.3: Indian Telecom Sector Revenues from Different Services (2003-09)

Revenue *(Rs Billion)*	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09
Basic services	259	330	326	342	302	267	246
Cellular services	86	143	233	360	562	766	952
National long distance operators	60	51	63	90	72	97	144
International long distance operators	50	44	38	73	115	115	150
ISP	13	16	16	16	20	54	75
Others	3	4	5	5	6	6	5
Total	**471**	**588**	**681**	**886**	**1077**	**1305**	**1572**

Source: Rekha Jain,[134] Indian Institute of Management, Ahmedabad. Compiled from various Edition of Voice and Data, New Delhi, India.

"*In the handset market in 2008 Nokia dominated with a 72.5% share followed by Motorola with 11.1%, LG with 11%, Sony Ericsson (6.5%) and Samsung (5.6%)".*[135]

It is worth noting than recently, the Indian telecoms authorities are reportedly set to reserve chunks of 2G and 3G spectrum to be "*exclusively used for developing indigenous telecommunications networks,*" echoing the model used by China which led to the creation of the TD-SCDMA 3G technology used by China Mobile.[136]

Internet and broadband penetration is still very low, accounting for a mere 4.7% of the total telecom revenues,[137] but increasing. The number of Internet subscriptions doubled between 2007 (declared the "year of broadband", 2.7 million) and 2008 (4.9 million)[138] to reach 11.74 million in 2010.[139]

Wireless broadband will be crucial to achieve an improved penetration. 3G penetration went up to 8 million (an increase of nearly 600%) over 2009.[140] The number of 3G subscriber connections in India is forecast to reach 400 million within four years, representing almost 30% of the country's total.[141]

The main issue is nevertheless how to extend the BOP model to broadband.[142,143] Mobile voice success was achieved because the necessary conditions were created for massive investment in network build-out. Building networks capable of broadband is not just incremental; it is the building of an overlay network that requires massive investment, but they are some major hurdles according to Rohan Samarajiva:[144]

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134 Presentation at the TPRC 2010.
135 OECD (2010), p. 34.
136 GSMA Mobile Business Briefing, 14 January, 2011.
137 See Table 2.3.
138 OECD (2010), p. 35.
139 EITO (2011), India pp. 18-23.
140 EITO (2011).
141 According to a new Wireless Intelligence study published on 3 March and reported in Mobile Business Briefing 3 March 2011
142 This section follows LirneAsia's CEO, Rohan Samarajiva's intervention at the Americas Communication Research Network (ACORN) conference, Brasilia, 14-15 May, 2010.
143 "*Indian GSM operator Tata Docomo looks set to become the first privately-owned operator to launch 3G services in the world's fastest-growing mobile market. "We are all set to launch 3G services on Diwali," Deepak Gulati, President of Mobility at Tata Teleservices Ltd (TTSL), told The Hindu Business Line. Nine circles are due for simultaneous launch on 5 November; Delhi, Mumbai, Maharashtra, Gujarat, Tamil Nadu, Kolkata, Haryana, West Bengal and Uttar Pradesh (East). Initially, 3G coverage will be available only in the largest cities within each circle*." GSMA Mobile Business Briefing 12 October 2010.
144 Presentation at the Americas Communication Research Network (ACORN) Conference.

- *"Not enough cash-flow from commodity voice business,*[145]
- *Governments have gotten greedy and are extracting lots of taxes,*
- *Great Recession (tempered by Arab and other funds seeking non-US locations)*
- *Internet economics: unprofitable companies being purchased for high prices*.
- *Operators need to be hospitable to applications providers ("app store"):*
- *Create a platform for seamless entry by applications providers,*
- *Reasonable revenue shares with applications providers, e.g. 40% if no advertising is done by app provider, 90% if applications provider advertises".*

The penetration of subscription TV is not impressive with respectively 90 725 million for cable TV, 27 212 million for satellite TV and 32 643 million subscribers for Digital TV. The former is almost stable with a growth around 5% since 2008, the other two have a two digit growth nevertheless.[146]

2.1.4 Computer Services and Software (CSS)

Within the computer related services, exports of software services constitute more revenue than the so-called ITES (Information Technology Enabled Services). In software services most of the revenue comes from onsite services, where Indian firms send workers to client sites abroad on hourly basis, also called as body shopping rather than offshore services where Indian firms execute the projects with more control over the processes. This infers higher revenue coming from the low end activities like maintenance and testing of existing software of the clients than the high end software services driven by the intellectual property blocks or patents. In the geographical destination, most of the revenues are generated from US: over 60%. Among the industry domains, banking, financial services, and insurance (BFSI) constitute more than others (see Table 2.3).

Table 2.4: Indian ICT Industry Structure (2008)

Description	Revenues (US$ billion)
Software & services Hardware	52 12
Business Process Outsourcing / IT enabled services: Software services	12.5 40
Major export destinations in percentage USA Europe	 61.4%; 30%
Dominant technology domains in exports, in percentage: Banking, Financial Services and Insurance Hi-tech / telecom Manufacturing	 41%; 20% 17%.
Share of top six Indian ICT regions in exports	97%

Source: The Indian IT-BPO sector, Strategic Review, NASSCOM, 2009.

In the late 1990s, the Indian software firms have diversified into the provision of back end services, also called as ITES or call centre industry and are equally successful. However, the size of the ITES sector is small when compared to software services. This uneven distribution

[145] As an example, Reliance Communications while still expanding its customer base of 36.3% in 2010 to 117 million and increasing minutes of usage is affected by falling ARPU generating a 39.8% fall in its net income. GSMA Mobile Business Briefing, 15 November 2010.

[146] EITO (2011). PricewaterhouseCoopers, (2011), predicts however an average increase of 13% until 2015 for the total entertainment and media market.

of the destination of the services exports makes the industry vulnerable to global market fluctuations. For instance, changes in temporary visa legislations in US would badly affect the revenue flow of the onsite dominated industry. Due to current slowdown, BFSI segments are affected resulting in decline in revenues for the entire industry.

The success of the Indian software sector is largely attributed to availability of high skilled technical labour for the exports. The under-utilization of engineering talent was exploited by the Indian software services firms to meet the rising global needs, especially US, largest consumer of the software in the world. India's rise in the global ICT sector during the year 2000 boom period is well documented. There were two major developments that served as catalyst: the exit of IBM in 1970s leaving numerous machines in India that provided services opportunities to Indian entrepreneurs and the establishment of Texas Instruments in Bangalore for executing designs and subsequent success that demonstrated the feasibility of providing software services using local capabilities.

There were two sets of firms of Indian origin that drove the Indian services sector: a first set of entrepreneurial firms started by professional who were working for the multinationals in early 1980s (examples include Patni Computer Systems and Infosys) and a second one consisting of ICT manufacturing firms that diversified into software (examples include HCL and Wipro) and software divisions started by the established industrial groups (examples include TCS and Satyam). Some of the recent research studies (for instance, Balakrishnan, 2006; Sharma, 2008) credit the late impetus provided by the government in establishing software technology parks (including fiscal incentives like tax exemption for ten years) for enabling these software service exports.

2.2 R&D expenditures

The overall level of R&D investment is low. Total GERD in India reached some € 3.8 billion in 2004 representing around 0.7% of GDP, from 0.58% in 1990-91 and growing to 0.89% in 2005-06.[147] Banerjee (2009[148]) in addition states that "*both in nominal and real terms, there has been a decline in the overall GERD and the GERD to GDP ratio has declined during the post reform period*" and observes that the business enterprise sector shows sharp BERD increase, but still at only 20% of total GERD.

Table 2.5: Indian ICT R&D expenditures profile (2004[149])

Total GERD	€3.8 billion[150]
Total GERD/GDP	0.69%[151]
Total BERD	€0.76 billion
ICT BERD	€0.27 billion
ICT BERD / Total BERD	35.9%
ICT R&D employment	15 000 people

Source: Adapted in Euros from data in: Malik P., Vigneswara Ilavarasan P., 2011 (forthcoming).

[147] To compare with the € 30 billion (2006) observed in China, see Table 3.2. In EU27, GERD was above €200 billion and US GERD above €300 billion at the time. See the IPTS annual report on R&D expenditures: "The 2010 report on R&D in ICT in the European Union" available at: http://is.jrc.es/pages/ISG/PREDICT.html

[148] p.136.

[149] Latest official statistics available.

[150] In Banerjee, 2009: GERD = €3.2 billion for 2002-03.

[151] Stated to be 0.8% (with no reference year) in Bhattacharya M., Vickery G., (2010).

Consequently and based on available data, the level of ICT R&D in India is very modest. Also, its share of GERD ranks second to the pharmaceutical industry R&D (20% of total GERD) and the automotive industry, which is not the case in developed economies where ICT R&D expenditures usually rank first.

Hence, one of the major short comings of the Indian ICT sector, repeatedly discussed by existing studies, is the scarcity of R&D expenditures and activities performed by firms in the Indian ICT industry.[152] The level of investment is still low and "*R&D institutions lack resources and industry support*"[153] Besides, there is no reliable data available on number of research personnel in the Indian ICT industry.[154] As an indication, the total number of full time researchers (full time equivalent) also appears low, 154 827 in 2007 compared to China (1 423 380)[155] and this might hence reflect a data collection issue.

There are two sets of players who are performing R&D activities – larger domestic players and subsidiaries of multinationals. Larger domestic players undertake two kinds of innovative activities: internal and external. Internal ones are those to help service delivery process improvement and are consumed by the firms themselves. The amount spent on these activities is not disclosed by the firms. Compilation by independent academic researchers shows that R&D expenditure by the Indian firms is very low.

The second set of activities is performed for the external clients who outsource their product development activities. In industry terms these are called as 'engineering services and R&D, and Software products' and is mentioned as high end work. It constituted around 13% of total industry revenues in 2008. However, revenue generated out of the software products or licensing of software intellectual property blocks by the firms in India is small with only US$ 1.1 billion in 2008.[156]

2.2.1 Patents

There is no data in the Indian patent office for ICT. Policy changes took place with the adoption of the Indian Patent Act,[157] nevertheless assessing the impact may require further analysis. The number of national patents (all industries), according to the Unesco report,[158] "*granted by the India Patent Office has increased tremendously but over three-quarters are still being granted to foreign entities*". In the field of ICT, according to the 2008 NISTADS report, Indian patenting activity in the field of ICT grew slowly since 1990 but went through "*a sudden spurt in growth during 2002-2007*".[159]

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[152] There is no reliable recent data on ICT R&D expenditures, neither on research personnel in the Indian ICT industry. Estimates are pointing at very low numbers. Mita Bhattacharya, Graham Vickery, (2010) state the following: "*Attempts in deducing the data using proxy and projection measures shows that there is growth in full time personnel who are involved in the research and development from 3 651 in 2000 to 15 045 in 2004*". Such lows estimates might be due to two possible reasons: the large public sector (estimated recently to account for 1208 R&D centres) could host a majority of not-accounted for researchers, as well as the importance of services where again, research is little or not accounted for.

[153] OECD (2010), p. 28.

[154] OECD (2010): Attempts in deducing the data using proxy and projection measures showed that there is growth in full time personnel who are involved in the research and development from 3 651 in 2000 to 15 045 in 2004.

[155] Unesco, p.496, Table 4. "Total researchers per million inhabitants, 2002 and 2007".

[156] OECD: NASSCOM, 2009.

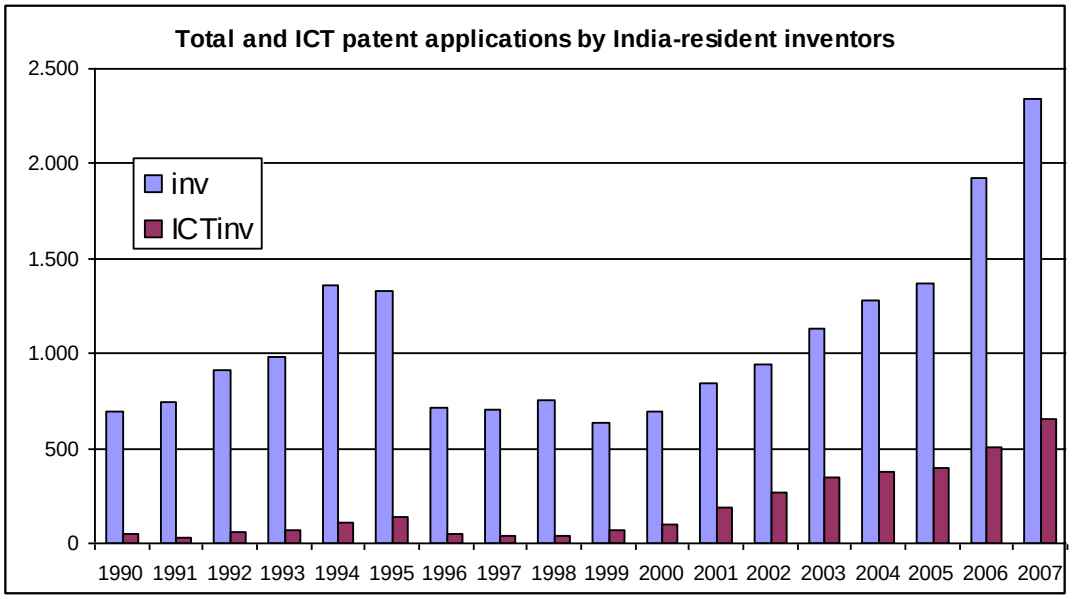
[157] Unesco, p.369. IR quoting the same data in the NSTMIS study p.35.

[158] Id, p. 375.

[159] Id, p. 271.

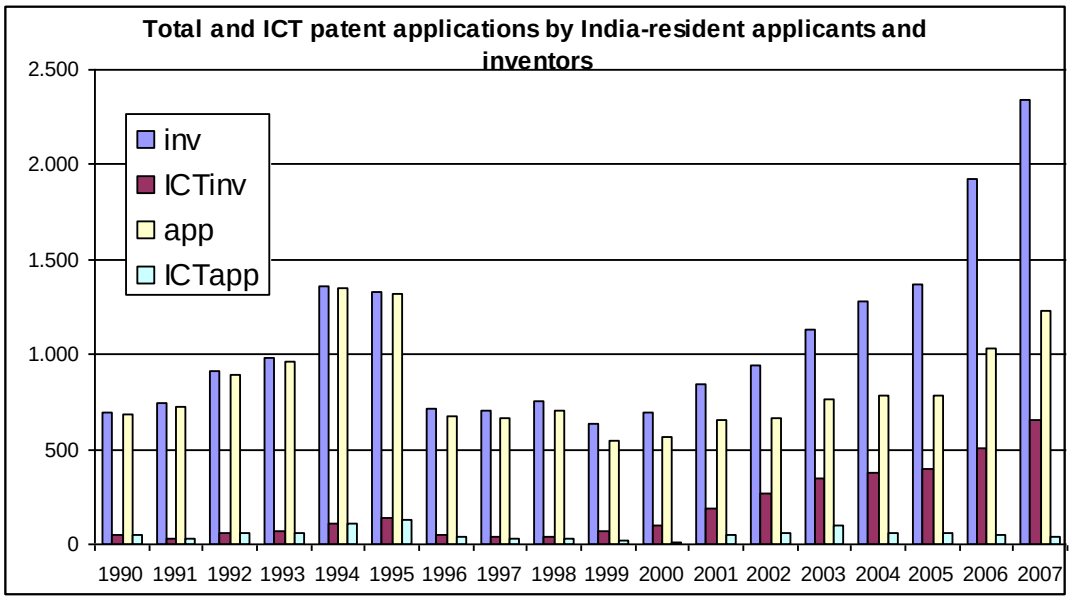
This is in line with PREDICT findings, based on the JRC-IPTS calculations (Figure 2.6).[160] Figure 2.7 shows that applications with India-based inventors increase much faster than applications with India-based applicants. This suggests that many inventions produced with India based inventors are owned by foreign applicants.

Figure 2.6: Total and ICT patent application by India-resident inventors



Source: JRC-IPTS calculations based on PATSTAT data (April 2010 release). Priority patent applications to the EPO, the 27 Member States' National Patent Offices, the USPTO, the JPO, and 29 further Patent Offices. Inventor criterion.

Figure 2.7: Total and ICT patent application by India-resident applicants and inventors



Source: JRC-IPTS calculations based on PATSTAT data (April 2010 release). Priority patent applications to the EPO, the 27 Member States' National Patent Offices, the USPTO, the JPO, and 29 further Patent Offices. Inventor and applicant criterion.

[160] See 'The 2011 report on R&D in ICT in the European Union', Chapter 5: Performance of ICT R&D – ICT patenting, in Section 5.3. JRC Scientific and Technical Report, Institute for Prospective Technological Studies, Joint Research Centre, European Commission. Available at: http://ipts.jrc.ec.europa.eu/publications/pub.cfm?id=4399

Furthermore, analysis by independent researchers and trade press reports show that number of patents awarded to the multinational firms is greater than the Indian firms. For instance, Nollen (2004) showed that in the year 2001-2003, US software patents awarded to Indian firms is four when compared 118 patents awarded to US and other foreign firms operating in India. One more piece of evidence from Dataquest (2008) reinforces this view (See Table 2.6):

Table 2.6: Patents by ICT firms in India

Firm	Patents Granted in 2008	Patents Granted in 2007
HP (Multinational)	50	77
Infosys	2	0
TCS	17	3
Sasken	5	6
Subex	8	4
i-flex	0	0
Mindtree	0	0

Source: Adapted from Dataquest, 2008.[161]

Some have argued that with software developments coming to the fore on the Indian ICT sector, patents may not be an accurate proxy for innovation.[162,163] Therefore a "*low propensity to patent*"[164] is to be found in services. New ways of capturing and assessing R&D output and innovation in services-centric economies, such as the Indian one, may be required.

2.2.2 The role of Foreign Direct Investment (FDI) in ICT R&D

Some positive inferences can be made from the amount of FDI made by foreign firms. The total amount of FDI went from just US$ 2 million in 1993 up to about US$ 19 billion in 2009 according to the Unesco report.[165] "*India emerges as the most preferred location for R&D location, followed by US and then China*" according to "The Economists Intelligence Unit survey, 2007".[166]

Foreign direct investment (FDI) followed three successive stages in India. The first set of firms came to India to exploit the local market in India. For instance, Suzuki, Japan was the first major automaker to collaborate with the Indian government followed by all major players of the world. The second stage saw the entry of the big software houses in India, either directly or through joint collaborations. The third stage is the establishment of R&D centres by the existing players or new players.

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[161] OECD (2010): This table is indicative, as the list is not exhaustive. Texas Instruments (India centre), one the top patent filers, is missing from this list.

[162] Rohan Samarajiva, presentation at the Conference 'The Asian Rise in ICT R&D – Looking for evidence' held in Brussels on 16-17 February 2011.

