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The Internet in India and China

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The Internet in India and China

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Abstract

This article compares the diffusion of the Internet in China and India. Using a six–dimension framework for characterizing the state of the Internet in a nation, we observe that, while both nations have made significant progress since our last comparison (in 1999), China enjoys a substantial lead over India.

We also examine determinants of Internet diffusion. We find that the Chinese Internet has benefited from economic and trade reform begun in the late 1980s, a strong government commitment to the Internet, complementary human and capital resources, etc. The two nations have very different governments and policies, leading to differing approaches to the introduction of telecommunication competition and infrastructure development. China has pursued a strategy of competition among government–owned organizations while India has set policy via recommendations of publicly visible task forces. It remains to be seen whether India's relatively transparent and market driven approach to Internet policy (and access) will prove effective in the long run.

India and China have approximately 40 percent of the world population, and most of their inhabitants live in rural villages that lack basic telephone service. If the Internet is to succeed in raising the level of human development and curtailing migration to teeming urban centers, it must succeed in India and China. What we learn there may enable us to provide communication and information to the world's 1.5 million unconnected villages.

Contents

Introduction

One cannot ignore India and China [1] — they are like elephants in the living room. They have 40 percent of the world population (primarily in rural areas), have rich histories and aspire to superpower status, share a border with contended territory, have growing middle classes that are an important global market, and are major producers and polluters. China and India have very different political and economic systems, but both have assigned high priority to information technology and the Internet, and the Internet may play a pivotal role in the development of the relationship between the two nations [2]. Their differences act as an experiment, shedding light on Internet diffusion and development in general. India and China are home to a large percentage of the world's impoverished people. If the Internet is to improve the state of human development, it must succeed in India and China.

In 1998, we conducted studies of the Internet in China and India [3], and, in 1999, published a paper comparing the two [4]. For the studies and comparison we used a comprehensive, six–dimension framework we developed for characterizing the state of the Internet in a nation [5]. This framework, which has been applied in 30 national case studies and three surveys [6], consists of six dimensions along which we assign one of five ordinal values ranging from zero (non–existent) to four (highly developed). Table 1 summarizes our six dimensions. Note that several of the dimensions have explicit sub–components.

Table 1: Dimensions of Internet diffusion.

Pervasiveness	Our primary indicator of *pervasiveness* is the number of Internet users per capita. While this indicator is difficult to define and pin down, we are satisfied to classify nations using a rough, order–of–magnitude estimate.
Geographic Dispersion	Nearly all nations have some Internet connectivity today, but access may only be available in large cities. As such, we selected *geographic dispersion* as our second dimension. This variable measures the concentration of the Internet within a nation, from none or a single city to nationwide availability with points–of–presence (POPs) or toll free access in all first–tier political subdivisions and common rural access.
Organizational Infrastructure	*Organizational infrastructure* is a measure based on the state of the ISP industry and market conditions. A highly rated nation would have many ISPs and a high degree of openness and competition in both the ISP and telecommunication industries. It would also have collaborative organizations and arrangements like public exchanges, ISP industry associations, and emergency response teams.
Connectivity infrastructure	*Connectivity infrastructure* is our fourth dimension. It is based on domestic and international backbone bandwidth, exchange points, and last–mile access methods. A highly rated nation will have high–speed domestic and international backbone connectivity, public and bilateral exchange points, and a high proportion of homes with

	broadband connections.
Sectoral absorption	While widespread access is desirable, the payoff is in use of the Internet. This is accounted for in our *sectoral absorption* dimension, a measure of the degree of Internet utilization in the education, business, health care and public sectors. These sectors are seen as key to development, and were suggested by the measures used in the United Nations Development Programme (UNDP) Human Development Index.
Sophistication of use	*Sophistication of use* is a measure ranking usage from *conventional* to *highly sophisticated and driving innovation.* A relatively conventional nation would be using the Internet as a straightforward substitute for other communication media like telephone and FAX, whereas in a more advanced nation, applications may result in significant changes in existing processes and practices and may even drive the invention of new technology.

Table 2 summarizes our findings when we first compared India and China in 1999. While India joined the Internet in 1988, six years before China, China rapidly overtook India once they decided the benefits of a controlled Internet outweighed its political and cultural costs. By 1999 China had a significant lead on each of our dimensions. We have subsequently revisited both nations [7], and this paper updates our comparison.

Table 2: Summary of 1999 comparison.