[163] The Indian department of science and technology publishes an annual report, the NISTADS report. At a general level it states R&D statistics relating to Indian S&T sector for two financial years namely 2006-07 and 2007-08, it states: ". *Global Research Report prepared by Thomson Reuters has brought out the growth trends in scientific publications from India. CAGR of publication rate is assessed at about 12% per annum for the last three year period. This is to be compared to the global rate of about 4% for the corresponding period. Relative position of India with respect to filing patents in the USA has improved from 25th in 2000 "to 19th in 2006 and 16th currently*". New Delhi, 2010. For publication is science and engineering see Chaudhuri, A., (2011).

[164] Payal Malik, presentation at the Conference 'The Asian Rise in ICT R&D – Looking for evidence' held in Brussels on 16-17 February 2011.

[165] P. 364.

[166] Quoted by the Nistads report, p.143.

OECD (2010) claims: "*Electrical equipment (including computer software – usually classified with services - and electronics) has attracted the highest inflows of FDI, followed by financial and non-financial services and telecommunications*".[167] OECD (2010) concludes "*Global ICT leaders such as Dell, Microsoft, IBM, Oracle, Ericsson, Unisys, Motorola, HP, Texas, Fujitsu, Siemens, and Bosch have invested in India*".[168]

Analysis of data on total FDI shows that Mauritius[169] is the top investor during the period 2000-2009 with US$ 43 143 million, followed by Singapore (8 667) and USA (7 443).[170] Among the various sectors, the services sector (financial & non-financial) dominates with US$ 21 728 million followed by computer software & hardware (9 334) and telecommunications (8 120) (DIPP, 2009).

During 1998-2003, in the list of top hundred firms in the R&D domain analysed by the Technology Information Forecasting and Assessment Council (2006),[171] USA leads the table with 53 firms followed by UK, Japan and Germany with seven firms. Other countries that have presence are Switzerland, Sweden, South Africa, Norway, Netherlands, Mauritius, Denmark, Canada and Australia In the same period, R&D investment worth of US$ 1.13 billion has flowed into India. Cost of high skilled personnel is relatively low when compared to industrialized countries. It is estimated that an entry level top notch scientist can be hired for $ 10 000 per year. Irrespective of the technological domain, Bangalore is the most preferred location among the investors.

An attempt to understand the nature of ICT R&D centres in India reinforces the perceived role of the US. Investment from the European Union countries is very low (See Table 2.7). The Unesco report stressed the "*relatively sparse collaboration with European partners and especially the UK*",[172] adding that this shortcoming is being addressed by the EU with recent initiatives under the EU's Seventh Framework Programme and Technological Development (2007-2013).

Table 2.7: Country location of Head Quarters of ICT R&D centres in India

Country location of Head Quarters	Number of firms
Austria	1
Brazil	1
Canada	1
China	1
Finland	1
France	6
Germany	7
Israel	1
Japan	5
Netherlands	3
Singapore	1
South Korea	6

[167] OECD (2010), p. 27.
[168] OECD (2010), p. 42.
[169] Mauritius is part of the Mascarene Islands, and is a major telecom hub in the Indian Ocean.
[170] It remains difficult to understand what is hiding behind these data.
[171] TIFAC.org.in.
[172] P. 375.

Sweden	2
Switzerland	2
Taiwan	1
Country location of Head Quarters	**Number of firms**
Turkey	1
UAE	1
UK	9
USA	129
Total	179

Source: Compilation by P. V. Ilavarasan, 2009, IR at 28.

There are multiple reasons for the US dominance. The US is the major consumer of software services that are originating from India. Firms that explored the Indian market for offshoring are from US. Also, historically, high skilled Indians migrated to US for higher studies, and later stayed back for working in the high technology sector. Reverse migration of Indian immigrants connected the demand in US with the supply in India through their professional networks and understanding of market and technology, and helped the industry to cement the sector linkages between US and India in the ICT sector.

"*The first US ICT multinational company to enter India was Texas Instruments, in 1988. Until the early 1990s, MNCs relied on interim IT service contractors in India, known as 'body shopping'. Currently more than 500 major international firms have IT operations in Bangalore alone, and other centres such as Hyderabad have rapidly increased in importance. Major IT MNCs, IBM and Oracle have Indian development centres as part of all global application development projects - for example IBM has six such centres, and Electronic Data Systems and Computer Sciences Corporation have substantially increased their presence. Other major MNCs with Indian subsidiaries that export IT services include Microsoft, Hughes, Hewlett-Packard, Siemens, Lenovo, Genpact, Nortel, Motorola, Intel, i2 and Cisco*".[173]
An analysis of secondary data showed that most of the multinational firms come to India to make use of low cost high skilled labour and continue working on the activities delegated by the headquarters. Over a period of time, India centre gains confidence and starts undertaking high skilled work from the parent firms. Also, India offers a strategic location to stay closer to the emerging markets like middle-east Arab countries and other East Asian countries.

Zinnov (2008) reports that 594 R&D centres have been created in India over the last six years. Some of them claim they perform real 'research' work rather than 'development' work. All the MNCs follow the conventional outsourcing model, enter India as a cost centre and evolve into a technology centre. This transition is not reflected in hard statistics, for example, patents filed by the Indian firms are less when compared to Indian centres of multinationals as illustrated above.

On the other hand, innovation in hardware domain is skewed towards embedded software, especially in the telecom domain. Poor manufacturing capabilities, lack of adequate supportive infrastructure and competitive producers like China, Taiwan and Korea will make Indian ICT industry still walk on one leg in the future.

[173] OECD (2010), p. 47.

2.2.3 Offshoring

A trade association report claims that the contribution of the Indian ICT sector in outward FDI, measured through values of mergers and acquisitions (M&A), is significant with the total number of deals involving Indian ICT firms increased by nearly 17%, US$ 3.4 billion in 2008 from US$ 2.9 billion in 2007.[174] Acquisitions are typically made in the software development and semiconductor design areas, followed by the associated business processing domains. There is also some evidence of acquisition of R&D centres of multinationals by the Indian firms.

In the ICT sector, M&A deals vary with the size of firms. Larger firms acquire firms that add a niche domain expertise to their current offering. They prefer to acquire this way, as achieving a significant size is not a priority. Second tier firms acquire in order to achieve larger scale operations and gain niche expertise. A third set of smaller firms looks for similar smaller players to enhance their niche technology strength. Apart from strengthening the variety of niche technology domains, acquisitions are also used by the Indian firms to diversify into different geographical areas. Acquisitions are typically made in the software development and semiconductor design areas, followed by the associated business processing domains.

Though Indian firms are expanding their global reach and technology domains in service through acquisitions, it will be difficult to conclude that R&D capabilities are acquired. Indian firms continue to cater to the western clients in terms of software product development or engineering services and innovate for in-house consumption, rather than developing product for open markets.

Indian innovation system appears impressive with a broad-based network of government-supported research and development laboratories with multi-disciplinary expertise, a large education capacity with world class engineering teaching institutes, dynamic private sector significant number of MNCs and R&D units, efforts to nurture technology entrepreneurship by the government and increasing foreign investment in R&D. Yet, deeper examination suggests that within these apparent strengths are embedded a number of limitations such as a lack of dynamism of the government R&D system, poor research output of the higher education system, absence of a vibrant high-technology sector, limited scope and impact of government support programmes for R&D, a science-technology divide, and inadequate spillovers of foreign direct investment in R&D.

2.3. The Indian ICT sector: company-level perspective

The industry is dominated by the larger players with the top two hundred firms contributing to 86% of the total revenues. Out of top two hundred firms, the top twenty firms account for about 63% of the total revenue, the next 30 firms constitute about 17% and next 150 constitute about 20%. Multinational firms also dominate the industry revenues with 12 firms listed among top twenty firms and around 67% in the top 200 firms (Dataquest, 2008).

Table 2.8: Revenue from different segments in the Indian IT sector (2004-07)

US$ billion	**2004**	**2005**	**2006**	**2007**
IT Services	10.4	13.5	17.8	23.6
Exports	7.3	10.0	13.3	18.

[174] OECD (2010); Nasscom, 2009.

Domestic	3.1	3.5	4.5	5.6
ITeS-BPO	3.4	5.2	7.2	9.5
Exports	3.1	4.6	6.3	8.4
Domestic	0.3	0.6	0.9	1.1
Engineering services and R&D, software products	2.9	3.9	5.3	6.5
Exports	2.5	3.1	4.0	4.9
Domestic	0.4	0.8	1.3	1.6
Total software and services revenues	16.7	22.6	30.3	39.6
Of which, exports:	12.9	17.7	23.6	31.4
Hardware	5.0	5.9	7.0	8.2
Total IT Industry ***(including Hardware)***	**21.6**	**28.4**	**37.4**	**47.8**

Note: Totals may not match due to rounding off, E is estimate; Hardware does not include export component.
*NASSCOM estimates have been reclassified to provide greater granularity. Historical values for a few segments have changed due to availability of updated information.
Source: NASSCOM (2006a and b), Indian IT Industry Fact Sheet. OECD (2010), p. 24.

Table 2.9: Top 20 firms in terms of revenue

S. No.	Name of the company	Starting year	Product and services	Employees	Revenue (million Rs.) 2007-08
1	Tata Consultancy Services (TCS)	1968	Software services, IT consulting, and BPO	110061	214650
2	Wipro Technologies	1981	Services – IT; product engineering & consulting	68944	168840
3	Infosys Technologies	1981	IT services, IT products, BPO, consulting	91187	157580
4	HP India	1989	Enterprise servers, software & storage, hardware, IT services & solutions	30228	154540
5	IBM	1992	IT services, BPO, servers, storage, middleware, and systems software	75000	101790
6	Ingram Micro	1996	Distribution of IT products and consumer electronics	1200	86200
7	Satyam Computer Services	1987	IT Services		78890
8	Cognizant Technology Solutions	1994	IT Services and BPO	48000	63100
9	Redington India	1993	Distributor of PCs, servers, peripherals, consumables, and networking equipment and components		62800
10	HCL Technologies	1991	Software, infrastructure, and BPO	49802	62000
11	Cisco India	1995	Networking	4000	58370
12	Oracle India	1993	Database, middleware, application software		58080
13	HCL Infosystems	1996	Computers, storage systems, managed systems, infrastructure, office automation, software and network integration	5901	50580
14	Intel India	1988	Processors, platforms, boards, R&D	2500	43100
15	Accenture	1987	IT services & Consulting		38000
16	Tech Mahindra	1986	Software services & BPO	22810	36360
17	Microsoft India	1981	IT services, software & consulting		32630
18	SAP India		Packaged Software and services	5000	32600
19	Dell India	2000	Desktops, Laptops, and servers & storage	13000	32000
20	Lenovo India	2005	Desktops, Laptops, and workstations	331	30140

Source: Dataquest, 2008

Box 2.3: The three leading Indian IT firms

Tata Consulting Services Ltd:
Established in 1968 as a Division of Tata Sons, TCS was a pioneer IT company and continues to maintain it's pre-eminence in India. In 2006-07, total income increased by 34% compared to the previous year and net profit was 25% of total income. The company had 148 offices globally. Additionally, there are many delivery centres outside India with major sites in Hungary, Brazil, Chile, Uruguay and China. The United States was the largest market; contributing 52% of the consolidated revenue, while the United Kingdom and Europe together contributed 29%. The company has expanded into emerging markets including Latin America, the BRICs and the Asia Pacific region. It has made acquisitions/alliances in Switzerland, Australia and China, and is widely recognised including:
• Ranked among the Top 10 US application management services vendors
• Company of the year-2006 in the Economic Times
• Top position in 'Top 10 Best Performing IT Services providers' category in the 2007 Global Services Listing.

Infosys Technologies Ltd:
Established in 1981 it was the first Indian firm listed on the NASDAQ, in 1999. It was the first to benchmark its organisational practices to global standards. In 2005-06, growth in revenues was 34% and growth in earnings was 31%, with 66% of revenues are earned from North America, 24 % from Europe, and 8% the rest of the world. Revenues from software exports increased by 32% in 2006-07, and gross profits were 46% of revenue.33 The company has, amongst others, subsidiaries in Australia (Melbourne), China (Shanghai), the United States (Texas) and Progeon Limited in India. It also has operations in Europe, Japan and Africa. Infosys pioneered the Global Delivery Model (GDM), which is used in distribution and management across multi global locations. By 2005-06, the company ranked No. 10 in the annual Business Week InfoTech100, and had reached a high level of maturity, systematically benchmarked against world-class operating models. Infosys' R&D process is, to a large extent, based on software engineering and technology labs (SETLabs), which is the centre for applied technology research in software engineering and enterprise technology.[175]

Wipro Ltd:
Wipro commenced operations in 1946 as a Vanaspati oil manufacturer and entered the IT sector in 1980. In 2007, revenues grew by 41% to INR 149 982 million and profit after tax grew by 42% to INR 29 421 million. The company had 50 subsidiaries in 29 countries and is listed on the New York Stock Exchange (NYSE). R&D efforts were equivalent to nearly 8.5% of total revenues in 2005-06. In India, the Middle East and the Asia Pacific Wipro Infotech manufactures personal computers (PCs), with growth of desktops of 21% to 4 million units in 2006, and growth of laptops of 167% to 0.6 million in 2006. This segment is a leading strategic partner for the firms providing IT solutions. Wipro Technologies (NYSE:WIT) operates globally, providing IT consulting and software services.

Source: OECD.[176]

2.4 Conclusion

India, as a number of other Asian countries, is becoming increasingly more present in the ICT market, ICT industry and ICT R&D global landscape. The economic rise of India creates possibilities for both domestic and foreign companies, which pose some challenges to their business models and ways of delivering new products.

Nasscom, the IT trade association looks rather optimistic for future growth building on the "*Indian IT-BPO value proposition (low cost of delivery, high calibre talent pool, robust process delivery, improved business environment and infrastructure)*". Domestic growth is providing room for this as India became the fourth largest economy by purchasing power parity. The ICT sector is playing a significant role in the development of the country. The

[175] Source: Dr. Jai Ganesh, Principal Research Scientist, Future Web Research Lab, SETLabs, Infosys, presentation at the Conference 'The Asian Rise in ICT R&D – Looking for evidence' held in Brussels on 16-17 February 2011.
[176] OECD (2010), pp. 46-47.

tremendous growth of the mobile market and the innovation that took place during this growth are certainly supporting this optimism.

Regarding the development of the domestic market, the focus of the Indian government of telecom policies was not matched by a similar attempt to reform the broadcasting sector. The slower reform of broadcasting is reducing the expected benefits for development. This may trigger some issues at a time of technological convergence and may constitute a hurdle for the deployment of broadband especially as India is lagging behind with still a low Internet penetration. In a converged world, with applications triggered by customers demand, the uneven development of the telecom and broadcasting subsectors may become a significant obstacle for a future growth.

Concerning the ICT industry, together with most observers, the OECD states: "*India has become the global front office, handling customer service calls, and back office, helping to process payments and run accounting and other computer systems. However, the current 'lift and shift' model will not continue in the long run. India needs to become one of the head offices –innovating new products and techniques or shaping major corporate strategies – and a provider of higher value added services in this changing environment, including in growth areas such as cloud computing, security and privacy*".[177] Among its policy recommendations, the OECD report stresses a need for improvement on R&D and innovation, infrastructure and SMEs. As highlighted, the level of investment in R&D is still low.

Lastly, as stressed by Malik (2001) the amount of high-skilled labour (i.e., PhDs), is inadequate for the R&D demand. The Unesco report,[178] also emphasizes that improving the quality and quantity of science and technology personnel is the main challenge, otherwise the country is likely to face a shortage of scientists and engineers. The increased migration of highly skilled researchers is also impacting negatively.

2.5 References

Banerjee P. (Ed.) (2009), India. Science and Technology, 2008. National Institute of Science, Technology and Development Studies, CSIR. New Delhi.

Balakrishnan, (2006), Multinational firms and the evolution of the Indian software industry. Working paper (51), Economics Series. Honolulu, Hawaii: East-West Center Working Papers.

Bhattacharya M., Vickery G., (2010), The information and communication technology sector in India. Performance, growth and key challenges, OECD, June 2010.

Business Line, 2007, Go to Tier II Cities for Expansion, Maran Tells IT Cos', Business Line, 8 February. Available at: http://www.blonnet.com/2007/02/08/stories/2007020807260100.htm, accessed on December 10, 2007.

Business Line, 2009, Infosys China breaks even in fourth quarter. Business Line, April 16, 2009. http://www.thehindubusinessline.com/2009/04/16/stories/2009041651450300.htm, accessed on 2 November, 2009.

Chaudhuri A., (2011), "Creeping Tiger, Soaring Dragon: India, China and Competition in Information Technologies" forthcoming.

[177] OECD (2010), p. 43.
[178] P. 373.

Dataquest, 2007. Indian Software Products: No More Standalone http://dqindia.ciol.com/dqtop20/2009/CompanyRanking/default.asp (accessed on 8 May 2010).

Dataquest, 2008, DQ Top Ten. Available at http://dqindia.ciol.com/dqtop20/2008/CompanyRanking/ accessed on 3 February 2009.

Dataquest, 2009. Industry overview, mixed signal, http://dqindia.ciol.com/dqtop20/2009/CompanyRanking/default.asp (accessed on 8 May 2010).

DIPP (2009). Fact sheet on foreign direct investment (FDI) From August 1991 to March 2009, Department of Industrial Policy & Promotion, Ministry of Commerce and Industry, Government of India, Retrieved from: Government of India. 2009. Economic Survey, Ministry of Finance. Delhi. Available at: http://indiabudget.nic.in.

http://www.dipp.nic.in/fdi_statistics/india_FDI_March2009.pdf, on 29 June 2009.

EITO Special Report, BRIC countries' ICT markets, 2007-2011, 3 January, 2011.

Galpaya H., "Examples from Emerging Asia. Information Society Policies: What worked and did not work". Available at http://www.eurocpr.org/conferences/eurocpr-2010/

IBEF (2008). Electronics: Market and opportunities. Indian Brand Equity Foundation, Gurgaon, India.

India, Science & Technology 2008, National Institute of Science, Technology and Development Studies (NISTADS), CSIR. Available at: www.nistads.res.in

India 2009, 2009. Publication Division, Ministry of Information & Broadcasting, Government of India. www.publicationsdivision.nic.in/others/india_2009.pdf, accessed on 1 November 2009.

Jain R., "Role of Policy and Governance in Unlocking the Potential from Convergence: Lessons from India", available at: http://www.tprcweb.com/index.php?option=com_content&view=article&id=89&Itemid=54

The Economic Times (2009), IT companies may not have it easy in Europe. 19 November 2009. http://economictimes.indiatimes.com/infotech/ites/IT-companies-may-not-have-it-easy-in-Europe/articleshow/5245239.cms, accessed 20 November, 2009.

KPMG, DoT, FICCI, (2009). The Indian Telecom Success Story, India Telecom 2009, New Delhi.

Malik P., (2010), Telecom Regulatory and Policy Environment in India: Results and Analysis of the 2008 TRE Survey, http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1555459

Malik P., Vigneswara Ilavarasan P., (2011), Trends in Public and Private Investments in ICT R&D in India, JRC Technical Note – JRC 64578. Institute for Prospective Technological Studies, Joint Research Centre, European Commission. Available at: http://ipts.jrc.ec.europa.eu/publications/pub.cfm?id=4359

Mitra, M. Raja. India's emergence as a Global R&D center - An overview of the Indian R&D systems and potential. Swedish Institute for Growth Policy Studies. Working Paper, R2007:012, Sweden.

Mrinalini N. and Wakdikar S. (2008), Foreign R&D centers in India: Is there any positive impact? Current Science, 94(4), 452-458.

National Association of Software and Services Companies (Nasscom), Nasscom Industry Trends, 2008 data.

Nasscom Report 2009.

Nasscom Strategic Review 2010.

National Science and Technical Manpower Information Systems (2009), Research and Development Statistics 2007-2008, Government of India, Ministry of Science and Technology, Department of Science and Technology, New Delhi.

Nokia (2008a), Affordability key in bringing digital inclusion. Expanding Horizons, 1.

Nokia (2008b), A roadmap to affordable mobility in emerging markets. Expanding Horizons, 4.

OECD (2010), Information Technology Outlook. OECD. Paris.

OECD (2010), Main Science and Technology Indicators, Volume 2010/1.

PricewaterhouseCoopers (2011), Global Entertainment and media outlook.

Reserve Bank of India (2009), Indian Investment Abroad in Joint Ventures and Wholly Owned Subsidiaries: 2008-09 (April-March). RBI Bulletin.

Samarajiva R. (2009), How the developing world may participate in the global Internet Economy: Innovation driven by competition. Report for Joint Workshop on Policy coherence in the application of information and communication technologies for development, organized by the Organization for Economic Co-operation and Development (OECD) and the Information for Development Program (infoDev), World Bank, 10-11 September 2009, Paris, France. Available at: http://lirneasia.net/wpcontent/uploads/2009/09/OECD_Oct09_Samarajiva_final.pdf.

Silicon India 2008 (2008), Special IT Regions on the Anvil, Silicon India, 22 March. Available at: http://www.siliconindia.com/print_article.php?40553 , accessed on 30 March 2008.

Technology Information Forecasting and Assessment Council (TIFAC) (2006), FDI in the R&D Sector Study for the pattern in 1998 – 2003. Department of Science and Technology, Government of India.

Unesco Science Report 2010, see Sunil Mani, India, Chapter 17, pp. 363-377.

Unveiling the R&D Offshoring Scenario in India (2008), Bangalore, India.

Vang J., Chaminade C. (2006), Building RIS in Developing Countries: Policy Lessons from Bangalore, India. JRC-IPTS. European Commission. Mimeo.

Zinnov Management Consulting (2008), Strategic Guide on Indian R&D Centres 2008.

3 China

Source: Jean Paul Simon

With an area of 9 596 960 square kilometres (3 696 000 square miles) and a population of 1 328 000 inhabitants (2008), China is the most populated country in the world and the largest in Asia, the third largest in the world, next to Russia and Canada. China is divided into 34 administrative units in the form of 23 provinces, 5 autonomous regions, 2 special administrative regions and 4 municipalities directly under the Central Government.[179] China's basic political system is Communist Party of China (CPC)-led multi-party cooperation and political consultation system. The people's congress system is China's fundamental political system. During the past 3 decades, the Chinese government has been fostering a dual economic structure that has evolved from a socialist, centrally planned economy to a socialist market economic system, or a "market economy with socialist characteristics."

[179] These sections are based on the report commissioned by IPTS on China. Ling Wang & Shiguo Liu, Institute of World Economics and Politics, Chinese Academy of Social Sciences (IWEP), Forthcoming 2011. (hereafter JRC-IPTS China Report); Stephan Pascall, EU-China Cooperation of Information and Communication Technologies in RTD. Status and way ahead, DG INFSO, February 2010. ECC in the rest of the text. In the last section, the author also refers to the "ARCEP Mission in China" written by the French telecom regulatory commissioners Joëlle Toledano and Nicolas Curien. Available at: www.arcep.fr French and English version, November 2009, p.70. AMC in the text: see Box 4 and Section 4 "Case studies".

Figure 3.1: China Map[180]

China is a country that went since the early eighties through accelerated reforms and economic growth, while opening its doors to global trade, commercial agreements at WTO and outside WTO, and to foreign direct investment (FDI) flows. Since the reforms and opening up policies after 1978, the Chinese economy moved from a centrally planned system to a more market-oriented economy with a rapidly growing private sector. China is becoming the manufacturing engine of the world and is now a major player in the global economy.

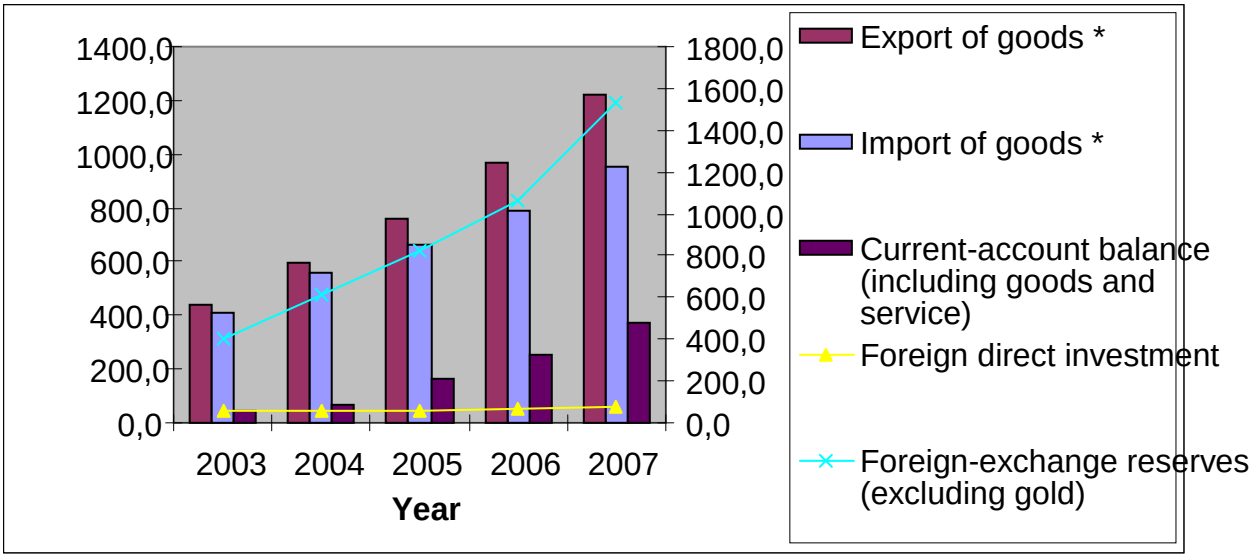
China's GDP has achieved a more rapid growth than most countries in the world.[181] In real prices, China's average annual growth rate reached 9% for the period of 1978-2008, much higher than the 2.29% and 3.06% growth rate for the Euro Area and the world during the same period (World Bank, WDI Databases, 2009). In 2006, China's GDP was US$ 6156.32 billion on a purchasing power parity (PPP) basis, the 2nd largest in the world after the US, being about 41% of total EU27 (World Bank, 2009). The GDP per capita has grown steadily with a compound annual growth rate of 12.8% during the last decade,[182] reaching €1 857 in 2008.[183] Still, GDP per capita lags behind at a very low level, putting China far below the US or the EU equivalent in the rankings.[184]

China is the second biggest trade partner of the EU (after the USA) whilst the EU itself is China's most important trade partner (2007) accounting for 6% of EU27 exports and 16% of EU27 imports. From 2003 to 2008, Sino-EU bilateral trade enjoyed a strategic annual growth

[180] Source: Wikipedia Commons.
[181] It will overtake Japan by the end of 2010 according to the Unesco Science Report 2010, at 379.
[182] RMB 2 2640, Chen Jinqio, Deputy Chief Engineer, Ministry of Industry and Information Technology, "China Telecom Sector Market and Regulation", key-note presentation at the CPR South Conference, Xi An, 6 December, 2010.
[183] JRC-IPTS China Report, p. 11.
[184] See for example the rankings of the IMF and the World bank at: http://en.wikipedia.org/wiki/List_of_countries_by_GDP_(PPP)_per_capita

rate of 21.7%. Trade in goods is concentrated on industrial products such as machinery and transport equipment.

Figure 3.2: Main economic indicators of China (US$ billion)



Source: Ling W., Shiguo L. (2011), * excluding service trade.

EU27 trade in goods with China more than tripled in value between 2000 and 2008: the EU27 exports to China rose to €78 billion in 2008 compared with €26 billion in 2000, imports rose to €248 billion from €75 billion. Germany was the largest exporter and importer for China, among the EU27 Member States, accounting for 43% of EU27 exports to China and 21% of EU27 imports from China. *"Nearly 60% of EU27 exports to China in 2008 were machinery and vehicles, more specifically aircraft and motor cars, while the main imports included computers, parts, mobile phones and video games."*[185]

3.1 The size of the ICT sector

3.1.1 The ICT sector[186]

The ICT sector is certainly representative of the massive changes in the Chinese industry and economy. It has developed a strongly growing manufacturing arm, with large inward and outward FDI flows and export-led activities. Since China's economic reform and opening-up in 1978, China's information and communication technology (ICT) manufacturing has been growing rapidly. The ICT sector rose as a pillar of the Chinese economy.

Over the last years the Chinese government has been paying more and more attention and investing more money in the sector. The sector has seen a very rapid growth from 2000 to 2004 with growth rate of 45% per year, from 2005 to 2007 it became a steady 20% growth. However since 2008, it went through a sharp slowdown with a growth rate reduced to 5% allegedly due to the lack of R&D over the last ten years.[187]

Manufacturing dominates China's ICT industry. A total of 80% of the ICT industry revenue comes from computer systems, electronic elements & components, communication equipment

[185] ECC, p. 23.
[186] All the data unless specified otherwise come from JRC-IPTS China Report.
[187] Huang Linli, "ICT and R&D in China", China Center for Information Development (CCID), presentation at the Beijing IPTS / IWEP meeting, 3 December, 2010.

and home audio and video products. For the period 1978-2006 (Graph 2), at current prices, the annual average growth rates of value-added in ICT manufacturing was 25.8%, much higher than the 15.84% and 15.86% annual average growth rate of GDP and industry during the same period (NBSa, 2007). As of 2006, the value added of total ICT sector has increased to €176.2 billion.[188] **China has become the largest producer of ICT products.** More specifically, in 2006, the value added of ICT manufacturing has increased to €94 billion; it reached €23 billion for wholesale of computers, computer peripheral equipment and software,[189] €0.42 billion for telecommunications,[190] and €0.17 billion for the software industry.

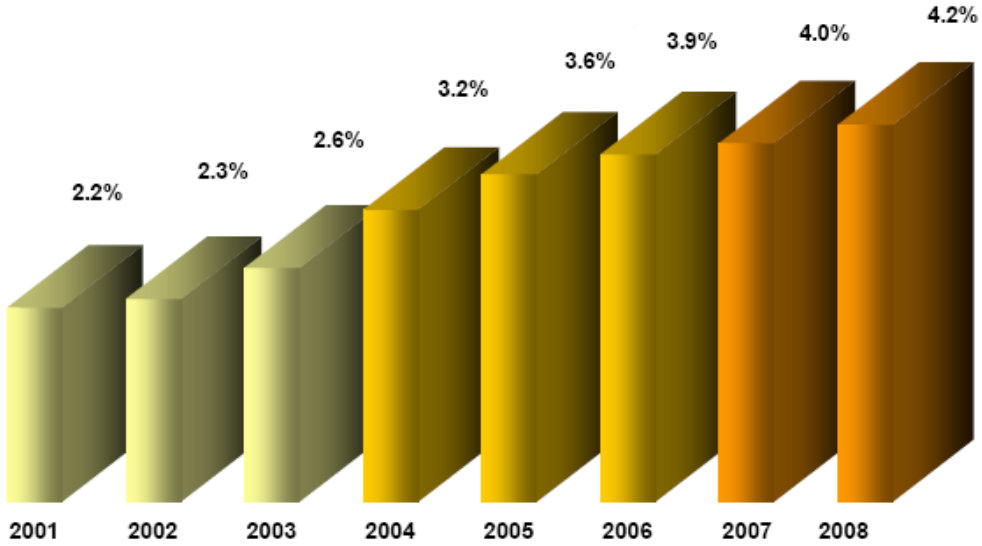
In 2006, the ratio total value added of ICT to GDP was of 8.4%.[191] The ICT manufacturing represented 4.48% of the GDP: 1% for wholesale of computers, computer peripheral equipment and software, 2% for telecommunications, and 0.82% for the software industry. Figure 3.3 follows the growth of the percentage-share of ICT industry within China's GDP. Table 1 below shows the trend of ICT manufacturing's role within the industry and GDP for 1978-2006.

Table 3.1: Ratios of Value Added of ICT manufacturing in industry and GDP (1978-2006, %)

	1978	1983	1988	1993	1998	1999	2000	2001	2002	2003	2004	2005	2006
GDP	0.79	0.77	1.19	1.33	1.83	2.03	2.40	2.48	2.68	3.30	3.62	4.02	4.48
Industry	1.79	1.94	3.09	3.32	3.70	4.24	5.36	5.44	5.72	6.45	7.96	11.66	12.05

Source: Calculated from NBSa (2008), MIIT (2008) and NBS/MSTa [192](2002-2007).

Figure 3.3: Percentage-share of ICT industry within China's GDP[193]



[188] It does not include the value added of 5152 (Wholesale of electronic and telecommunications parts and equipment), 7123 (Renting of office machinery and equipment) and 72 (Computer and related activities), but value added of software industry is included.

[189] 5151.

[190] 6420.

[191] It doesn't include value added of 5152 (wholesale of electronic and telecommunications parts and equipment), 7123 (renting of office machinery and equipment) and 72 (computer and related activities), but the value added of the software industry is included.

[192] National Bureau of Statistics of China and China's Ministry of Science and Technology.

[193] Source: http://www.paradiso-fp7.eu/documents/conference/Day2/Session3/Jun.pdf

For the period 1978-2006, the annual average growth rates of value-added and productivity were 25.17% and 17.08%. In 2007, China produced 48% of phone handset, 46% of PC, 42% of colour TV, 65% of monitors, 58% of program-controlled switchboards, and 57% of digital cameras for the world. China's ICT sector has played an increasingly important role in China's industry, the total economy and international trade. In terms of industry segments, the sub-sector that made the greatest contribution to the whole industry is the manufacture of electronic valves, tubes and other electronic components (NACE Code 3210), followed by manufacture of office, accounting and computing machinery (NACE Code 3000) and manufacture of television and radio transmitters and apparatus for line telephony and line telegraphy (NACE Code 3220).

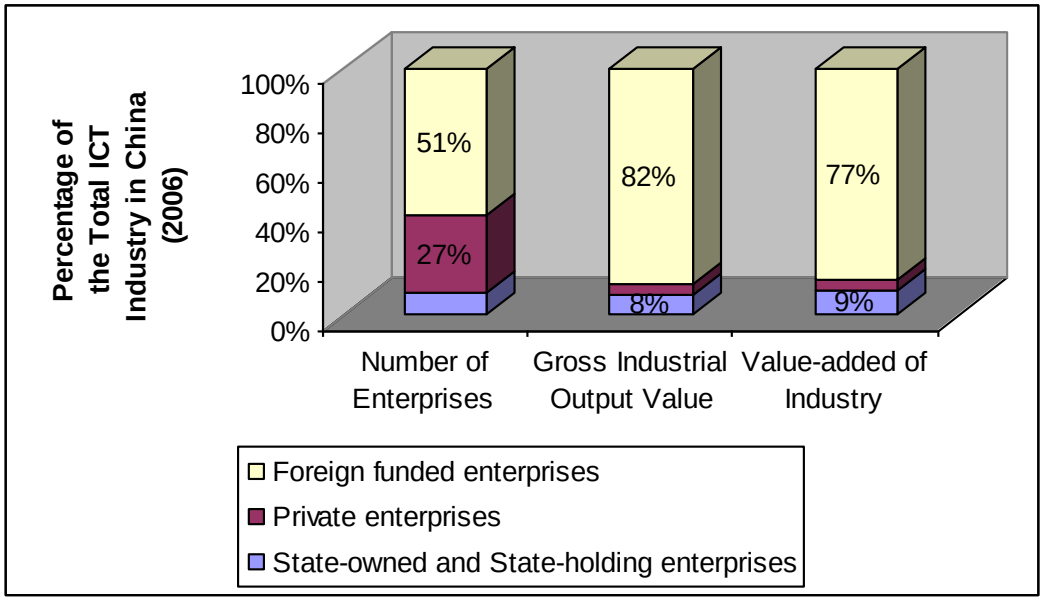
Box 3.1: NACE Code and Corresponding industries in China's ICT sector

3000 Manufacture of office, accounting and computing machinery
3130 Manufacture of insulated wire and cable
3210 Manufacture of electronic valves and tubes and other electronic components
3220 Manufacture of television and radio transmitters and apparatus for line telephony and line telegraphy
3230 Manufacture of television and radio receivers, sound or video recording or reproducing apparatus, and associated goods
3312 Manufacture of instruments and appliances for measuring, checking, testing, navigating and other purposes except industrial process control equipment
3313 Manufacture of industrial process control equipment
5151 Wholesale of computers, computer peripheral equipment and software
5152 Wholesale of electronic and telecommunications parts and equipment
6420 Telecommunications

For the period 1979-2006, the annual average growth rates of the employed persons amounted to 6.87% for ICT manufacturing, above the 3.77% annual average growth rate of industry as well as above the 2.36% growth rate of the total economy during the same period (MIIT, 2008; NBSa, 2007). The number of employed persons in ICT sector has reached 7.6 million (1% of total employment and an annual average growth rate of 6.87% in ICT manufacturing for the period 1978-2006).

Within the Chinese ICT sector, foreign funded companies made up a large portion of the total number of enterprises, the gross industrial output value and the value-added of industry as shown in Figure 3.4. The majority of national enterprises were privately-owned, rather than State-owned and State-holding.