Pervasiveness	The Internet is more pervasive in China where there are an estimated 1.2 million accounts versus only approximately 200,000 in India, and host count estimates give China a lead of roughly eight to one. The research and university networks have been particularly effective in China, where they account for more than half a million users.
Geographic Dispersion	Commercial Internet access is available in over 200 cities representing all Chinese provinces, while India has Internet POPs in only 17 of 32 states and union territories. China qualifies for a higher rating on our scale, but usage is concentrated in large cities in both nations, and villages (roughly 70 percent of both populations) are completely unserved.
Organizational Infrastructure	Organizational infrastructure is concerned with competition in the telecommunication and Internet industries and with coordination and organization in the Internet industry. Telecommunication is monopolized in both nations. Ironically, there has been more Internet competition in China where there are four interconnecting networks. Two of these serve only education and research, but the other two are open, and there are 200 competing access networks downstream from these. Until recently, the Indian government monopolized the Internet, but backbone and access competition have now been authorized. While interconnecting network competition is beginning in India, the ministries that operate China's commercial interconnecting networks, the Ministry of Electronic Industries (MEI) and Ministry of Post and Telecommunications (MPT), are being merged into a new Ministry of Information Industries (MII), which may reduce backbone competition.
Connectivity infrastructure	Connectivity infrastructure is a function of domestic backbone, the prevalence of high–speed access, Internet exchanges, and international bandwidth. India has little terrestrial backbone, relying almost exclusively on satellite links. China uses both satellite and terrestrial links. For example, ChinaNET connects its centers with 155 Mbps circuits and connects to its 200 POPs at between two and 34 Mbps. Nothing close to this exists in India. Neither nation operates Internet exchange points at present, but China has plans to do so. China has more organizations connecting with leased lines, and is experimenting with cable modem and xDSL (digital subscriber line), but they are not deployed in either nation. Finally, China has more than double India's international bandwidth. In spite of China's relative advantage, we must bear in mind that aggregate bandwidth per user is very low compared with that of a developed nation, rendering interactive applications such as Web access impractical in many cases; e–mail is the primary application in all developing nations.
Sectoral absorption	China leads in sectoral absorption as well. Business connectivity is rare (under 10 percent) in China, but fewer than 400 businesses are connected in India. While connectivity is almost nonexistent in primary and secondary schools in both nations, over 300 Chinese universities and 200 research institutes have direct connectivity. Government connectivity and Web sites are rare in both nations as is usage in the health sector.
Sophistication of use	Sophistication of use is comparable in the two nations, with the Internet increasing efficiency of conventional organizations and processes, such as in substituting for mail and fax. Both nations may make similar innovations in the future since they are demographically similar in many ways. For example, both have large rural populations and will be motivated to innovate in the use of the Internet to address the needs of villages and in inventing new applications, technology, and organizations to enable that service. (The Indian government has officially recognized this as a priority.).

Section II, Comparison along our Dimensions, describes the Indian and Chinese Internets on our six dimensions. We find that while the Internet has grown rapidly in both nations since 1999, China has maintained their lead.

Our analysis framework also includes determinants of Internet diffusion. Some of China's success is explained by conditions at the time they

joined the Internet. Chinese reforms of the late 1980s resulted in a relatively open and fast growing economy and an industrial policy that focused on infrastructure, including telecommunications and high technology. The two nations also have very different political systems and have taken different approaches to introducing competition and privatization in the telecommunication and Internet industries. Section III, Determinants of Internet Diffusion, reviews these and other determinants of Internet diffusion in India and China.

Comparison along our dimensions

This section compares India and China along our six dimensions and their constituent sub–dimensions. (Impatient readers may want to jump to Table 13, which summarizes the comparisons for 1999 and today).

Pervasiveness

Table 3 shows estimates of the numbers of Internet users in India and China [8]. The variation in the estimates reflects different methods and timing, but all agree that, as in 1999, China has a significant lead over India. Using the Netsizer estimates, user rates are roughly 1.6 percent of the Indian population versus 3.7 percent in China.

Table 3: Number of users (millions).

	CNNIC, July 2002	ITU, December 2001	CIA, December 2002 (estimate)	Netsizer, August 2002
India		7	16.6	10.3
India		7	16.6	10.3
China	45.8	33.7	47.8	41

Table 4 shows estimates from three sources of the numbers of hosts in China and India or registered in the *.in* and *.cn* domains [9]. Each organization uses different estimation techniques, and all find China in the lead.

Table 4: Host counts (thousands).

	CNNIC, July 2002	NW, January 2001	Netsizer, July 2002
Chinese hosts	161		194
***.cn* domain names**	126	89	119
Indian hosts			96
***.in* domain names**		83	68

Geographic dispersion

ChinaNet, China's dominant ISP, had established access nodes in all of the provincial capitals by early 1996. During 1997 and 1998, the provincial Post and Telecommunications Administrations extended the Internet to other cities in the provinces, but India has POPs in only 22 of 32 states and union territories today. India has POPs in roughly 140 cities (double 1999), while ChinaNet alone, has POPs in 360 cities.

China has a lead in geographic dispersion, but coverage in both nations remains concentrated in urban areas. For example, 31 percent of www Web sites in the *.cn* domain are in Beijing or Shanghai, and 29.4 percent of users are in Guangdong, Beijing or Shanghai. The Internet (and other infrastructure) is strongest in Eastern China and weakest in the west, and, in both India and China, rural villages have essentially no Internet connectivity. This is a daunting challenge, but also an opportunity to make a significant contribution to global quality of life.

Organizational infrastructure

This dimension is concerned with the ISP industry and market conditions. India and China both began with state–controlled telecommunication monopolies that were inefficient and resisted new technology, Videsh Sanchar Nigram Limited (VSNL) and China Telecom [10]. In an effort to spur growth and efficiency, China established Unicom as a competitor to China Telecom in 1994, and in 1998 consolidated control by creating the Ministry of Information Industries (MII) to oversee telecommunications, multimedia, broadcasting, satellites, and the Internet. MII encouraged competition through support of Unicom and by dividing the basic telecom service industry into four government–owned companies specializing in different types of service in 1999, and dividing China Telecom into northern and southern companies in February 2002 [11].