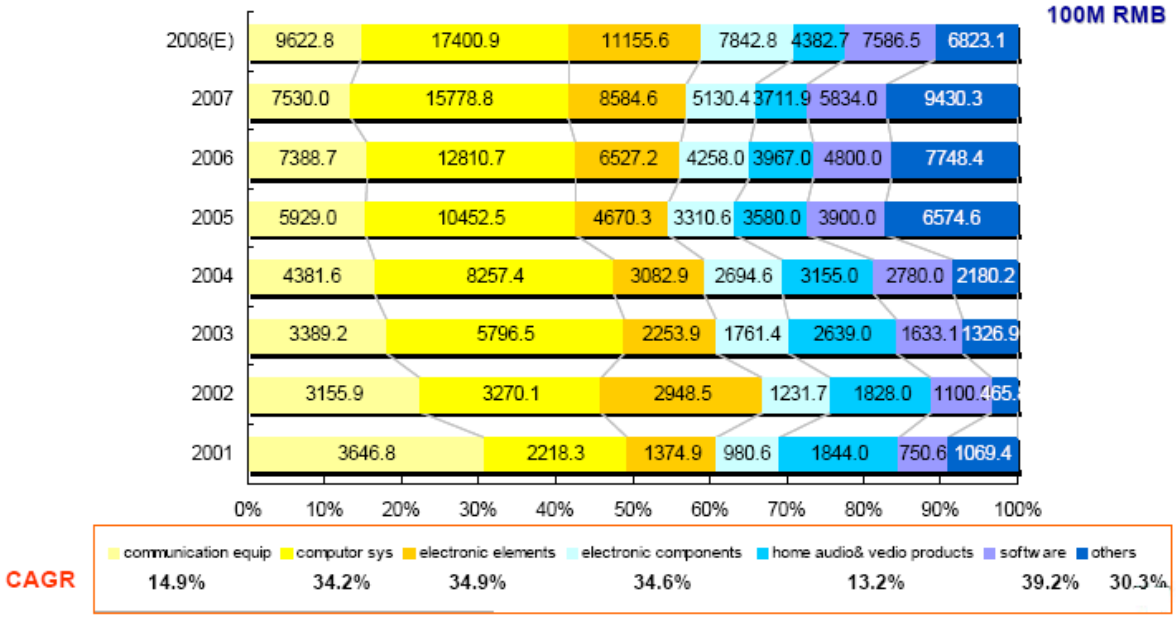
Figure 3.4: ICT Industry Structure in China (2006)



China's ICT manufacturing is characterized by the regional concentration of its production and export. The eastern region contributed the most to the China's ICT manufacturing, particularly in Guangzhou. Large-sized enterprises and joint venture enterprises play a most significant role in industry at large.

China's software industry continues to grow rapidly, with an increase in sub-sector revenue from 6.3% to 11.7% in the last 8 years. There were 14 373 firms in China's software industry (85.84% domestic). Huawei, ZTE and Digital China ranked top 3 software companies in 2008 (with respective revenues of €5.43 billion, €2.52 billion and €1.08 billion) from software.[194] However, as stressed by S. Pascall, "*China's software industrialization is currently at the initial stage. Most software companies specialise in homogeneous business with a team of less than 50 people*".[195] Figure 3.5 introduces the distribution.

Figure 3.5: Sub-sector revenue of China ICT industry (2001-08[196])

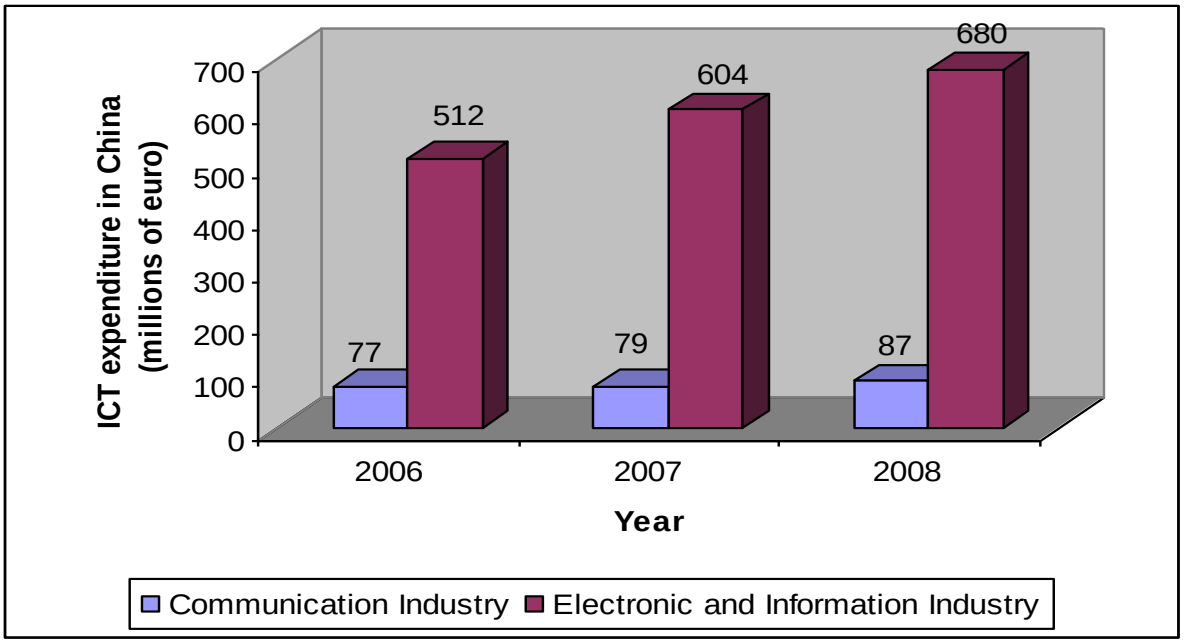


In most Chinese reports and statistics, the ICT industry in China is presented as composed of the Communication Industry and the Electronic Information Industry.

Figure 3.6 shows that the whole industry has enjoyed a steady growth in the last three years. The communication industry, accounting for approximately 12% of the whole ICT industry, grew by €10 million in the period 2006 to 2008. Meanwhile an average increase of over 13% can be seen within the electronic information during this period.

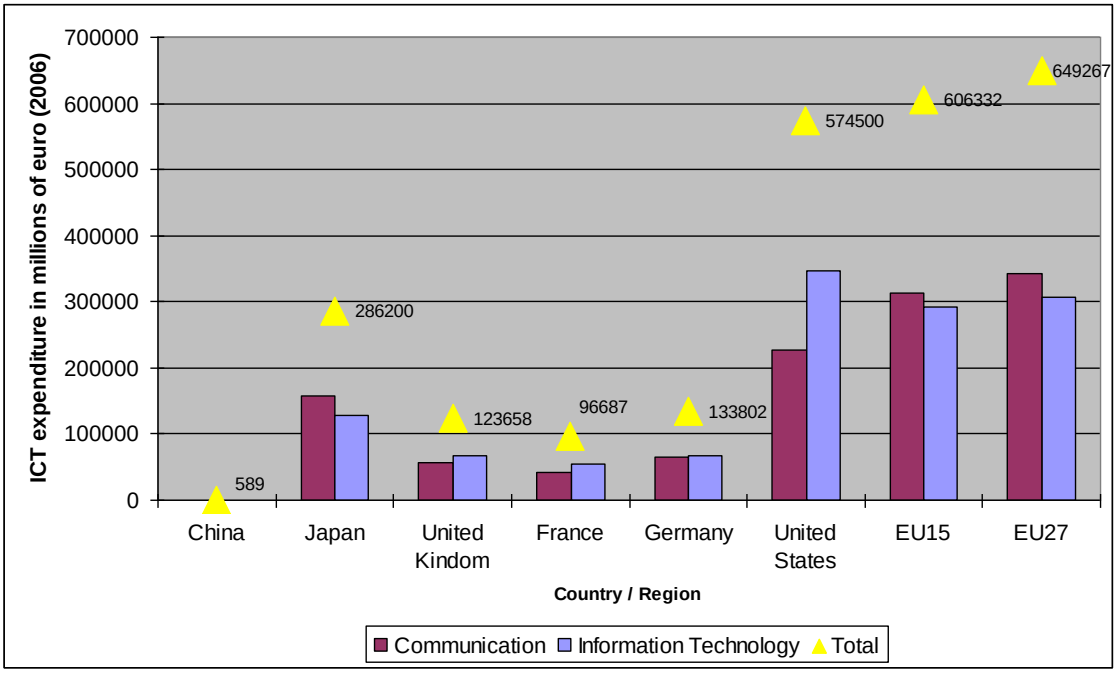
[194] JRC-IPTS China Report, p. 36, source: MIIT, 2010.
[195] ECC, p. 69.
[196] http://www.paradiso-fp7.eu/documents/conference/Day2/Session3/Jun.pdf

Figure 3.6: ICT expenditure in China[197]



However, despite the extensive growth within the Chinese ICT industry in the past three years, the overall market size is small compared to countries such as Japan, Germany and the US. For example, ICT expenditure in China is less than 1/20th of that of Germany (Figure 3.7).

Figure 3.7: ICT expenditure / GDP & GDP per capita in US$ (2006)[198]

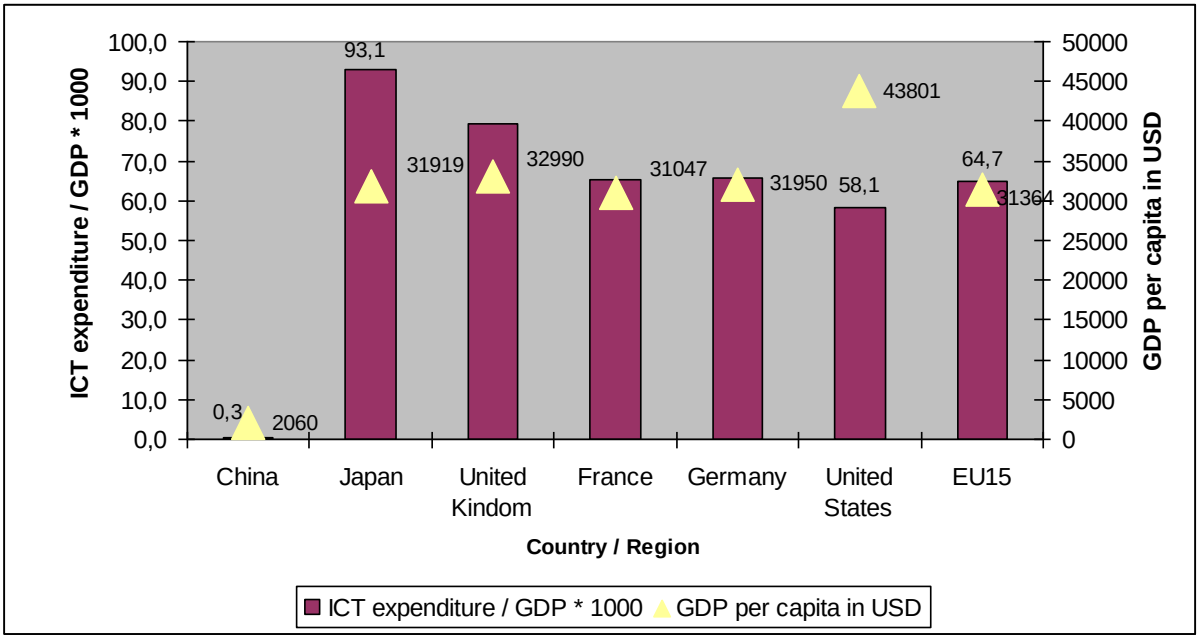


[197] Source: http://www.miit.gov.cn/n11293472/n11293832/n11294132/n11302737/index.html

[198] Source: http://stats.oecd.org/wbos/Index.aspx?DataSetCode=PATS_IPC; http://www.stats.gov.cn/tjsj/ndsj/2007/indexch.htm
Exchange rate: 1US$ = 7.8087 RMB (from National Bureau of Statistics of China, end of 2006).

By the same token, (Figure 3.8) China has the lowest ICT expenditure in millions of Euros. The 'ICT expenditure / GDP * 1000' coefficient is 0.3 for China whilst it is 64.7 for EU15. This clearly leaves a lot of room for the potential growth of China's ICT sector.

Figure 3.8: ICT expenditure / GDP & GDP per capita in US$ (2006)[199]



3.2 ICT R&D Expenditures

Over the past decade, China multiplied its gross domestic expenditure (all industries) on R&D by a factor six and became one of the world's biggest spender on R&D.[200] In 2006, GERD reached 1.42% of the GDP (around €30 billion[201]),[202] up from 1.23% in 2004. In 2006, BERD of ICT manufacturing related R&D[203] was about €3.83 billion, while GERD was about € 8.38 million for ICT services.[204,205] An estimated 20% of total GERD was dedicated to ICT R&D. If China continues to grow expenditures at the same rate (21% per year) as it grew for the past twenty years, it will have passed the US level of 2010 (US$ 390 billion) in 2020 (US$ 454 billion) (von Zedtwitz, 2011).[206]

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199 Source: http://stats.oecd.org/wbos/Index.aspx?DataSetCode=PATS_IPC; http://www.stats.gov.cn/tjsj/ndsj/2007/indexch.htm
Exchange rate: 1 US$ = RMB 7.8087 (from National Bureau of Statistics of China, end of 2006).

200 Unesco report at 379 and 389, an average growth rate of 22.8% between 2000 and 2008 for GERD.

201 JRC-IPTS China Report.

202 US$ 3 767.15 billion in US$ 2009, 1 €= RMB 8.65581 as of 14 September, 2009. 1 CNY = € 0.114264; € 1 = 8.75166 CNY as of December 2010.

203 Data of ICT manufacturing includes industry 3000, 3210, 3220, 3230 and 3312, data is estimated by sum of large-sized and middle-sized enterprise; data of 3130 and 3312 are unavailable. R&D expenditure of government research institute in manufacturing is too small to be incorporated.

204 Including Telecom & Other Information Transmission Services, Computer Services and Software Industry.

205 In comparison, EU27 GERD was above €200 billion and US GERD above €300 billion. EU27 ICT expenditures alone were similar to the total Chinese GERD. See Predict 2011: "The 2010 report on R&D in ICT in the European Union": http://ipts.jrc.ec.europa.eu/publications/pub.cfm?id=4399

206 Presentation at the IPTS conference "Asian rise in ICT R&D – Looking for evidence: Debating collaboration strategies, threats and opportunities", 16 - 17 February 2011, Brussels, Belgium. Presentations and proceedings at the following link: http://is.jrc.ec.europa.eu/pages/ISG/PREDICT/AsiaICT.html.

Table 3.2: Chinese ICT R&D expenditures profile (2006[207])

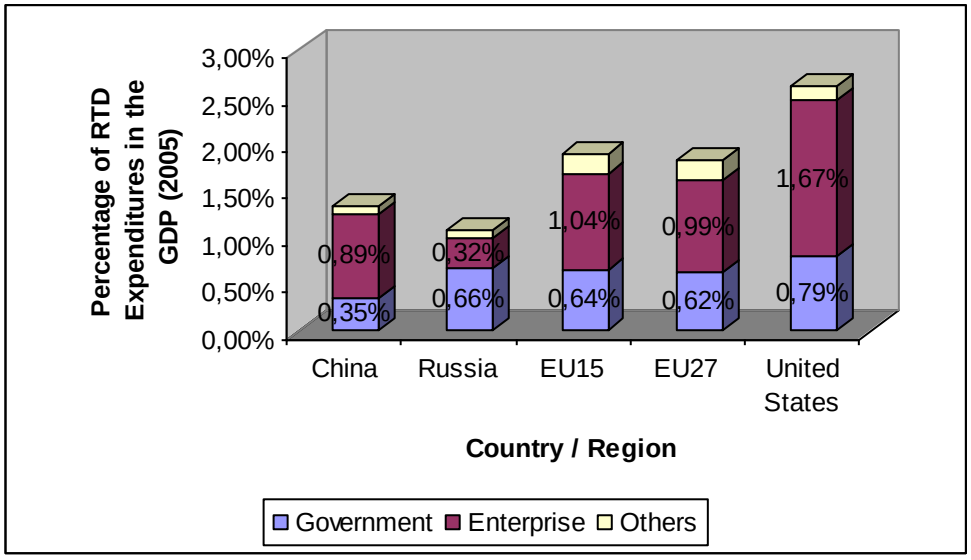
Total GERD	€ 30 billion[208]
Total GERD/GDP	1.4%
ICT Manufacturing BERD	€ 3.83 billion
ICT Manufacturing BERD / Total GERD	12,8%
ICT R&D employment	593 420 people

Source: Adapted in Euros from data in: Ling W., Shiguo L. (2011), (forthcoming).

Share of BERD of ICT manufacturing in national BERD increased from 13.12% in 1997 to 17.97% in 2006. During 1998-2006, annual average growth rate of BERD related ICT manufacturing was 35.12%, higher than 30.45% for total BERD. China-based R&D is considered by most experts as increasingly value-adding, not just cost-oriented.

However, in spite of the growth, the level of expenditure remains modest, a mere 2.7% of the total R&D expenditures in 2009.[209] There is still a big difference between China's R&D expenditures as a percentage of the GDP (1.4% in 2006) and that of the EU (nearly 2% in 2006) and the US (over 2.5% in 2006), see Figure 3.9. R&D expenditures appeared to be more focused on the D side (82% and up to 97% for ICT[210]) that on the more fundamental R side (4.7%), the remaining 13.3% are invested in applications. Nevertheless, China achieved some significant breakthroughs in core technologies such as system-on-chip technology, multi-application processor, digital TV and communication IC. Some experts claimed that the Chinese ICT industry achieved a breakthrough in R&D industrialisation of TD-SCDMA[211] which included a complete industrial chain.

Figure 3.9: Funding Source for RTD Expenditures in 2005[212]

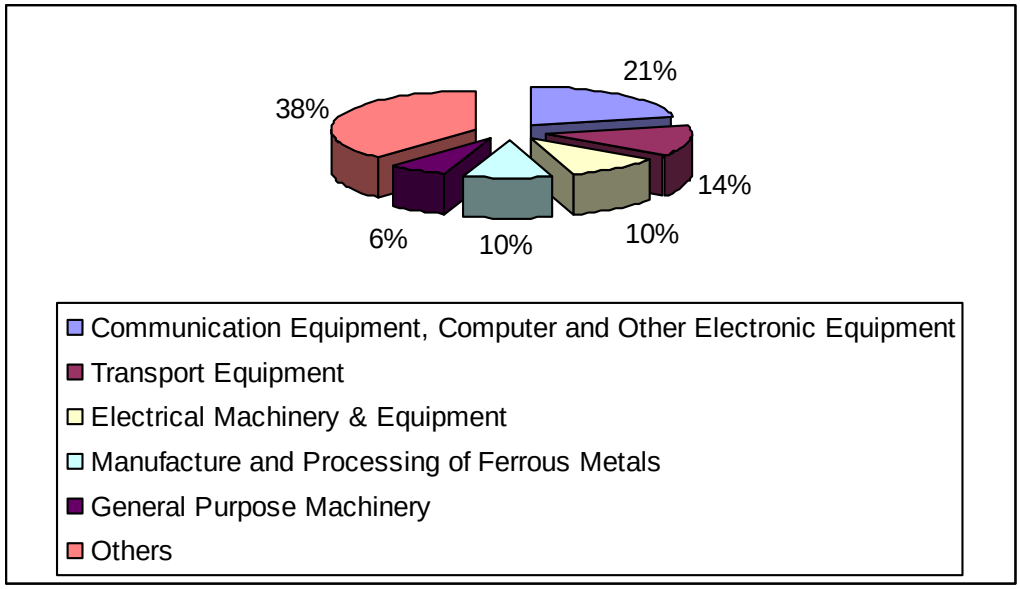


[207] Latest official statistics available for the JRC-IPTS China Report.
[208] Total GERD (all industries) in 2008 € 46.16 billion, Unesco (2011: 389), 2009: 58, source Huang Linli (2010).
[209] Huang Linli, "ICT and R&D in China", op.cit.
[210] Huang Linli, id.
[211] Time Division Synchronous Code Division Multiple Access (TD-SCDMA) is an air interface for 3G/UMTS mobile. The technology was developed by the China Academy of Telecommunications Technology (CATT), Datang and Siemens.
[212] Source: Europe: Eurostat; China: http://www.stats.gov.cn/tjsj/ndsj/2007/html/U2138e.htm

R&D funding comes from the government, from firms or from other channels. Companies account for over 50% of R&D funding in the EU and up to 79% for ICT R&D in China in 2009 (72% all industries). The level of government funding is weak for ICT: 4% (v. 24% all industries). The rest is coming from foreign funds (15.7%) and "other funds".