India has pursued competition in a different way. The government established the prestigious National Taskforce on IT and Software Development in May 1998 to formulate IT policy [12]. The Task Force released a 108–step IT Action Plan in July 1998, an IT Action Plan on the Development, Manufacture and Export of IT Hardware in October 1998, and a Long Term National IT Policy in April 1999. In October 2000, the Department of IT issued a progress report on the initial 108 steps (summarized in Table 5) [13].

Table 5: Implementation of India's Initial IT Action Plan [14].

Implemented	56
Not implemented	72
On–going	22
Not accepted	3
Total	108

India sought telecommunication liberalization by appointing an IT Task Force that has generated visible, publicly debated Action Plans; China by central control and state–owned competitors. While the incumbents remain powerful, there is growing competition in both nations.

China has licensed eight interconnecting backbone networks, as shown in Table 6. This is up from four at the time of our previous study, but China Telecom still controls 73 percent of international bandwidth indicating that they remain the dominant ISP [15].

Table 6: Interconnecting networks, March 2002 [16].

Networks	Category	International bandwidth (mbps)
China Telecom (ChinaNet)	Incumbent	5,507
China Netcom	Commercial	920
China Unicom (Uninet)	Commercial	443
CERNET	Academic	257.5
China Mobile	Commercial	200
Jitong (ChinaGBN)	Commercial	168
CSTNET	Academic	55
CIETNET	Commercial	2
Total		7,552.5

Table 7 presents another indication of China Telecom control. Bilateral agreements between China Telecom and the other Interconnecting networks account for over half of the committed backbone link capacity.

Table 7: Chinese contracted link capacity, 31 March 2002 [17].		
	Mbps	
Bilateral agreements with China Telecom	20,435	53%
Bilateral agreements among others	1,155	3%
Beijing NAP	16,973	44%
Total	38,563	100%

India's Department of Telecommunication has issued Class A (all India) ISP licenses to 79 organizations, and 44 of these had started service as of July 2002 [18]. Six infrastructure providers have been licensed to sell end–to–end bandwidth and 49 others have been licensed to provide infrastructure such as dark fiber, right–of–way, and tower and duct space [19]. While the Indian backbone market is open, there is also a state–financed national Internet backbone (NIB). In both nations, the backbone service market is an oligopoly with dominant incumbents, so we rate them even.

In addition to Class A licenses, India has granted 357 licenses for access in limited regions or local areas, but only about 90, financially pressed ISPs are in operation [20]. In spite of India's gains, China still seems to have a more competitive local access market with more than 500 ISPs by the end of 1999. These behave like free market organizations, with many going out of business and attendant layoffs.

We did not explicitly report on international gateways in 1999, but India has granted 20 companies permission to operate 45 international gateways in 16 cities (see Table 8). At least nine government and private organizations currently operate international gateways, and ISPs are free to purchase capacity directly from undersea cable operators. Indians are also free to install VSAT connections to the Internet. (VSATs played a major role in India in 1999, as there was little international cable connectivity). The situation is more competitive than China where interconnecting networks are required to lease the Chinese leg of their international lines from either China Telecom or Unicom, who then lease international circuits from multinational carriers.

Table 8: Licensed International Gateways.	
City	**Licenses**
Delhi	7
Hyderabad	5
Chennai	5
Bangalore	5
Mumbai	4
Ahmedabad	4
Pune	2
New Delhi	2
Kolkata	2
Chandigarh	2
Bhopal	2
Secunderabad	1
Lucknow	1
Gurgaon	1
Cochin	1
Bharauch	1
Total	45

In addition to providing for competition in Internet service provision, India's 1999 Telecommunication Policy opened competition in basic telephone, mobile telephony, infrastructure provision, intranational and international long distance, VSAT, paging, etc.

Voice over Internet Protocol (VOIP) is a critical technology for developing nations with low teledensity and income and large expatriate populations [21], but, until recently, VOIP was banned in India order to protect telephone revenue. By contrast, China concluded that the benefit of low–cost telephony would offset revenue cuts, and has encouraged VOIP. At least four major networks, China Telecom, China Netcom, China Unicom, and China Mobile offer VOIP [22]. VOIP revenue has been instrumental in funding competitors to China Telecom strengthening our assessment of the Chinese lead in access–provider competition.

Industry organizations constitute the final component of Organizational Infrastructure. India and China each have several Internet and e–commerce organizations, so we rate the two nations as *even* on this component.

Connectivity infrastructure

China's aggregate international bandwidth was roughly twice India's (Table 9) in October 2001, the latest time for which we have comparable

data [23]. While China enjoyed a considerable lead, we must bear in mind that these are both developing nations, and the Internet experience is slower and less reliable than in a nation like the U.S. or Japan. The combined international capacity of India and China was only 11 percent of U.S.–Asia capacity and three percent of Europe–U.S. capacity. Note also that these are capacity figures, not traffic, so it is difficult to speak to their adequacy. On a per–user basis, Indian capacity exceeds that of China.