In terms of expenditures, the ICT sector ranked second and represented, in 2006, 21% of the expenditure for all industries.

Figure 3.10: RTD expenditure percentages by industrial sector in China (2006)[213]



China's ICT R&D Employment followed a similar trend and reached a significant size. The share of R&D employment in ICT manufacturing increased from 3.04% in 1995 to 8.78% of the total national R&D employment in 2006. The total number (full time employment) was distributed as follow by order of magnitude: 131 926 in ICT manufacturing, 3 360 in ICT services, 1 450 in information transmission computer services, telecommunications, and 470 in other computer services.[214] There is a lack of highly educated professionals (only 2% with PhDs) in this area. If China has become one of the world's biggest reservoir of R&D personnel, the density of researchers remains lower than that of developed countries.[215]

3.2.1 The role of Foreign Direct Investment (FDI)[216] in the ICT R&D trends

FDI inflow has increased rapidly during the past three decades. Most FDI concentrates in manufacturing, while Foreign Invested Enterprises (FIEs)[217] has occupied a large domain in

[213] Source: http://www.stats.gov.cn/tjsj/ndsj/2007/indexch.htm. 21-43 Basic Statistics on R&D Activities of large and medium-sized industrial enterprises by industrial sector.

[214] However, according to Huang Linli, the total amounts to only 90 553.

[215] Unesco, p. 390.

[216] China's FDI inflows reached US$ 83.52 billion in 2007 according to UNCTAD (2007). There's significant data difference between NBS (2008) and UNCTAD (2007) mainly because China's FDI statistics deviate significantly from international standard (UNCTAD, 2007). China's FDI stock is simply only cumulated flows according to the book value or historical cost. Utilization of FDI refers the realized FDI, namely the investment by the foreign companies that has been put into commercial operation.

[217] FIEs refer to enterprises established under Chinese law using foreign investment, which constitutes an important form of utilizing international private direct investment. Literally an FIE refers to an enterprise with foreign investment. According to current Chinese law, FIEs are divided into four categories: Sino-

China. During 2002-2006, the average annual growth rate of FIEs value added in China's ICT manufacturing was 34.80%, somewhat greater than the 31.06% growth rate for total ICT manufacturing, indicating that FIEs' role in China's manufacturing is increasing. Although their R&D intensity is lower than that of domestic enterprises. China's FIEs have increasingly strengthened investment in R&D. During 2002-2006, the average annual growth rate of FIEs R&D expenditure and R&D personnel in China's ICT manufacturing were 35.42% and 41.71, greater than 26.20% and 22.67% growth rate for total ICT manufacturing (NBS&MSTA, 2007). Max von Zedtwitz (2011) claims than more than 1,200 foreign R&D centres have been set up in China by 2009 (all industries) with early entrants in ICT, telecoms, and software. ICT accounts for half with a strong presence in Beijing.[218]

A large proportion of MNCs' R&D centres in China are in ICT industry. In 2004, among R&D centres surveyed by *Business Week* 1000 MNCs in China, the software sub-sector ranked 1st with a 17.2% share, immediately followed by the telecommunication sub-sector with a 16.3% share and the industrial equipment and components sub-sector with a 8.8% share.

Under the NACE classification, the main R&D centres are concentrated in 3220 (e.g. Motorola China Research and Development Institute, Ericsson China R&D Institute, Bell Labs Research China and Nokia R&D Center) and 3230 (e.g. Motorola China Research and Development Institute, Ericsson China R&D Institute and Nokia R&D Center). There are many MNCs' R&D centers in China's software industry (e.g. Microsoft Research Asia, Microsoft China R&D Group, 3M China Research & Development Center, Cisco China Research & Development Center, eBay China Development Center and EMC-Oracle China Technology Development Center).

FDI in China is mainly located in the Eastern coastal areas, such as Guangdong, Zhejiang and the Fujian Provinces. However, many FIEs locate only labour intensive activities in these areas. Most R&D centres of MNCs are located in advanced cities such as Beijing, Shanghai, Guangdong. Other important cities such as Tianjin and Xi-An have also attracted large amount of foreign R&D investment.

At the early stage of foreign R&D Centres location in China, their main activities included offering services for the local market, conducting applied research, and developing new adaptive technology. In recent years, the focus of foreign R&D centres has gradually shifted to striking a balance between local market demand and global strategy. According to Monika (2007), the reasons why high-tech companies envisage pushing R&D activities in China include the access to human resources, the proximity to customers/markets, and to benefit from China's R&D environment. The most important parameter that affects MNCs' R&D investment in China is to acquire high quality human resources, followed by the level of Chinese economy development, the market scale and opportunities, and science and education development. China is emerging as one of the most important sources of R&D personnel.

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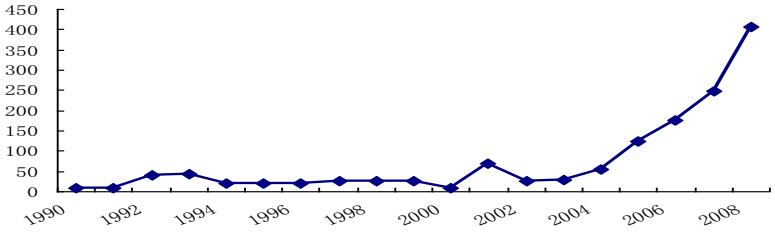
foreign equity joint ventures ("EJV"), Sino-foreign co-operative joint ventures ("CJV"), wholly foreign owned enterprises ("WFOE") and foreign investment companies limited by shares ("FICLBS"). Source: CR, http://www.stats.gov.cn/tjzd/tjzbjs/t20020327_14299.htm).

[218] Presentation at the IPTS conference "Asian rise in ICT R&D – Looking for evidence: Debating collaboration strategies, threats and opportunities", op. cit.

3.2.2 Asian R&D offshoring

China is also rapidly becoming an important source of outward foreign direct investment (OFDI). Starting from an absence of OFDI in 1979, the initial year of China's open door policy, China has accumulated over US$ 117.91 billion of OFDI till the end of 2007 (ECCOM, 2009). China's OFDI flow and stock now stands as the 4th and 6th largest, respectively, among developing countries, but its OFDI stock accounts for only 0.6% of global OFDI (OECD, 2006). Even in the context of the international financial crisis, China's OFDI showed an extremely rapid growth trend with 63.6% growth rate in 2008 compared with 2007, while global FDI fell by around 20%. However, compared to the large FDI inflow into China (2007: US$ 74.77 billion), China's OFDI is on a smaller scale and has little experience due to its short history; it is still in the early stages.

Graph 3.1: China's non-financial OFDI flows for (1990-2008, US$ 100 million)



Source: Data 1990-2001 comes from UNCTAD's World Investment Report, data 2002-2007 comes from NBSa (2003, 2008), data 2008 comes from China's national economic and social development statistical Bulletin 2008 (NBSe, 2008).

The direct investment of Chinese companies is split between three groups of locations. The first one is industrialized economies, especially the US: it accounted for 2.1% of total Chinese OFDI stock. The second destination is the newly industrialized economies and other transition economies, including Hong Kong and Macao. Along with overseas investments in Russia and Middle Asia, it accounted for more than 70% of the total OFDI. The third destination is developing countries, especially South Asian economies (Vietnam, Cambodia, and Laos) and African countries. China has become a leading source of FDI in Africa (ECCOM, 2009).

A study of large Chinese MNCs found that they operated 77 R&D units at the end of 2004, including a surprisingly high 37 units abroad (UNCTAD, 2005). Von Zedtwitz (2005) found that Chinese firms account for about half of all international R&D sites owned by another developing nation, but most of these R&D units are quite small in size, with a few exceptions such as Huawei and Haier. China's R&D globalization has already reached a level comparable to some smaller but more advanced European countries.

Box 3.2: China's R&D offshoring – the Huawei Case[219]

Huawei has more than 80 000 employees world-wide. At Huawei, 35% of all employees work in R&D. Huawei is committed to investing 10% of their sales revenue in R&D every year and has 12 R&D centres globally. It was the first Chinese company to set up an R&D centre in Bangalore in 2000, earmarking over US$ 100 million for the Indian R&D site,[220] which it expects to serve the Indian subcontinent, the Middle East, and Africa as strategic markets. Huawei also operates joint ventures with Siemens, 3C, Qualcomm and Microsoft to position itself favourably in the upcoming next-generation mobile communication technology. By the end of 2007, Huawei has filed 26 880 patent applications, the number of core UMTS 3G patent applications saw Huawei ranked among the world's top five.
Source: CR based on iSuppli, 2008; Maximilian von Zedtwitz, 2005. See: http://www.huawei.com/research_and_development.do).

Box 3.3: China's R&D offshoring – the ZTE case[221]

ZTE has around 48 000 employees world-wide. At ZTE, 48% of all employees work in R&D. ZTE committed to invest 10% of its sales revenue in R&D every year. By the end of 2007, ZTE had applied for over 12 000 patents world-wide and most are core patents for CMMB, 3G, NGN, WiMAX and optical equipment. ZTE established its first three foreign R&D centres in the US and Chile in 1998, and founded R&D labs in Korea and Sweden since. ZTE has set up a technology development centre to co-ordinate 16 R&D institutes in China and abroad.
iSource: CR based on iSuppli, 2008; Maximilian von Zedtwitz, 2005. See: http://www.zte.com.cn/cn/).

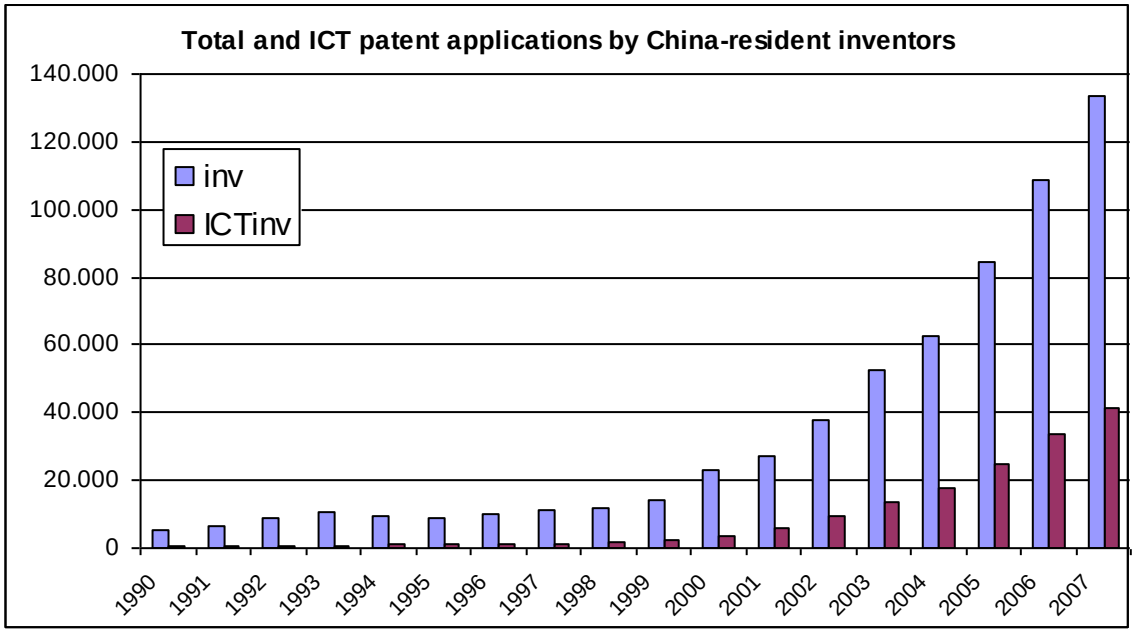
3.2.3 Output

Chinese indigenous innovation capabilities are increasing as China is turning into one of the most prolific countries in terms of applications for, and grants of, domestic resident invention patent.[222] In 2007, the number of patent applications by China-resident inventors was 40 804 for ICT manufacturing (from 610 in 1990, 3 467 in 2000) (Predict 2011), while the total national number of patent applications was 693 917. "*The number of applications filed doubled year on year from 2002 to 2006. However, ICT patents play a bigger role in China than in other countries, topping 57% in 2006, which exceeds both the average level of EU27 and of the world.*[223]"

This is in line with the IPTS report 'The 2011 report on R&D in ICT in the European Union', (2011), shows how China made an impressive entrance in ICT patenting activity.[224] China's inventive output increased massively starting in 2000 and overtaking both the EU and US output by the mid-2000s. Figure 3.11 clearly illustrates this massive growth.[225]

[219] See case study in Section 3.4 of this report.
[220] For India ICT R&D, see Chapter 2 of this report.
[221] See case study in Chapter 4 of this report.
[222] Unesco, p. 391.
[223] ECC, p. 25.
[224] See 'The 2011 report on R&D in ICT in the European Union', Chapter 5: Performance of ICT R&D – ICT patenting, at 5.2.2.
[225] As explained in the above report (Annex 5 – Methodology for patent data): the indicators proposed are intended to provide the best measure of the inventive capability of countries, rather than of the productivity of patent offices. To achieve this objective, patent applications are taken into account, rather than granted patents. The figure can vary according to the methodology adopted.

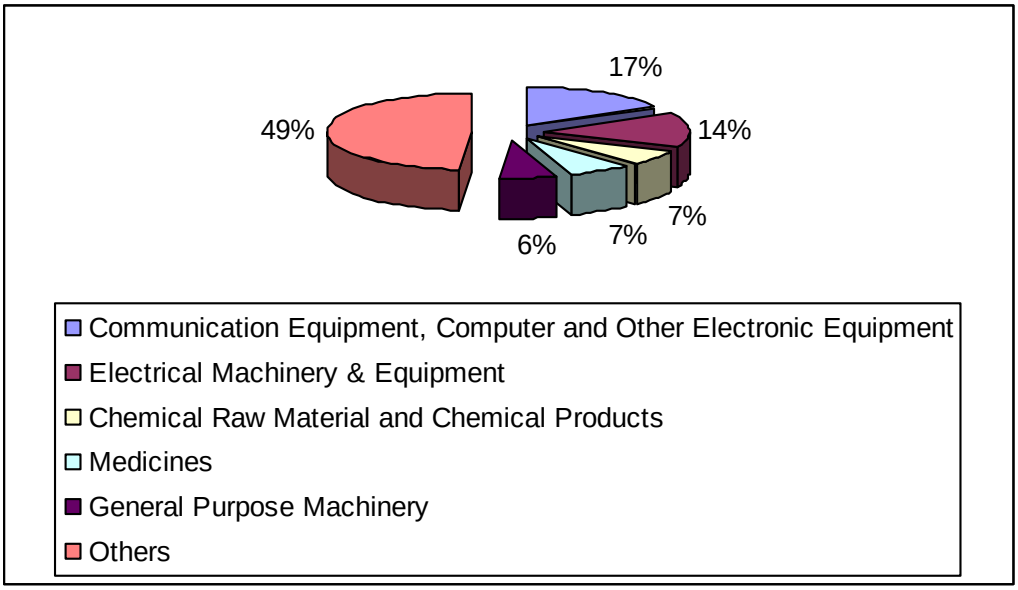
Figure 3.11: Total and ICT patent application by China-resident inventors



Source: JRC-IPTS calculations based on PATSTAT data (April 2010 release). Priority patent applications to the EPO, the 27 Member States' National Patent Offices, the USPTO, the JPO, and 29 further Patent Offices. Inventor criterion.

According to Figure 3.12, the ICT sector was responsible for 17% of inventive patents owned by the industrial sector in 2006, the largest proportion amongst the industrial sectors,[226] however a slightly lower proportion than the R&D expenditures.

Figure 3.12: Inventive patents owned by the industrial sector in China (2006) [227]



[226] For the EU and US see 'The 2010 report on R&D in ICT in the European Union', Chapter 6, "patents".

[227] Source: http://www.stats.gov.cn/tjsj/ndsj/2007/indexch.htm
Enterprises for Manufacture of communication equipment, computers and other electronics equipment.

Nevertheless, the efficiency of the researchers appears to still be much lower than that of most developed countries according to the most recent Unesco report.[228]

These outputs and the growth of R&D expenditures are the results of the specific policies meant to encourage business investment in R&D and of the priority granted to the development of the ICT sector. This priority is maintained in the three main science and technology programmes and IT is identified as one of the five strategic areas of the "Outline of the Medium-and Long- Term Plan for National Science and Technology Development" (2006-2020) with a significant allocation (23.8% of the total: € 1.22 billion).[229] "*In mid-February 2009, China adopted a plan for supporting the electronics and ICT sector for the next three years. The plan is devoted, on the one hand, to deploying 3G mobile networks and a digital TV network and, on the other, to increasing the country's IT services skills (e.g. outsourcing). Electronics and IT firms are being encouraged to "go outside the country" and build R&D centres, production bases and sales networks abroad. Their export taxes will be reimbursed*".[230]

The policies were implemented through various tools: "*(…) preferential taxation, high-technology industrial zones, assimilation of foreign technology and diversified funding support in S&T*",[231] "*talent development*".[232]

3.3 The major ICT players

Table 12 lists the top 20 ICT firms operating in China according to the revenues from their core business.[233] The total revenue and employment of the top 20 China ICT firms accounts for €139.4 billion and 1.2 million employees in 2006. It shows that the top 20 ICT firms in China originate from 7 countries and regions: Taiwan (7 out of 20), China (6 out of 20), the United States (4), Finland (1: Nokia, rating 6 in terms of revenues), Korea and Japan.

Table 3.3: Top 20 ICT firms in China (2006, ranked by revenues from principal business)

Rank	Company	Revenue (Bn Euros)	Employment (Heads)	Export (Mn US$)	Import (Mn US$)	R&D (Mn Euros)	R&D Employment (Heads)	Location of Headquarter	Nationality[c]	Registration Status[d]	Subsector/main products
1	China Mobile Communications Corporation	29.42	138,368[a]				2500[e]	Beijing	China	State holding	Telecom
2	China Telecom Corporation Ltd.	17.49	243,072				1300	Beijing	China	State holding	Telecom
3	Hongfujin Precision Industry (Shenzhen) Co., Ltd.	15.64	131,864					Shenzhen, Guangdong	Taiwan	Solely owned	Computer peripheral equipment
4	China Unicom Ltd.	9.62	463,000[a]					Beijing	China	State holding	Telecom
5	Motorola (China) Electronics Ltd.	8.50[a]	16,987[a]	2601	6236			Tianjin	USA	Solely owned	Mobile phones, walkie-talkie, wireless communication equipment

[228] On p. 392.
[229] For a summary of the three major programmes see Unesco, pp. 386-7.
[230] AMC, p. 34.
[231] ECC, p. 33.
[232] ECC, p. 35.
[233] Revenue from core business refers to operating income achieved from major production and business activities for enterprises (group).