Table 9: International Link Capacity.			
China		**India**	
Nation	**Mbps**	**Nation**	**Mbps**
United States	1640	United States	1166
Hong Kong	654	Singapore	145
Japan	388	Italy	76
Taiwan	257.3	United Kingdom	60
Republic of Korea	155	Hong Kong	22
Australia	151	Japan	16
Singapore	51	Germany	8
Others	1.5	Austria	8
Chandigarh	2	Chandigarh	2
		UA Emirates	8
		Switzerland	1.5
Total	3297.8	**Total**	1510.5

We can get a sense of the rapid rates of growth of the Internet in both nations by noting that total international bandwidth from India was only 82 mbps in January 1999, and that China had doubled its international bandwidth to 7,466 mbps by March 2002 [24]. (It is also interesting to note that the percentage of Chinese link capacity to the U.S. rose from 50 to 79 percent between October 2001 and March 2002).

Turning to domestic backbones, India's NIB has not kept pace with its initial plans, but has deployed its first phase which provides ten 2.5 Gbps capacity self–healing rings, connecting 33 large cities including the major state capitals. This may be compared to China Telecom's 16 trunk lines (eight east–west and eight north–south) with capacity of 2.5Gbps each. University networks remain stronger in China, but, the domestic backbone capacity is roughly even in both nations, particularly on a per–user basis.

A major Internet exchange point (IX) is now operating in Beijing, and two others have been constructed in Hanghai and Guangzhou, but pricing and management issues remain to be resolved. There are also several local IXs, for example in Shanghai [25]. As shown in Table 10, the IX and domestic bilateral exchange points have the capacity to handle 84 percent of Chinese traffic, indicating that China has weaned itself from the U.S. and other backbones.

Table 10: Chinese contracted link capacity, 31 March 2002 [26].		
	Mbps	
International links	7,553	16%
Beijing IX	16,973	37%
Domestic bilateral	21,590	47%
	46,116	100%

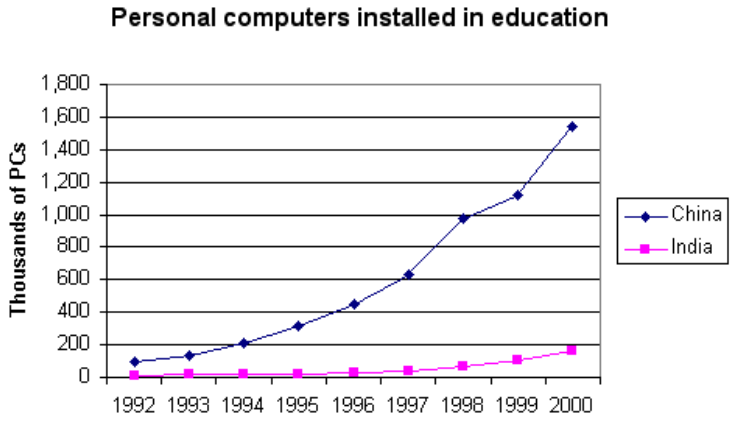
VSNL has established an exchange point, and exchange points are part of the NIB plan. The Internet Service Providers Association of India and the Band–X bandwidth and collocation space brokerage have announced plans for Indian IXs, but their implementation seems to be stalled, perhaps by the dot com bust. While we do not have complete data for India, it seems that China is leading in IX capacity and the capacity to handle domestic traffic domestically.

China has the lead in broadband [27] access with two million cable and DSL and 3.15 million ISDN users. Another 16.6 million users connect via a LAN with a leased line [28]. While we do not have comparable statistics for India, they clearly trail China in broadband access, although the per–user gap would be smaller. China Telecom has also made "large investments in fiber MAN and high–speed access networks" for fiber–to–residence, fiber–to–building, and fiber–to–curb [29]. Unicom and China Netcom have also deployed fiber to buildings in some urban areas. We do not know the extent of this fiber or its use. (Metropolitan fiber access has been slowed in the U.S. with companies like Yipes and Metromedia Fiber Networks filing for bankruptcy).

Sectoral absorption

Both nations have assigned high priority to commercial Internet application. 192,340 Chinese enterprises have registered in either the *.com* or *com.cn* domains, and 78.4 percent of .cn Web sites are *.com* [30]. China has some e–commerce in support of trade and India has a 10 billion dollar software industry, but commercial use is not wide spread in either nation (see *sophistication of use,* below).

Although both nations have committed themselves to connecting secondary schools to the Internet, few are currently online. In both India and China, the Internet began in the universities. While India's Education and Research Network is older, dating back to 1986, the Chinese Education and Research network (CERnet), and Science and Technology network (CSTnet) are stronger. CERnet provides over ten million accounts (most for students) at 900 Chinese campuses and CSTnet provides 800,000 accounts on 100 campuses. Both operate backbone networks and conduct important networking research [31]. The number of PCs in all levels of schools is shown in Figure 1.



Few organizations in the Health sector have an Internet presence as evidenced by always–on connectivity or a significant Web site, so we rate them as even in this area.

The governments of both nations have been slow to use the Internet, but, in 1999, both adopted policies that encourage and mandate the use of the Internet by government agencies. Table 11 shows the numbers of national government agency Web sites analyzed by the Cyberspace Policy Research Group (CyPRG) [32]. (Note that these totals are far below the numbers of domain names registered to government agencies in the two nations).

Table 11: National government agency Web sites.

	1997	1998	1999	2000
China	1	8	34	39
India	12	76	107	110

CyPRG examines 23 characteristics indicating Web site transparency and 22 characteristics indicating interactivity [33]. As Table 12 shows, they find Indian sites to be more transparent and interactive. In addition to a greater willingness on the part of the Indians to open government data and services, this may reflect the relative age of the Web sites, in that more information has been added over time and search, chat, and other interactive features have been programmed.

Table 12: CyPRG average of total scores.

	Transparency	Interactivity
China	2.4	1.0
India	5.6	1.7

Some Indian state governments are also highly committed to the Internet. The state of Karnataka has long offered incentives that built Bangalore into India's "Silicon Valley." More recently, Chief Minister Naidu of Andhra Pradesh has made IT a key component of his political and governance strategies [34]. Naidu has attracted IT investment to the region, uses management information systems, and is attempting Singapore-like e–government applications. Gujarat also has an IT Policy calling for infrastructure, training, and incentives to attract investment [35].

Sophistication of use

This dimensions focuses on the extent to which deployed applications alter the lives and behavior of individuals and organizations. E–mail, game playing, chat, etc. are all available in both nations, and are used for recreation and to substitute for telephone and written communication.

Domestic e–commerce has not taken off dramatically in either nation due to constraints in the delivery, payment and legal systems, and network shortcomings. E–mail and passive Web pages are the norm for businesses that use the Internet. Our survey of publicly traded Indian companies found that less than 10 percent of those with working Web sites [36] do e–commerce. Thatcher's study of international B–B e–commerce in China found that

> "There is relative agreement that active use of Web sites, ERP systems, CRM systems, and SCM systems all constitute B2B e–commerce tools but companies are much more likely to use e–mail and passive Web sites as tools for conducting business … . The newness of electronic B2B tools in the PRC and the more recent availability of reliable wide area data networks may explain the low rate of adoption there." [37]

Since China has encouraged VOIP while VSNL successfully fought it until recently, Internet telephony has had a greater impact in China — both in providing service to the public and in funding China Telecom competition.

CERNet has an active IPV6 research program, and China is deploying Ipv6 with an eye toward the expanded address space needed for large numbers of users and portable devices and the quality of service requirements for audio and video.

Determinants of Internet diffusion

Table 13 shows that India did not lead China on any dimensions or subcomponent in 1999. While China retains a clear lead over India, they

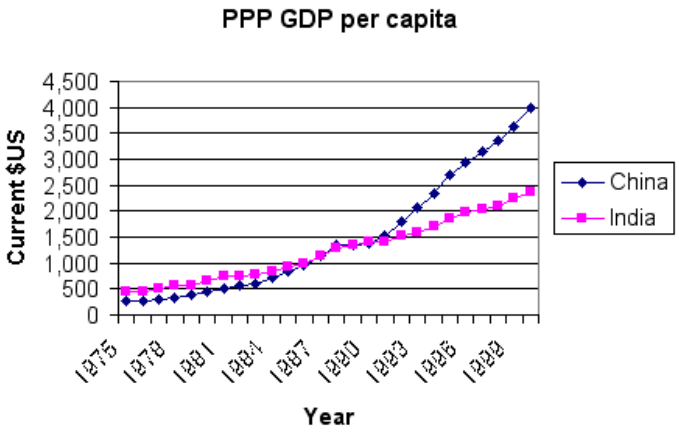
have closed the gap in a few places. This section looks at some of the key determinants — factors underlying the levels of Internet diffusion. Again, we will consider our six dimensions.

Table 13: Dimension comparison summary.		
Dimension or Component	**1999 Advantage (C = China, E = Even)**	**2002 Advantage (C = China, I = India, E = Even)**
Pervasiveness		
Users	C	C
Hosts	C	C
Geographic dispersion		
Top–tier political divisions with POPs	C	C
Number of cities with POPs	C	C
Sectoral absorption		
Commercial	E	E
Education	C	C
Government	E	I
Health	E	E
Connectivity infrastructure		
Domestic backbone	C	E
Broadband access	E	C
Exchanges	E	C
International bandwidth	C	C
Organizational infrastructure		
Telecommunication competition	E	I
International gateway competition	—	I
Backbone competition	C	E
Access provider competition	C	C
Coordinating organizations	E	E
Sophistication of use	E	E

Pervasiveness

Minges and Gray cite seven determinants of Internet pervasiveness: affordability, complementary infrastructure (PCs, telephone lines and electricity), literacy, education, awareness, computer literacy, and language [38]. Let us look at each of these.

Affordability is a function of income and the cost of Internet access. While both nations are largely impoverished, Chinese income is higher. In the late 1980s, China exchanged Karl Marx's slogan "from each according to his ability, to each according to his needs" for Deng Xiaoping's "getting rich is glorious." The resulting increase in GDP per capita is shown in Figure 2. After decades of approximate parity, China began pulling away from India in 1990, and today Chinese GDP per capita is $3,976 versus $2,358 for India [39]. (Unfortunately, Chinese air and water pollution have also surged, bringing them to second place behind the U.S. This may be a limiting factor.)