Rank	Company	Revenue (Bn Euros)	Employment (Heads)	Export (Mn US$)	Import (Mn US$)	R&D (Mn Euros)	R&D Employment (Heads)	Location of Headquarter	Nationality[c]	Registration Status[d]	Subsector/main products
6	Nokia (China) Investment Co., Ltd.	7.79	3,496	2638	5973			Beijing	Finland	Solely owned	Mobile phones, digital program-controlled switchboards
7	Huawei Technology Co., Ltd.	6.56	35,673	1219	2953	711		Shenzhen, Guangdong	China	Private owned	Program-controlled switchboards, software
8	Fu Tai Hong Precision Industry Co., Ltd.	5.24	60,834	4684	4733			Shenzhen, Guangdong	Taiwan	Solely owned	Mobile handset accessories
9	Inventec Technology Co., Ltd.	4.60	10,221	1853	5745			Shanghai	Taiwan	Solely owned	Notebooks, enterprise servers, storage products, wireless communications, network applications, consumer mobile devices, & wireless solutions
10	Hisense Group Co., Ltd.	4.34	12,924					Qingdao, Shandong	China	State holding	Colour TV, cell phone
11	Shanghai Dafeng Computer Co., Ltd.	3.81	6,948	5934	13603			Shanghai	Taiwan	Solely owned	Notebook computers, servers, mobile phones, LCD monitors, LCD TVs & other IT products.
12	Shanghai Dagong Computer Co., Ltd.	3.79	7,515					Shanghai	Taiwan	Solely owned	Computer and notebooks
13	Lenovo Information Products (Shenzhen) Co., Ltd.[b]	3.50	4,563	0	3916			Shenzhen, Guangdong	USA	Solely owned	Commercial desktop computers, multimedia computers, notebook computers
14	Shanghai Daye Computer Co., Ltd.	2.80	5,084					Shanghai	Taiwan	Solely owned	GSM mobile phone & accessories; micro-computer & accessories
15	Lenovo (Beijing) Co., Ltd.[b]	2.78	4,130					Beijing	USA	Solely owned	Electronic computer & components, computer peripherals, software, information systems & networking products, electronic information productions.
16	Flextronics Industrial (Zhuhai) Co., Ltd.	2.77	11,040	2653	3376			Zhuhai, Guangdong	USA	Solely owned	PCBA(PCBA= Printed Circuit Board +Assembly)
17	Panda Electronics Co., Ltd.	2.74	11,629					Nanjing, Jiangsu	China	State holding	Wireless base stations, program-controlled

Rank	Company	Revenue (Bn Euros)	Employment (Heads)	Export (Mn US$)	Import (Mn US$)	R&D (Mn Euros)	R&D Employment (Heads)	Location of Headquarter	Nationality[c]	Registration Status[d]	Subsector/main products
											switches, colour TV, cell phone
18	Qun Kang Science and Technology (Shenzhen) Co., Ltd.	2.73	16,020	2584	3103			Shenzhen, Guangdong	Taiwan	Solely owned	Display production, electronic components, semiconductors & components , product-specific materials
19	Beijing Sony Ericsson Putian Mobile Communications Co., Ltd.	2.69	10,444					Beijing	Sweden/ Japan	Joint venture	Mobile
20	LG Philip LCD (Nanjing) Co., Ltd.	2.60	6,056	2092	1006			Nanjing, Jiangsu	Korea	Solely owned	LCD Monitor
Sum	-	139.41	1,199,868								

Source: *Yearbook of China's large industrial enterprises 2007* (NBSf, 2007); Data for China Mobile Communications Corporation from www.chinamobileltd.com; Data for China Telecom Corporation Ltd. from www.chinatelecom-h.com; Data for China Unicom Ltd. from www.chinaunicom.com.hk. Data on the location of headquarters, nationality and registered status from *Searching System of the General Book of the Registration data of the Nationwide Foreign Invested Enterprise (*Registration Bureau of Foreign-Invested Enterprises of State Administration for Industry and Commerce, 2005.[234]

Seven firms are controlled by Taiwan. However, the respective shares of Taiwan for revenues and employments are 27.7% and 20%, much lower than its share in the top 20 firms. These firms funded by Taiwan are in ICT manufacturing. They import ICT components and parts from Taiwan, Korea and Japan, process and assemble them in China, and finally export the final products to developed American and European markets. They bring huger trade flows but smaller employments to China.

The United States firms own a much higher share in total revenues and employments than their European and East Asian competitors. Their share the total number of firms, revenues and employments are 20%, 12.6% and 3.1%, respectively. As a whole, American firms ranked 3rd in China's Top 20 ICT firms. American ICT firms in China have a higher productivity than firms from other nationality with the exception of Finland. In 2006, they ranked 2nd in the top 20 firms, which is lower than that of Finland firms, but higher than Japanese firms, and much higher than Taiwanese firms or than Chinese firms.

[234] a. Data on revenue and employment of China Mobile Communications Corporation and China Unicom Ltd. for 2008, Data on Motorola (China) Electronics Ltd. for 2007.
b. Both Lenovo Information Products (Shenzhen) Co., Ltd. and Lenovo (Beijing) Co., Ltd. belong to Lenovo Group. According the origins of registered capital, Lenovo Group is classified as an American firm.
c. Firms' nationalities are attributed on the basis of the nationality of the controlling owner of its registered capital.
d. State-owned enterprises (SOEs) are non-incorporation economic units which are funded completely by the State who owns all assets. State-funded corporations (SFCs) are mainly funded by the State as the controlling owner of all assets. State-owned joint-operation enterprises are funded partly by the State who is rather ordinary owner than controlling owner. Enterprises with funds from Hong Kong, Macao and Taiwan refer to all enterprises with funds from Hong Kong, Macao and Taiwan. Foreign Funded Enterprises (FIEs) refer to all industrial enterprises with foreign funds. The latter two subcategories must be registered as the joint-venture, cooperative, sole (exclusive) investment enterprises and limited liability corporations.
e. It means the number of employees in China Mobile Group Design Institute Co., Ltd in 2008. See http://www.cmdi.chinamobile.com.

Box 3.4: American firms in China's Top 20 ICT firms

Motorola (China) Electronics Ltd. ranked 5th with a revenue of €8.5 billion in 2007. Set up in 1987 by Global Fortune 500 Motorola, a global communications leader, Motorola (China) Electronics Ltd. mainly produces pagers, cell phones, walkie-talkie, wireless communications equipment, semiconductors, automotive electronics and other products. In China's hand-held mobile phone market, Motorola had occupied the 1st position around 2001, but currently fell to the 2nd position with its status being challenged by Korean Samsung. The first position has been taken by Nokia Co, Ltd.

Lenovo Information Products (Shenzhen) Co., Ltd. ranked 13th with revenues of €3.5 billion. **Lenovo (Beijing) Co., Ltd**. is ranked 15th with €2.78 billion revenue. Lenovo has had substantial share in China's notebook PC market which has surpassed HP and Dell.

Annex Table PC Market Share in China by Unit Shipments (Thousands)

Rank	Company	2007	2008	Year-to-year growth (%)	2008 market share (%)
1	Hewlett-Packard	49571	55966	12.9	18.7
2	Dell	39493	43262	9.5	14.4
3	Acer	20140	31807	57.9	10.6
4	Lenovo	20108	21790	8.4	7.3
5	Toshiba	11140	13604	22.1	4.5
	All others	127920	133002	4.0	44.4
	All	268371	299430	11.6	100.0

Source:iSuppli (2008)

Firms from Finland and Sweden contribute to 6.6% of the total revenues and to 0.7% of the total employment. The secret hiding in the asymmetry between these two ratios is the rather high productivity of European ICT firms.[235] European firms in China's ICT industry also bring giant trade flows to China. In 2006, Nokia (China) Investment Co. Ltd. exported for US$ 2 638 million and imported for US$ 5 973 million.

Box 3.5: European firms in China's Top 20 ICT firms

Nokia (China) Communication Co., Ltd. ranks 6th in the top 20 firms with principal business revenue of €7.79 billion. Its main products include a variety of mobile phones and the system base station. The company is invested by Nokia, the world's leading mobile phone supplier and a leading supplier of mobile and fixed telecom networks including related customer services. Nokia (China) has become the largest mobile phone manufacturer in China. In 2008, Nokia accounted for 31.27% in China's mobile phone market (iSuppli, 2008).

Beijing Sony Ericsson Putian Mobile Communications Co., Ltd. is ranked 19th with €2.69 billion revenue from principal business. As a leading manufacturing and supply centre of Sony Ericsson Global, BMC focuses on industrializing, manufacturing and distributing the most competitive mobile phones, and providing after sales service to Sony Ericsson customers worldwide. In 2007, it stood the 4th or 5th position with LG in China's mobile phone market (iSuppli, China's mobile phone market will continue to grow: http://www.enfodesk.com/minisite/mainad/index_info.php?menu=search_enfodesk_detail&info_id=82994&key_id=).

[235] The main revenue per capita of Finland's Nokia (China) Investment Co. Ltd. is €2 228 thousand.

Annex Table: Mobile phone market share for different brands (%)

Mobile phone brand	2007	2008 January-June
Nokia	32.7	31.2
Motorola	15.5	15
Samsung	10.5	9.5
Sony-Ericson	6.6	5.7
Lenovo	4	4.3
Philips	2.1	2.9
Dopod	1.2	2.5
LG	1.9	2.3
CECT	2.4	1.9
Haier	1	1.7
Others	22.1	23.1

Source: Data Centre of China Internet (DCCI), 2008.

Although on a larger, most Chinese ICT firms have a much weaker competitive power than the foreign-funded ICT firms. The main revenue per capita in Chinese ICT firms is €78 thousand in 2006. However, some Chinese ICT firms, such as Huawei Technology Co., are accumulating and increasing technological advantage over its overseas competitors and becoming the most important provider in some ICT products for the world market.

3.3.1 Telecommunications services

By 2010 the total number of subscribers (fixed, mobile and Internet: Internet users increased 16 times over 8 years reaching 384 million in 2010: 29% penetration[236]) exceeded 1.14 billion: China ranks on "top of the world". China is the world's largest mobile market and hit 853 million subscribers in January 2011 and 900 million in April 2011.[237] However, telecom revenues are, just like in more mature western markets, suffering from a fast decrease. The compound growth rate from 1998 to 2008 reached 17.2% (see Box 4) but plummeted to 3.9% after. The ratio revenue to GDP after reaching an historical peak of 3.5% in 2002 was of 2.7% in 2008 because of fast declining tariffs (fell by 58% between 2003 and 2008). However, mobile operators are still adding over 8 million subscribers each month.

China is already achieving another world record for the deployment of mobile 3G networks making 3G service available in one year. The customer's base reached 15 million in 2009 but is expected to rise to 50-60 million over 2010.[238] China aimed to have 150 million 3G mobile users by 2011.[239] China Unicom is now adding more 3G customers than 2G customers.[240] The key success factors are new contents (mostly music)[241] and applications, proper tariff and new devices such as data cards, network laptop and smartphones.

[236] A 29% increase over 2009. Source: China Internet Network Information Center (CNNIC), 346 million broadband users and 233 mobile internet users.

[237] MIIT, "Operation of China's Telecommunication industry", 24 May, 2011, see http://www.miit.gov.cn/n11293472/n11293832/n11293907/n11368223/13767994.html

[238] Source: Chen Jinqio, MIIT Statistics. GSMA Mobile Briefing 26 November 2010 reported 38.64 3G users by the end of October (China Mobile 16.98, China Unicom 11.66). EITO Special Report (2011) gives almost 84 million for 2011, China pp.24-29.

[239] According to a Xinhua report quoted by Mobile Business Briefing 26 November 2010.

[240] GSMA Mobile Business Briefing, 20 October 2010.

[241] € 3.58 billion for mobile phone content, the largest segment of China's digital publishing industry. See footnote 284.

The first cable systems in China were the Industrial Community Television or "factory zone TV" within a factory zone (or Dan Wei in Chinese), which was the basic unit of local community during the period of planned economy.[242] In 1991, local governments and the state-owned factories were allowed to invest in the building of cable networks. Those local-government owned networks were regulated by the local Ministry of Broadcasting, Radio and Film branches, which also started to build their own citywide cable network. However, no private companies were allowed to invest in the Chinese cable infrastructure. Since 1999 several attempts were made to modernize and change the structure of the market but with mixed results.

By the end of 2005, China still had some 1 200 cable operators. The State Administration Radio, Film and Television (SARFT) planned to hook up 30 million digital TV subscribers by 2005 and to complete the coverage by 2010. However, after nearly 10 years, less than 35% of cable subscribers were digital by the end of 2009,[243] So far, the household cable penetration had reached 44% nationwide (end of 2009).

The Chinese administration is now encouraging more convergence between telecom and cable (so called "three networks convergence") to stimulate the broadband market with new channels. It is regarded as one of China's strategic policies in response to the global financial crisis (State Council, 2010). If cable companies once authorised can make inroads into the telecom market, it remains to be seen whether the specificity of TV regulation and control in China may hinder this development of converged services altogether. As stated by Chun Liu: "*the Chinese government continues to leave telecommunications and cable to different regulators mainly due to the ideological concern. However, without a major institutional change, the convergence plan is unlikely to succeed*".[244] An opinion shared by another Chinese researcher, He Ning: "*A central point in this paper is that Chinese regulatory practice may need a drastic overhaul in order to be able to accept convergence*".[245] The regulatory bodies (MIIT,[246] SAFRT) remain separated.

[242] This section is based on Chun Liu, "Mapping the future of China's telecommunications regulatory regime: a layered perspective", paper presented at the 38th TPRC 2010, Washington, 3-5 October and at CPR South Fifth, Xi An, 6-8 December, 2010.

[243] See SARFT's statistics, available at: http://gdtj.chinasarft.gov.cn/showtiaomu.aspx?id=8db2a88e-5fd7-447f-8f9f-0f1aedfa6000.

[244] Id.

[245] He Ning, School of Economics and Management, Xi'an University of Posts and Telecommunications, "Current and future regulation challenges for the Chinese Telecommunications sector", paper presented at the CPR South Fifth, Xi An, 6-8 December, 2010.

[246] MIIT was established in March 2008 by merging the previous MII, the Commission of Science Technology and Industry for National Defence of the People's Republic of China (COSTIND), the State Council Office of Developing Information Society, and some offices of PRC National Development and Reform Commission (NDRC). The MIIT became the leading player/ regulator when the market structure was reorganised and the market split between three national wide carriers: China Mobile, China Telecom and China Unicom.

Box 3.6: The telecommunications and internet markets: historical background

Telecommunications networks in China are still recent.

There were very few phone lines in the country for a long time: only 3 million at the start of the 1980s and 12 million in 1990, or one line for every 100 inhabitants. It was not until the late 1990s that the telecommunications networks began to expand, and the figures are spectacular:

- 368 million fixed phone lines in 2006, or 28 lines per 100 habitants (the majority of households are connected). The fixed network has (already!) shrunk since then, with more and more subscribers switching from their fixed line to mobile solutions that are deemed more attractive. There is competition on mobile networks but not on the fixed network.
- 900 million mobile subscribers as of Q1 2011. The number of mobile subscribers has been growing exponentially at a rate of around 17% a year since 2005.
- 384 million Internet users, including 233 million mobile Internet users, according to the China Internet Network Information Center (CNNIC).

Internet services

The Internet leaders from the West (Google, Yahoo, Microsoft Live Messenger, eBay, etc.) are largely dominated by home-grown players in China:

- close to three quarters of searches are performed through the Baidu portal;
- virtually all Internet users chat using QQ.com;
- the Taobao portal accounts for virtually all online sales;
- the Sina news portal and social network is very popular, outdoing its Chinese counterparts.

The e-commerce market (B2C and C2C) more than doubled in 2008, reaching close to €13 billion. Also worth noting is the youth of China's Internet users: 70% of the country's 298 million Web users are under 30. E-commerce is thus likely to grow as users enter into the workforce and earn more money.

Customer-to-customer, or C2C sales account for the vast majority of transactions (92% of the market or close to € 12 billion). A subsidiary of the Alibaba group, the Taobao online auction site ("find something precious") is by far China's leading online sales site, reporting a turnover of 99.96 billion RMB in 2008 (over € 11 billion, or around 90% of the market).

Most payments are paid for COD (cash on delivery), although direct payments made online increased from €1 billion in 2004 to close to €28 billion in 2007. Online games generated revenue of €2.92 billion in 2009,[247] marking an annual increase of more than 50%.

Sources: Arcep report p.12, 62, CNNIC, GAPP.

[247] "*China's digital publishing industry brought in revenues of ¥ 79.9 billion (€ 9.13 billion) by the end of 2009, up 50% from the previous year, exceeding that from traditional publishing for the first time, according to the General Administration of Press and Publication (GAPP)*", "Digital learning market to grow", *China Daily*, Monday, 13 December, 2010. The revenues are split as follows, for 2009 in billion Yuan: on-line newspapers 0.91, electronic books 1.4, online advertising 20.61, on line gaming 25.62, mobile phone content 31.4. Source: General Administration of Press and Publication.

Box 3.7: Internet companies: moving to the top

Tencent, Baidu and Alibaba.com now rank 4th, 6th, and 12th among the Top Global 15 Publicly-Traded Internet Companies by Market Value – 2010. These companies were not even listed in 2004 as Alibaba, Baidu went public post 2004.

Tencent

Founded in 1998. Momentum continued as revenue rose 55% Y/Y, driven by IVAS (Internet Value Added Services) growth of +57% Y/Y (now ~79% of total sales) and MVAS (Mobile Value Added Services) growth of +56% Y/Y (13% of sales). Market value of US$ 41 billion and revenues of US$ 1 822 million in 2010.

Online game sales supplied the majority of IVAS growth (+67% Y/Y to 49% of total sales) as titles such as CrossFire and QQ Speed reached record usage levels (measured by concurrent users). Tencent blends in a unique fashion revenues from social networking, virtual goods (it accounts for 29% of the market shares of the top 10 companies by virtual goods revenues[248]), 2D and 3D worlds/ gaming venues. The firm derived $1.4B of virtual goods revenue (from users customizing their avatars / purchasing game items…) in 2009. As the largest social network in China with 637 million active IM users, it outgrew Facebook (620 million visitors) in 2010.

Online ad revenue maintained healthy growth (+30% Y/Y) and continued to expand its advertiser base following the momentum gained during the World Cup in June and July.

Base of 198 million average monthly unique users.

Baidu

Paid search revenue growth accelerated to 76% Y/Y, as online advertising customers increased 26% Y/Y (to 272K, <1% of total SMEs in China, leaving room for ample upside) and advertiser ARPU rose 41% Y/Y as large corporate customers continued to increase their online marketing spend. Market value of US$ 39 billion and revenues of US$ 641 million in 2010.