China's greater income combines with lower access costs and lower costs of computers, to make the Internet more affordable. Table 14 shows dial–up tariffs.

Table 14: Dial up tariffs, US$, 30 hours use per month, 2001.				
Nation	**Monthly PSTN subscription**	**PSTN usage charge**	**ISP charge**	**Total**
India	5.6	0.2	10	15.75
China	3	0.1	6.5	9.69

Part of China's relative advantage in access cost reflects dramatic improvement in telecommunication since they decided to invest in this area in 1990 [40]. This decision predates Chinese awareness of the Internet, but it has certainly facilitated its growth. Chinese telecommunication progress is illustrated by the rapid growth in the number of landline telephones (Table 15). In 1990, India and China had the same teledensity, .6 main lines per 100. By 2000, China had leaped ahead. In one year, 2000, China installed 35 million new fixed lines — more than in the entire developed world in 1999 and 2000 combined. China has also surpassed the United States as the world's largest mobile market with 145 million subscribers [41]. This growth parallels growth in the general economy — the Chinese made the decision to invest in telecommunication, and they were able to afford it.

Table 15: Teledensity, 1990–2000.

	Teledensity		National rank	
	1999	**2000**	**1999**	**2000**
China	0.6	17.8	159	95
India	0.6	3.6	160	145

China also has a commanding lead in PCs. The ITU estimates approximately 25 million PCs in China versus six million in India, and the *Computer Industry Almanac* estimates 34 million versus 5.2 million [42]. Using either estimate, the gap is growing rapidly (it was 3.7 versus 1.1 million in 1996) due to better affordability in China and a domestic PC manufacturing industry that produced 7.5 million PCs and six million PDAs in 2001 [43]. Lower PC cost makes Internet access even more affordable in China than India.

Electricity to power PCs and network equipment is also more abundant in China. (This can be a limiting factor in a rural area). China's electricity consumption is 746 KWH/capita versus 384 in India [44].

China also leads in education and literacy indicators, Table 16. Text is the dominant data type on today's Internet (especially in a low–bandwidth developing nation), so literacy is very important.

Table 16: Education indicators.

	Adult literacy rate	**Secondary school enrollment rate**	**Mean years of schooling for those 15 and older**
India	52%	39%	5.1
China	81.5%	50%	6.4

Awareness of the Internet is difficult to compare. One would expect it to correlate with usage, but Indian city dwellers see constant ads and information about the Internet. We assume that computer literacy would correlate with installed PCs, since Internet access in public schools is not widespread.

Language is multifaceted determinant. India has an advantage in that the educated people who are most likely to use the Internet speak at least some English, the dominant language on the Internet at this time [45]. This advantage is offset by greater language diversity in India. India has 387 living languages and China 201. Their respective language diversity indices are .48 and .93 respectively. (The higher the value, the less likely it is that two people will speak the same language). This is due in part to 70 percent of the Chinese population speaking Mandarin while only 50 percent speak Hindi in India [46]. China is well aware of the importance of English, and has embarked on a program of English–language training.

China's advantage over India in the indicators we have presented leads us to expect that the Chinese will continue to lead in pervasiveness for some time. Factors like economic productivity, telecommunication infrastructure, PC production, and literacy cannot be changed rapidly.

Geographic dispersion

Large rural populations are the major block to geographic dispersion in both nations. Both have made commitments to provide telephone connectivity to all villages, but widespread rural Internet connectivity will be difficult for either to achieve. Every factor we discussed under pervasiveness presents a larger problem in rural areas than cities. There is also significant variation in Internet diffusion among regions and states in both nations. For example, Table 17 shows the percentages of China's 742,000 villages that have telephone service [47]. As we see, Eastern China is better served than the West. (Such regional differences are generally more pronounced in developing nations than industrial nations).

Table 17: Village telephone availability.

	Percent with telephones
Eastern China	95.4
Mid–China	80
Western China	47
Overall	78

Note that even in villages with telephone connectivity, service may be minimal. For example, in a 1998 survey of 11 villages in Pondicherry India, the M.S. Swaminathan Research Foundation found 4,373 households with 21,465 people sharing 12 public and 27 private phones [48]. Ostensibly, each these villages had telephone service, but it was clearly insufficient to support Internet connectivity.

These are large, geographically diverse nations [49], and, as in other developing nations, there is insufficient demand to justify investment in backbone connectivity to rural areas, particularly where roads are bad. Government policy can help. As a licensing condition, regulators can require operators to cover rural area or a universal service fee may be set aside. The Chilean government asked telephone providers to bid for subsidies required to cover rural areas with success [50].

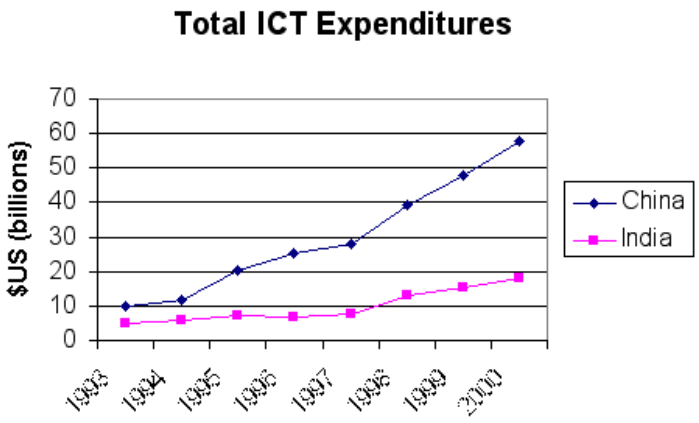
Low–Earth orbiting IP satellite technology may one day solve this problem, but rural connectivity is a daunting challenge in both India and China. While the recent bankruptcy of Teledesic, an IP satellite company, is discouraging, this technology will be more feasible in the future. The G8 industrial nations pledged billions of dollars for IT for development at their Okinawa summit in 2000. Could they or an organization like the United Nations accept the challenge of rural village connectivity and provide capital for such a venture?

India appears to give higher priority to rural networking than China. The Ministry of Information Technology has a Working Group on Information Technology for Masses [51] that issued a report recommending 56 actions in infrastructure and service, electronic governance, education and raising mass IT awareness in October 2000. If they succeed, they may surpass China in rural networking and hence geographic dispersion.

Organizational infrastructure

The transition from government–owned telecommunication monopoly to greater competition has been driven by politics and government policy in both nations. India and China present a stark contrast in governance. The UNDP surveys five measures of democracy in a nation, and India has a clear lead over China on each of them [52]. Few would question that there is greater freedom of expression, the press, the vote, and civil liberties in India. India's democracy has spawned many political parties, strong local governments, a coalition national government, and lively public debate.

The complex political landscape of India has made it more difficult for them to formulate policy and execute plans than it is for China. During the 1990s, China's industrial policy focused on infrastructure and high technology [53]. Figure 3 illustrates this emphasis, and China has been able to execute plans effectively by allocating resources to competing government–owned enterprises.



For example, in 1996, the Chinese State Council made the decision to allow the Internet and to connect all provincial capitals. Within a year, there were competing ISPs in every capital, one using fiber, the other VSAT. India set the same goal in 1998, but has yet to achieve it.

At the time of our earlier comparison, China had just consolidated telecommunication under the MII, and we wondered what the effect of that would be on competition and growth. They have continued the strategy of competition among government–owned enterprises, and, thus far, it has succeeded. We have observed this pattern of government planning combined with competition among partially or wholly government–owned organizations in Singapore, Vietnam and Cuba as well as China [54], and the ITU has also observed its efficacy in China:

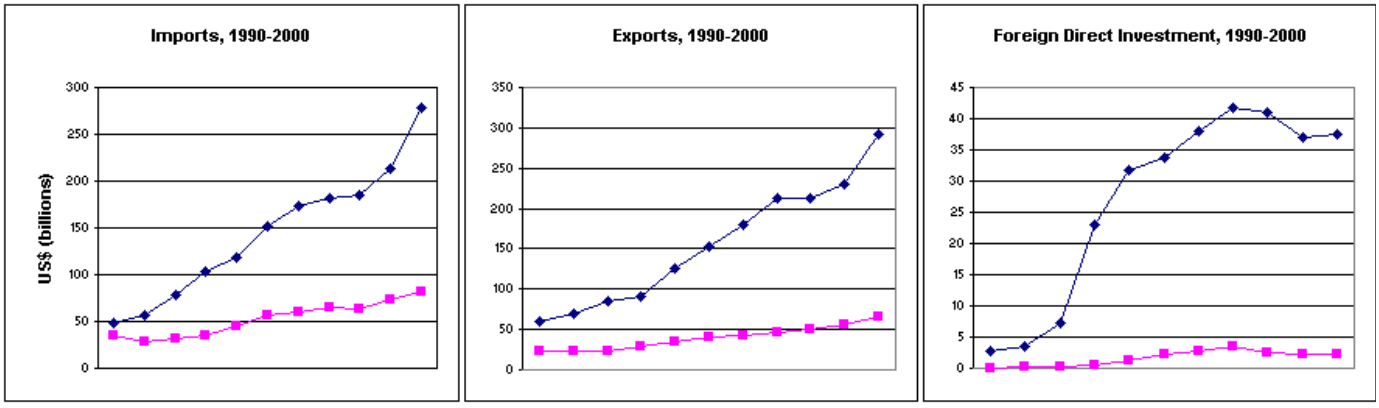
> "The main form of competition has been between ministries of the government … although it is unlikely that this form of competition between state–owned enterprises would feature in many economics textbooks, it has proved remarkably effective. The key underlying factor is the will of the state to invest in, and prioritize, telecommunication development." [55]

The UNDP also reports six indicators of the rule of law, governance effectiveness and corruption, and, China outscores India on each [56]. This is also contributes to China's ability to execute and to the confidence of investors. The Indian government is working to overcome inefficiency and corruption, as evidenced in part by strong support for the IT Action Plan, and since our previous study, they have made significant competitive progress.