Operating margin (56%) improved 2ppts Q/Q and 12ppts Y/Y, owing to pricing power vs. search advertising competitors and fixed-cost leverage over bandwidth and infrastructure costs.

Base of 185 million average monthly unique users.

Alibaba.com

Revenue growth remained strong at 40% Y/Y as international sales (outside China) grew 33% Y/Y (58% of total) and paying member growth continued (30% Y/Y to ~751K). Market value of US$ 10 billion and revenues of US$ 568 million in 2010.

Value-added services (such as keyword bidding, premium placement, and online translations) contributed 25%+ of China Gold Supplier sales and 20%+ of TrustPass revenue, up from mid-teens a year ago, and continue to improve the value proposition for suppliers.[249]

Base of 42 million average monthly unique users.

Source: Morgan Stanley, Ten Questions Internet Execs Should Ask & Answer, 16 November, 2010 presentation at the Web 2.0 Summit – San Francisco, CA., USA.

[248] Source, In-Stat, Virtual Goods in Social Networking and Online Gaming, November 2010 at 15, 21. The top ten companies accounted for 73% of 2010 virtual goods revenues. According to PricewaterhouseCoopers, (2011), the Chinese entertainment and media was one of the fasted developing markets globally with a 13.9% growth in 2010 and the growth will continue. China is now the second largest video games market in Asia, overtaking South Korea and the third largest behind Japan and the United States.

[249] The group is reported to be planning to develop its own mobile operating system, in order to drive mobile use of its various services. Mobile Business Briefing, 4 July 2011.

3.4 Case studies[250]

3.4.1. Huawei

"*Huawei is currently the world's third largest mobile equipment manufacturer, behind Ericsson and Nokia Siemens Networks. In the IP access market, Huawei is the leading producer of DSLAM equipment by shipment, with 30% of the global market, and is ranked second in the number of optical fibre connections (GPON). Its earnings exceeded 18 billion US$ (around € 13 billion) in 2008, after enjoying a year of very strong growth (+43% compared to 2007), notably in the Asia-Pacific region and in South America where its sales close to doubled.*"[251]

Huawei Technologies was initially established in 1988 in Shenzhen as the sales agent for a Hong Kong company producing Private Branch Exchange (PBX) switches. In 1990, the company embarked on research of PBX and then moved into areas such as rural digital switching, GSM-based solutions, and other telecommunication solutions. Now Huawei's products and solutions include wireless products, core network products, applications, software and terminals. Its products and solutions are deployed in over 100 countries and serve 36 of the world's top 50 operators. Major products are designed based on its own ASIC chipset with shared platforms. In June 2008, Huawei had over 87 502 employees, of whom 43% were dedicated to R&D.

Over a long period of time; Huawei has been investing a minimum of 10% of its annual revenue into R&D. As stated by the Arcep report: "*Huawei touts its research and development activities as the heart of its strategy*".[252] Huawei's global R&D centres (more than 14 R&D centres have been created: seven are outside of China) are located in Silicon Valley and Dallas in US, Stockholm in Sweden, Moscow in Russia and Bangalore in India (established in 1999, the largest foreign centre, employing a staff of 1 200 Indian developers[253]) in addition to those in Beijing, Shanghai, Nanjing, Shenzhen, Hangzhou and Chengdu in China.

"*In 2008, Huawei registered 1 737 patents with the World International Property Organisation (WIPO), and so topping the ranks among the countries that use the Patent Cooperation Treaty (PCT) to protect their innovations internationally*".[254] By the end of that year, the company had filed 35 773 patent applications, which accounted for 10% of the world's LTE essential patents (ranking among the top three in the world). In 4G technology development, Huawei is leading in the industry.

3.4.2. ZTE

The ZTE Corporation was founded in Shenzhen in 1985 as Zhongxing Semiconductor. Since then ZTE has developed a multi-product R&D strategy, covering wireless switching, transmission, access, videoconferencing and power supply systems in 1996. The company is the provider of products and services to 140 countries and regions. "*Operating initially in China and less advanced countries (e.g. Ethiopia),[255] ZTE is now forging itself a position in*

[250] This section is largely based on data from CR as well as AMC, Chapter 3 "Equipment manufacturers".
[251] Source: Informa. AMC at 50.
[252] AMC, p. 50.
[253] AMC, p. 50.
[254] AMC, p. 50.
[255] ZTE owns 51% of Congo China Telecom, the fourth largest operator in the Democratic Republic of Congo. Source: Mobile Business Briefing, 18 July 2011.

Western markets, in both the infrastructure and handset sectors".[256] In 2010, its fastest-growing market last year was Europe where year-on-year volume sales grew by 150%.[257] ZTE's goal is to become one of the top three handset vendors globally within the next five years, stating last year that it aims to enter the top five vendors within the shorter timeframe of three years.[258] The company is the leading 3G handset vendor in China.

ZTE has about 50 000 employees of which 8 000 are working in about 100 representative offices around the world. The telecommunications products offered by ZTE include wireless, switching, access, optical transmission, data, handsets and telecommunications software.

In 2008,[259] ZTE Corporation achieved € 4.7 billion in annual revenues, showing a 27% increase over the year before, and € 175.2 million in net profit. International sales amounted to US$ 3.9 billion (€ 2.8 billion), accounting for nearly 61% of all the revenues. In terms of ZTE's overall sales revenues, 65.4% came from infrastructure, 21.9% from handsets and 12.7% from software, services and other products. ZTE is listed on both the Hong Kong Stock Exchange and Shenzhen Stock Exchange. As of 31 December 2008, the top shareholders were state-owned Zhongxingxin with 35.52% and foreign-owned HKSCC Nominees Limited with 16.66%.

With more than 33% of the workforce dedicated to R&D and with 10% of its annual revenues channelled into this field, ZTE has established 15 R&D centres and institutes across North America, Europe and Asia. By the end of 2007, ZTE had applied for around 12 000 national or international patents.

3.4.3. Alcatel Shanghai Bell[260]

Since China's entry into the World Trade Organization in 2001, foreign investors have been allowed to control a stake in Chinese enterprises in proportions that vary depending on the type of business: 49% for telecommunications operators, 50% for value-added services and 100% for equipment manufacturers.

Alcatel Shanghai Bell is a joint venture between Alcatel-Lucent and the Chinese government. Alcatel-Lucent is the majority shareholder, controlling 50% plus one share. The way the joint venture is structured allows Alcatel Shanghai Bell to enjoy support from State organs for its development. Of the company's 10 000 employees, 4 000 are devoted R&D (the Alcatel-Lucent group employs a total staff of 77 000).

Alcatel Shanghai Bell generates annual earnings of €2.3 billion, making it China's number two equipment manufacturer in the domestic market. Exports account for 13% of its sales, a figure which is likely to increase in the coming years. South-East Asia is the company's largest export market.

3.4.4. Lenovo Group

Legend Holdings, founded in China in 1984, started marketing its products under the Lenovo brand in 2003. In 2005, Lenovo completed the acquisition of IBM's Personal Computing

[256] AMC, p. 52.
[257] GSMA Mobile Business Briefing, 5 January, 2011.
[258] Id.
[259] In 2010, ZTE generated CNY 38.07 billion (€ 4.35) in revenue outside of its home market, accounting for 54.2% of its total sales. Mobile Business Briefing, 18 March 2011.
[260] This section comes from AMC, p.54.

Division, making it the third-largest personal computer company in the world. The company has operations hubs in Beijing; Raleigh, North Carolina; Singapore; and Paris, a marketing hub in Bangalore, India, and major research centres in Yamato, Japan; Beijing, Shanghai and Shenzhen, China; and Raleigh, North Carolina. The company now employs more than 23 000 people worldwide, including 1 700 designers, scientists and engineers.

For the fiscal year 2007/08, Lenovo achieved sales of € 10.4 billion and pre-tax income of € 354 million. As figures from the fourth quarter show, overseas sales accounted for 66% of total sales. In terms of product category, Lenovo's Notebook computers were the largest contributor to total sales, accounting for 61% of total sales.

3.4.5 BYD Company[261]

BYD Company, established in 1995, is a high-tech private enterprise. BYD has nine production plants. The company has also set up branches and offices in America, Europe, Japan, South Korea, India, Taiwan, Hong Kong, as well as in other regions. The total number of employees stands at over 130 000. In 2008, BYD achieved a sales revenue of € 2.89 billion, representing year-on-year growth of 26%, and a net profit of € 110 million. The vehicle business increased rapidly in the last year, accounting for 32% of the total income, up from 9% in 2007.

The products can be split into two categories: IT industry (rechargeable batteries, chargers, micro-electronics and LED products) and auto industry. BYD has the top global market share of Nickel-batteries, Li-battery cell phones, and keypad manufacturing. In 2003, BYD entered into the auto business from the acquisition of Tsingchuan Automobile Company. The car manufacturing part of the company covers low to high-end fuel vehicles, dual-mode electric cars (plug-in hybrid) and all-electric cars. In 2008, BYD extended its upper industrial chains by the acquisition of Sino MOS Semiconductor. In December 2008, BYD launched its first dual-mode electric vehicle - these combine a pure-electric mode system with a hybrid drive system that incorporates a small gasoline engine.

In 2008, BYD allocated € 70.47 million to research and development, ranking it 17th out of the top 100 ICT companies in RTD expenditures. Up until now, the company has set up several research labs in China, such as BYD's Central Research lab, Electronics Research Institute, Auto Engineering Research Institute and Electric Power Research Institute.

3.4.6. China Mobile

China Mobile Limited (CML) was incorporated in Hong Kong on 3 September 1997, and listed on the New York Stock Exchange (NYSE) and The Stock Exchange of Hong Kong Limited (HKEx) in late October 1997, respectively. The Company's majority shareholder is China Mobile (Hong Kong) Group Limited, which, as of 31 December 2008, indirectly held an equity interest of approximately 74.25% of the Company through a wholly-owned subsidiary, China Mobile Hong Kong (BVI) Limited. The remaining equity interest of the Company was held by public investors.

As the leading mobile services provider in China, the Group boasts the world's largest mobile network and the world's largest mobile subscriber base (570 million in 2010[262]). In 2008, the Company was once again selected as one of the "FT Global 500" by *Financial Times* and

[261] This company is not listed in table 12 by CR as revenues are split between the two main activities.
[262] GSMA Mobile Business Briefing, 20 October 2010.

"The World's 2000 Biggest Public Companies" by *Forbes* magazine, and was recognized on the Dow Jones Sustainability Indexes (DJSI). The company reported this year a single-digit growth in revenue and profits, a sign of a maturing market.

CML operates a nationwide mobile telecommunications networks in all 31 provinces, autonomous regions and directly-administered municipalities in China, and in Hong Kong SAR through its thirty-two subsidiaries. As of 31 December 2008, the group had a total staff of 138 368, and enjoyed a market share of approximately 72.4% in China.

China Mobile Group Design Institute Co., Ltd.,[263] is the R&D entity with 2 500 employees (more than 75% achieved undergraduate education; more than 89% are professional and technical personnel with a number of China's well-known experts in information and communication industry). Its development history can be traced back to 1952 as a national survey and design unit. In recent years, it was named as *National Communications Industry Customer Satisfaction Enterprise* and *Advanced Communication Design Enterprises.*

Together with China Mobile, Nokia Siemens Network with their Chinese labs created one standard for the next mobile generation (TD-LTE: TD-SCDMA):[264] a standard reaching potentially 30% of the world market.[265] This acknowledges that China will become more important as a source of technology.

3.5 Conclusion

China's ICT industry is typically characterized as foreign-oriented. Over the past 30 years, China has become the largest country in the world in international trade of ICT products. In 2006, export of ICT sector[266] has reached to €325 billion. For the period 1997-2006, the annual average growth rate of export in ICT sector was 34.5%, higher than the 20.5% annual average growth rate of total import during the same period (but close to the 31.5% for ICT import). China's ICT sector has been playing an increasingly important role in international trade. The share of the ICT sector in total export and import has reached nearly 42% and 35% in 2006, respectively.[267]

In China's ICT manufacturing and software industry, foreign funded firms play a major role. Asian enterprises are dominant in the number of firms, revenues and trade flows, Foreign-funded firms from Europe and United States dominate the technology progress, R&D activities and productivity. Domestic firms contribute much to the total employment in the ICT industry. Most MNCs build their factories in China to benefit from cheap labour and other resources. Many domestic enterprises produce low value-added, low technology, non-brands, and labour-intensified ICT products for foreign companies because of the lack of core technology and competitiveness.

Since 2003, China has become the world's largest recipient of FDI, overtaking the US. Practically all global ICT industry leaders have begun to set up R&D centres in China. By

[263] http://www.cmdi.chinamobile.com/companyintro.aspx?ChannelId=1&ColumnId=1

[264] TD-SCDMA (3G) mobile technology has enormous potential in the largest mobile market in the world, with sales of over five million handsets a month. TD-SCDMA – China's chance, available at: www.palowireless.com/3g/docs/td-scdma-china.pdf

[265] According to Dr. Jörg Siewerth, Network Systems, presentation at the IPTS conference "Asian rise in ICT R&D". 7 000 employees (10% of Nokia Siemens Networks' global workforce) are working in China, for Nokia Siemens Networks, of whom 50% are involved in R&D.

[266] Including ICT manufacturing, telecommunications and 72 computer and related activities.

[267] NBSa, 2007; UNCTAD, 2008.

2004, China became the third most important offshore R&D location after the US and the United Kingdom, followed by India (sixth) and Singapore (ninth).[268] Much of the R&D offshoring to Asia is concentrated in the electronic industry, with China dominating R&D for hardware. As for non-equity forms of R&D internationalization ("offshore outsourcing"), China is now the third most important location behind the United States and the United Kingdom, ahead of Germany and France. Some experts predict that China will become a more attractive location for foreign R&D than even the United States (Dieter, 2008). China's R&D globalization has already reached a level comparable to some smaller but more advanced European countries but it is still at an early stage.

In the last two decades, the national strategy of building national champions has already yielded the creation of several ambitious companies. These companies pursue high value-added strategy, harbour long-term ambitions, and exhibit much higher R&D/sales ratios and higher patenting performance. Several Chinese electronics firms have become global players, including Huawei Technologies, Lenovo, and ZTE. Huawei and ZTE are now major players in the GSM, CDMA, optical and DSLAM equipment markets. Huawei Technologies has become a leading provider of telecommunications networks and increasingly challenges established competitors like Siemens, Cisco, and Alcatel. Lenovo has become a global leader in the PC market since it acquired the IBM Personal Computing; it is leading the PC industry in green computing by offering the most PC products that use post-consumer recycled materials.

However, these success stories may be misleading as very few Chinese corporations appear among the main R&D investors (there are scarcely a dozen Chinese corporations among the top 1 000 top R&D investors worldwide). Among these 1 000 top corporations, Chinese and Indian firms account for less than 1% of R&D expenditures (EU firms for 32%, North America for 40%).[269]

Though many Chinese ICT enterprises produce low value-added, low technology, non-brands, cheap, and labour-intensive ICT products for foreign companies and market with little R&D, there are some large enterprises with indigenous brands and advanced technology which conduct increasing R&D activities. Chinese indigenous innovation capability is increasing. Comparing with developed countries, the technical innovation ability of the Chinese ICT industry is still weak. Therefore, truly global R&D in Chinese companies is still a long way ahead. In spite of the growth of R&D expenditure, the level remains modest, much lower than in developed countries. As Ling Chen and Lan Xue sums up: "*China has a lot to learn from other developing countries in terms of creating an institutional environment favourable to technological innovations and industrial upgrading*".[270]

"*China is the most impressive "catch-up" economy in history*", to quote the *Financial Times*, columnist Martin Wolf.[271] However this impressive growth is based on some unbalance, according to the same article, which raises question about the sustainability of this production-oriented model. An issue already acknowledged by the Chinese government: "*In*

[268] UNCTAD, 2005.

[269] Source: Booz Global Innovation 1000. Quoted by Stéphane Grumbach, Senior Researcher, INRIA (China), presentation at the IPTS Conference "Asian rise in ICT R&D".

[270] Ling Chen, Lan Xue, "China's integrated circuit industry", China &World Economy, Vol.18, n°6, Nov-Dec. 2010.

[271] "*How China must change if it is to sustain its ascent*", Financial Times, Wednesday 22 September, 2010.

the case of China, there is a lack of balance, coordination and sustainability in economic development".[272]

3.6 References

Chen Jinqio, "China Telecom Sector Market and Regulation" available at: http://www.cprsouth.org/wp-content/uploads/2010

"China Cultural Industry Development Report 2010", an annual report by the Chinese Social Science Research Institute (CSSRI), a government think tank.

Chun Liu, "Mapping the future of China's telecommunications regulatory regime: a layered perspective" available at: http://www.cprsouth.org/wp-content/uploads/2010/12/Layered-Model-CPR_Chun-Liu.pdf

Curien N., Toledano J., "ARCEP Mission in China", French and English version, November 2009, p. 70. Available at: www.arcep.fr

Dieter E., "Can Chinese IT Firms Develop Innovative Capabilities within Global Knowledge Networks, East-West Center Working Papers, Economics Series, n°94, February 2008.

EITO Special Report, BRIC countries' ICT markets, 2007-2011, January 3, 2011.

Gassmann O., von Zedtwitz M., 1999, New Concepts and Trends in International R&D Organization. Research Policy, Vol. 28, 231-250.

He Ning, " Current and future regulation challenges for the Chinese Telecommunications sector", available at: http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1725129

International Monetary Fund (IMF), 2009, World economic outlook. IMF, USA

Infobank, 2008, Database Infobank, http://www.infobank.cn/

In-Stat, Virtual Goods in Social Networking and Online Gaming, November 2010.

iSuppli, 2008,China Communication Topical Report, Rising Star-ZTE and Huawei go international, Q3, iSuppli.

Ling W., Shiguo L., Trends in Public and Private Investments in ICT R&D in India, JRC-IPTS, Forthcoming, 2011.

Ling Chen, Lan Xue, "China's integrated circuit industry", China &World Economy, Vol.18, n°6, Nov-Dec 2010.

Ministry of Industry and Information Technology (MIIT), 30 years of statistical data of Electronic and information industry since reform and opening up , MIIT.

Ministry of Information Industry (MII), 2006, 2006 Yearbook of China Information Industry (MIT, (Communication Version), MII.

Ministry of Information Industry (MII), 2007, 2007 Yearbook of China Information Industry (Communication Version), MII.

Monica (2007), High Level International Business Symposium 'China and R&D Globalisation: Integration and Mutual Benefits' Beijing, 28 August 2007, http://www.oecd.org/dataoecd/59/15/39114368.pdf

[272] Premier Wen Jiabao at the "summer Davos" in Tianjin, quoted by M. Wolf.

National Bureau of Statistics of China and China's Ministry of Science and Technology (NBS & MST a), 2003-2007, Statistical Yearbook of China's High-tech Industries. China's Statistics Press.

National Bureau of Statistics of China and China's Ministry of Science and Technology (NBS & MST b), 2004-2006, China Statistical Yearbook on Science and Technology, China's Statistics Press.

National Bureau of Statistics of China and China's Ministry of Science and Technology (NBS & MST c), 2002, National Comprehensive Statistics on the R&D Census 2000, p4, China's Statistics Press.

National Bureau of Statistics of China (NBS a), 1998-2007, China Statistical Yearbook, 1998-2007, China's Statistics Press.

National Bureau of Statistics of China (NBS b), 2006, China's Economic Census 2004, China's Statistics Press.

National Bureau of Statistics of China (NBS c), 2006-2007, China Statistical Yearbook of the Tertiary Industry 2006-2007, China's Statistics Press.

National Bureau of Statistics of China (NBS d), 2008, Database Main Economic Indicators, IWEP purchased this database.

National Bureau of Statistics of China (NBS e), 2008, China's national economic and social development statistical Bulletin 2008, China's Statistics Press.

National Bureau of Statistics of China (NBS f), 2007, Yearbook of China's large-sized Industrial enterprises, China's Statistics Press.

National Bureau of Statistics of China (NBSg), 2006, China Yearbook of Enterprise Group, China's Statistics Press.

NBS Department of Statistical Design & Management, 2002, National Economic Industrial Classifications GB/T4754-2002, Department of Statistical Design & Management.

News Xinhua, 2009, brands in China's consuming electronic industry, http://news.xinhuanet.com/tech/2009-01/10/content_10634235.htm).

Organization for Economic Cooperation & Development (OECD), 2006, China will become world's second highest investor in R&D by end of 2006, finds OECD. http://www.oecd.org/document/26/0,2340,en_2649_201185_37770522_1_1_1_1,00.html (accessed 2 August, 2008).

OECD, 2008, CHINA'S OUTWARD FOREIGN DIRECT INVESTMENT, http://www.oecd.org/dataoecd/28/10/40283257.pdf

Pascall S., EU-China Cooperation of Information and Communication Technologies in RTD. Status and way ahead, DG INFSO, February 2010.

Simon J.P. (2011), "Asian rise in ICT R&D, Looking for evidence". Proceedings of the International Conference organized by JRC-IPTS, European Commission, on 16 – 17 February, 2011, Brussels. Presentations and proceedings: http://is.jrc.ec.europa.eu/pages/ISG/PREDICT/AsiaICT.html.

UN, 2008, United Nations Commodity Trade Statistics Database, http://comtrade. un. org/kb/article. aspx?id=10062.

TD-SCDMA – China's chance, available at: www.palowireless.com/3g/docs/td-scdma-china.pdf

Unesco Science Report 2010, see Mu Rongping, Chapter 18. China, pp. 379-399.

United Nations Conference on Trade and Development (UNCTAD), 2005, World Investment Report 2005(WIR05), http://www.unctad.org/en/docs/wir2005_en.pdf

United Nations Conference on Trade and Development (UNCTAD), 2008, World Investment Report 2008 (WIR08), http://www.unctad.org/en/docs/wir2008_en.pdf.

United Nations Conference on Trade and Development (UNCTAD), 2008. United Nations Commodity Trade Statistics Database, http://comtrade. un. org/kb/article. aspx?id=10062.

von Zedtwitz M. (2005), International R&D Strategies in Companies from Developing Countries – the Case of China, International R&D by Chinese Firms - UNCTAD and Ministry of Commerce (MOFCOM), 2009, available at: http://english.mofcom.gov.cn/aarticle/statistic/foreigninvestment/200607/20060702705397.html.

Zhongzhou Li (2006), China's Informatization Strategy and its Impact on Trade in ICT Goods and ICT Services, http://www.unctad.org/sections/wcmu/docs/c3em29p016_en.pdf.

4 Changing patterns in international trade and global value chain

4.1 The global production network and the case of Taiwan

Taiwan is not covered in this study, neither South Korea, however some aspects are worth noting about the Taiwanese case.[273] Taiwan shows an interesting shift from end-product manufacture (computers and related equipment) to component manufacture and now forms an ICT hub in the global value chain. The iPhone is a good example of this, and shows how Taiwan has become a facilitator for Chinese manufacturing (Figure 4). This model is very different from the vertically-integrated model to be found in South Korea and China.

Figure 4.1: The Global Innovation Network of Apple's iPhones and the Role of the Taiwanese ICT Firms

Components	Main Supplier
Display	Sharp, TMD
Touch Panel	Wintek, TPK

Components	Main Supplier
Baseband	Infineon
WCDMA PA	TriQuint
GSM/EDGE PA	Skyworks
Application Processor	Samsung
Mobile DDR DRAM	Samsung
NOR Flash	Numonyx
NAND Flash	Samsung, Toshiba
Bluetooth	CSR
A-GPS	Infineon
SAW Filter	TXC
Power Management IC	Infineon, NXP

Components	Main Supplier
Connector	Foxlink, Advanced Connectek
PCB	Unimicron, Nan Ya PCB, Compeq
FPC	M-Flex, Mektron, Fujikura, Flexium Interconnect, Foxconn Advanced Technology

Components	Main Supplier
Casing	Foxconn Technology
EMS	Hon Hai Precision

Components	Main Supplier
3.2-Megapixel CIS	OmniVision
Camera	Largan Precision

Source: Chen S.H., 2011.

The global production network is a production scheme where various stages of a manufacturing process are undertaken at different geographic locations where they can be carried out most efficiently (UNCTAD, 2005). In many cases, ICT products are characterised by modularisation, even in terms of their internal parts and components, involving a set of jointly-consumed interdependent products. On the basis of the network effects and product compatibility, successful innovations for ICT products often entail intensive interfaces between multiple actors with different knowledge and skills bases. By implication, not only does such an innovation often result from the collective efforts of inter-related firms, but it also demonstrates that the value chain does not need to be completely internalised within individual firms.

[273] This section comes from the IPTS country report on Taiwan. Chen S.H, Trends in Public and Private Investments in ICT R&D in Taiwan, JRC-IPTS, 2011. See 1.2.1 pp 17-18.

As stressed by Chen (2011) the majority of Taiwanese ICT OEM/ODM vendors tend to conduct R&D, product design and pilot run mainly in Taiwan, while leave the mass production jobs to be undertaken at their overseas plants. As a result, the offshore production of Taiwan-based ICT device firms has now substantially outweighed their domestic production, with China accounting for 89% of that production in 2007. Seven out of the 20 top ranking Chinese ICT firms are controlled by Taiwan. They are in ICT manufacturing.

4.2 New patterns of trade

The ICT industry illustrates the growing role of China in global production's networks. The emerging trade relationships between Asia and Brazil displaced the former relationships with other regions like the EU and the USA. Between 1998 and 2007, the volume of imports from China toward Brazil grew at an "exorbitant" four digit rate (over 2000%) (Kubota and Nogueira Milani, 2009) with an average annual increase of 46.60%. In the case of other Southeast Asian countries,[274] it jumped from 16.13% to 27.93%. In other words Asia stands for over 60% of the imports.

Not only it does affect the global trade streams but intraregional trade in Asia is playing a growing role as a part of a global value chain, as a supplier of intermediate inputs building a sophisticated value chain.[275] For instance, China coordinates an assembly networks taking inputs from other countries like India and shipping products outside. Only 30-50% of China's total export value is made in China, while the other portion is the value of imported components i.e. China is not the world's factory as often stressed, raising all kind of fears about potential loss of industries ("*the great hollowing out*"), but rather the world's assembler.[276]

There are numerous examples of the new intraregional relationships. A few recent examples may illustrate this trend. In January 2011, China Mobile, Japan's NTT Docomo and South Korea's KT struck an alliance to exploit opportunities in the mobile market in their home region and to take advantage of trends such as "the further globalisation of corporate activities" and the growing penetration of smartphones.[277] Indian operator Reliance Communications is set to secure US$ 1.93 billion of funding from the China Development Bank Corporation (CDBC). The agreement also includes up to US$ 600 million towards the purchase of equipment from Huawei and ZTE, on top of an existing US$ 750 million facility "already substantially utilised" for hardware and services from the Chinese vendors.[278] This exemplifies the major role of China.

[274] Brunei, Camboja, Filipinas, Indonésia, Laos, Malásia, Mianmar, Cingapura, Tailândia, Timor-Leste, Vietnã, Taiwan.

[275] This builds on the outputs of a joint OECD/World Bank Workshop 'GVCs and emerging economies', Paris, 22 September, 2010.

[276] Ari Van Assche, HEC Montréal and LICOS at the Paris, OECD, 22 September, 2010, workshop.

[277] "China Mobile, Docomo and KT join forces", Mobile Business Briefing, 19 January 2011, According to Wireless Intelligence, China Mobile has 570 million mobile users compared to Docomo's 57 million and KT's 16 million (all end-Q3 figures).

[278] "Reliance inks US$ 2 B financing deal with China", Mobile Business Briefing, 16 December, 2010.

Table 4.1: Emerging economies' trade in ICT goods
(1997-2007, US$ millions, current prices)

	1997	1999	2001	2003	2005	2007
BRAZIL						
Exports						
Communication equipment	214	402	1137	1349	2844	2332
Computer equipment	257	330	290	227	373	229
Electronic components	174	218	416	352	358	245
Audio & video equipment	400	334	375	240	176	178
Other ICT goods	131	194	222	164	287	397
Total ICT exports	1176	1479	2640	2332	4038	3380
Imports						
Communication equipment	2027	1588	2193	599	1150	3187
Computer equipment	1516	1424	1639	1188	1854	2457
Electronic components	2748	2876	3273	3077	5446	5404
Audio & video equipment	987	376	348	333	803	1146
Other ICT goods	1217	993	1247	976	1380	2122
Total ICT imports	8495	7257	8701	6173	10634	14315
RUSSIAN FEDERATION						
Exports						
Communication equipment	98	131	105	166	271	476
Computer equipment	53	74	31	50	66	115
Electronic components	153	260	191	189	266	385
Audio & video equipment	267	30	39	28	28	38
Other ICT goods	346	260	643	463	526	666
Total ICT exports	917	755	1009	896	1157	1680

Imports						
Communication equipment	1492	690	1090	1376	3804	7035
Computer equipment	373	230	478	716	1609	3971
Electronic components	238	124	250	552	934	1359
Audio & video equipment	321	73	317	421	1352	4051
Other ICT goods	907	664	827	958	1166	2887
Total ICT imports	3332	1782	2963	4024	8865	19303
INDIA						
Exports						
Communication equipment	63	49	84	101	161	355
Computer equipment	249	118	346	390	409	347
Electronic components	112	133	202	327	424	692
Audio & video equipment	77	59	122	262	161	140
Other ICT goods	44	85	127	182	268	344
Total ICT exports	545	444	880	1262	1424	1877
Imports						
Communication equipment	280	352	753	2674	5402	8320
Computer equipment	637	1012	1237	1899	3469	4075
Electronic components	598	671	867	1286	1641	2291
Audio & video equipment	103	140	176	313	694	1436
Other ICT goods	378	441	530	695	1309	1968
Total ICT imports	1997	2617	3564	6868	12516	18091
CHINA						
Exports						
Communication equipment	2685	3738	8759	14558	36303	82035
Computer equipment	7513	11697	21076	59245	105651	144514
Electronic components	4922	7766	11371	22879	46890	60841
Audio & video	7168	8453	12616	24289	43265	59570

equipment						
Other ICT goods	906	1009	1483	2332	4057	8608
Total ICT exports	2453	32663	55305	123303	235167	355568
Imports						
Communication equipment	2453	4904	7416	7812	6544	19618
Computer equipment	3864	6968	11607	22890	33705	38066
Electronic components	9664	18386	31333	67442	124455	173473
Audio & video equipment	1989	2345	2796	5438	8557	12418
Other ICT goods	1618	2169	4117	6949	9766	11891
Total ICT imports	19588	34771	57269	110530	183025	255195
SOUTH AFRICA						
Exports						
Communication equipment	119	182	219	186	193	274
Computer equipment	133	182	125	106	137	193
Electronic components	33	33	64	96	167	191
Audio & video equipment	32	42	55	79	99	212
Other ICT goods	77	86	81	148	201	271
Total ICT exports	394	525	545	615	798	1142
Imports						
Communication equipment	1211	1322	1165	1216	2342	2785
Computer equipment	1075	1104	991	1424	2303	2221
Electronic components	440	392	387	374	555	790
Audio & video equipment	358	336	328	441	798	939
Other ICT goods	433	370	383	483	742	972
Total ICT imports	3516	3524	3255	3939	6741	7707

Note: South Africa includes the South African Customs Union for 1996 through 1999.
Source: OECD 2008, based on the data from the joint OECD-UNSD ITCS database.

4.3 Policies and cooperation

During the last decade Brazil, India and China went through major transformations that yielded impressive results, especially in the ICT sector. This growth is likely to continue. Their share of the global demand will expand, especially taking into consideration their huge opportunities to further grow their respective domestic markets.

These countries play an increasingly important role in international trade as China has become the largest country in the world in international trade of ICT products. The amazingly growing role of Asia and especially of China as a trade partner for Brazil is a striking feature. The regional trade seem to be now more tilted toward Latin America much to the detriment of the EU and the US.

Several electronics firms, from India and China have become global players (Huawei Technologies, Lenovo, and ZTE in China and Tata, Wipro and Infosys). Despite, the achievements of these pioneering firms the ICT sector is dominated by foreign companies. EU firms operate in Brazil (mostly from the telecom sector: Telefonica, Portugal Telecom, Telecom Italia…), India (Ericson, Telenor, Vodafone, Siemens, Nokia…), China (Alcatel-Lucent, Nokia Siemens Network, Orange FT Group, Sony Ericson, Telefonica…).

The economic rise of these countries creates potential possibilities for both domestic and foreign companies. However, as illustrated by the Indian case it does pose some challenges to their business models and ways of delivering new products. One of the major issues that companies need to focus on is how to deliver fully-functional products to low-budget and numerous customers. Some of the strategies to address this challenge include, for example, sharing capital-intensive investments with other companies; collaborating with other firms on research and development and competing in the final product market; delivering new products developed and cut to the needs of local markets.

Nevertheless, as India experienced a real "service revolution", lessons may be learnt not only by other BRIC countries such as Brazil where the public policies appear to be less consistent than the ones follow in China, but also by more developed economies.

Most of the EU firms mentioned have opened R&D centres in Asia. Despite this presence of leading companies, US firms seem to fare better than their EU counterpart, showing a greater ability to grasp opportunities more rapidly than EU ones. The US dominates in term of collaboration, international patent analysis indicates that US companies have taken a 'first mover' advantage in developing ICT R&D collaborations with Asia (Predict 2010).[279] The US leads for setting up R&D centres especially in India where investment from the European Union countries is low. The US-Asia relation is taking a growing share in global networking. Inventive collaborations in ICT R&D with Asian economies is still relatively low (Pascall, 2010), but increasing. The changing dynamics of knowledge production and flows and the increasingly more important role of Southern and Eastern countries in this process are bringing opportunities.[280] The increase in Asian R&D may lead to higher growth for the world economy, and help meeting global challenges if R&D spillovers spread among economies as innovation is not a rival good.[281]

[279] Measured by ICT patent applications. Source: IPTS, Predict 2010 and 2011.

[280] Aqueil Ahmad, Walden University School of Management (USA) during the JRC-IPTS International Conference "Asian rise in ICT R&D: Looking for evidence".

[281] Vincenzo Spiezia, Head of ICT Indicators Unit, Directorate for Science, Technology and Industry, OECD, during the JRC-IPTS International Conference "Asian rise in ICT R&D: Looking for evidence".

Innovative capability in Asia is growing, the dynamics are strong. Asian countries are increasingly present in the ICT R&D global landscape. This is still not the case for Brazil. However, even if the dynamic is different, the level of investment in ICT R&D is still low in India. Beyond the substantial progress achieved, and the accompanying policies, the level of R&D expenditure remains modest for China. Comparing with developed countries, the technical innovation ability of ICT industry is still weak in the three countries even if uneven.

Brazil and India are plagued to improve the quality and quantity of science and technology personnel according to Unesco (2010). This contrasts with the Chinese priority on science and technology.

The rise of India and other Asian countries creates a challenge to developed countries and their policy making in such aspects as science, R&D, education, industry and international affairs. There is still room to improve the conditions for fruitful collaboration with these emerging economies. Some Asian countries, like China, are learning a lot very quickly from abroad. It remains to be seen if the EU is learning from China and other countries in the same way.

From an operational point of view, it seems that Europe lacks a broad strategic approach to its relations (competition, cooperation, co-invention), for instance with India and China. According to some experts[282] in the field this weakness appears to result from the fragmentation of European Member State strategies, and from insufficient strategic intelligence about Asian rise. The conditions for intelligence gathering and strategic decision-making at European level would probably gain from a firmer implementation of coordination at European level, a task that the European Commission could help structuring.

4.4 References

Chen S.H, Trends in Public and Private Investments in ICT R&D in Taiwan, JRC-IPTS, 2011. Available at: http://ipts.jrc.ec.europa.eu/publications/pub.cfm?id=4240

Kubota L.C, Nogueira Milani D., Relatório Setorial: Industria de tecnologia da informação e comunicação, Agência Brasileira de desenvolvimento industrial, Belo Horizonte, April 2009.

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[282] A consensus emerged during the JRC-IPTS International Conference "Asian rise in ICT R&D: Looking for evidence".

European Commission

EUR 26923 EN – Joint Research Centre – Institute for Prospective Technological Studies

Title: The ICT Landscape in Brazil, India, and China
Author: Jean Paul Simon

Luxembourg: Publications Office of the European Union
2014
EUR – Scientific and Technical Research series – ISSN 1831-9424
ISBN 978-92-79-44013-7
doi:10.2791/503714

Abstract

The Information Society Unit at IPTS (European Commission) has been investigating the Information and Communication Technologies (ICT) sector and ICT R&D in Asia for several years. This research exercise led to three reports, written by national experts, on China, India and Taiwan, each one including a dataset and a technical annex. This report offers a synthesis on three out of the four BRIC countries (Brazil, India, Russia, China).

The report describes, for each of the three countries (Brazil, India, China), its ICT sector, and gives a company level assessment. It also analyses Indian ICT R&D strategies, and assesses the innovation model.

In 2010, BRIC countries accounted for 13% of global demand, with spending of about €328 billion in ICT (EITO, 2011). Therefore, they are becoming major players as producers of ICT goods and services. China has become the world's largest producer of ICT products (exports of ICT increased fourfold between 2004 and 2008).

This impressive growth of the ICT market is translated into R&D expenditures and output. Innovative capability in Asia has grown, the dynamics in terms of catching up are strong. Asian countries are increasingly present in the ICT R&D global landscape.

The mission of the Joint Research Centre is to provide customer-driven scientific and technical support for the conception, development, implementation and monitoring of European Union policies. As a service of the European Commission, the Joint Research Centre functions as a reference centre of science and technology for the Union. Close to the policy-making process, it serves the common interest of the Member States, while being independent of special interests, whether private or national.

LF-NA-26923-EN-N

doi:10.2791/503714
ISBN 978-92-79-44013-7