Connectivity infrastructure

In addition to factors we have already discussed, a trade policy and other factors that encourage investment and the availability of a skilled work force are also key determinants of connectivity infrastructure.

India has a history of ambivalence about openness and trade versus self–sufficiency dating back to Gandhi, and before the 1990s, China was also insular and tied to the Communist block. Since the 1990s, Chinese trade policy has been more open and eclectic, resulting in significantly faster growth in imports, exports and the ability to attract foreign investment than India (Figure 4, China is shown in blue). This parallels the growth in GDP that we noted earlier.



Some of this increase in trade and ability to attract investment capital is due to pressure from the World Trade Organization (WTO). Michalopoulos finds that "China has [already] used the process of WTO accession to stimulate and make irreversible substantial trade liberalization and more broadly based reforms." [57] We expect this pressure to continue.

At the same time, India will see increased trade as they continue implementation of their IT Action Plans. In addition to the volume of

investment capital, we must consider its allocation. In the long run, India's greater diversity and openness may pay off, and China may find they have allocated resources sub–optimally, but, as recent events have shown, market economies can do the same.

Connectivity infrastructure also requires educated technicians and managers. China has a higher percentage of tertiary school students in science and engineering (43 percent versus 25 percent in India) [58], but India has excellent technical universities and a vibrant trade–school industry. Chinese telecommunication employees may also be more efficient — the number of mainlines per employee is 159 in China and only 77 in India.

Networking professionals (and sophisticated users) are also generated by hardware and software industries.

India was an early mover in software export [59], and the export of software and IT–enabled services (which include low–skill work such as data entry) was $8.26 billion in 2001. The total software industry of $10.1 billion was about 2.2 percent of Indian GDP [60]. While off to a later start, China currently exports approximately $1 billion in software, offers lower prices than India (some Indian work is subcontracted to China), and has begun English language training for programmers and engineers [61].

China enjoys a clear lead in IT hardware manufacturing. Chinese companies produced $23.9 billion in computer products in 2001, an increase of 24 percent over 2000 [62]. Thirty–nine percent of Chinese exports are high– and medium–tech products versus 16.6 percent in India, and, as we have seen, the absolute numbers are much greater for China. It remains to be seen whether India's Action Plan for Hardware Development, Manufacture and Export will enable them to close this gap.

Expatriate workers in Europe and the United states are also playing a role in the growth of information technology development in both India and China. AnnaLee Saxenian surveyed 2,273 first–generation immigrants who are members of Silicon Valley high–tech professional associations and found:

> "Twenty–seven percent of those surveyed advise or consult for companies in their country of origin, and about 30 percent meet with government officials. An even greater share (40 percent) had arranged business contracts in those countries. Half the entrepreneurs identified in the survey had set up subsidiaries, joint ventures, subcontracting, or other business operations in their native countries and most of the other respondents would consider doing so in the future." [63]

The survey included 1,271 first–generation immigrants from China, Taiwan and India, and found many had either been involved in founding or running a start–up company (Table 18).

Table 18: Percent founding or participating in a start–up.

	PRC	Taiwan	India
No participation	68	49	40
Part–time	17	17	17
Full–time	16	34	49

Since the survey was of members of technical professional societies, these results overstate the overall participation rates of expatriates in business, but, as Saxenian points out, the "brain drain" looks more like "brain circulation."

India enjoys a significant entrepreneurial lead in this survey, but that may reflect the time and place of the study, and the gap may close in the future. Regardless, much of this activity will encourage Internet use and investment in the two nations.

China's close commercial relationship with Taiwan and the Hong Kong handover provide similar sources of capital and expertise for the PRC. The Internet and telecommunication in Hong Kong and Taiwan are far more advanced than in China. In spite of long British rule and Taiwanese independence, there are strong cultural and business ties throughout the Chinese world. (Even before the handover, 46.75 percent of China's switched, outbound telephone minutes were to Hong Kong and another 8.02 percent to Taiwan, and Hong Kong ranks second to the U.S. in Internet connectivity from China) [64]. There are also ties to the Chinese in Singapore. For example, Shanghai Venture Capital has allied itself with Venture TDF Company in Singapore [65].

Sectoral absorption

University networks are growing in both nations, but the Chinese are more effective, and have gained a significant and strategic lead in the university that will trickle down to lower levels of school. Both nations have plans to wire schools, but that does not insure their execution, and very few lower schools are connected in either nation. The greater number of PCs in schools (and concomitant awareness and computer literacy) gives China an edge in this area, but both nations have a long way to go if they are to achieve their plans. Political will is probably the deciding factor in achieving school connectivity.

We expect that increased trade will lead to increased use of the Internet to integrate business supply chains and software project management. The expatriate communities mentioned above may play a key role here.

E–government requires priority and will on behalf of politicians, and India has a recommendation for 26 Electronic Governance actions, which, if implemented, will be significant [66]. We expect more variance in India, where state governments are relatively independent.

We see little evidence of use of the Internet in the health care sector in either India or China. This is typical of developing nations.

China has seen the result of Soviet *glasnost*, and is attempting to control the Internet much more than India. This has led to site filtering and proposals to create a "walled garden" national intranet with gateways to the Internet:

> "Since 1995, more than 60 laws have been enacted governing Internet activities in China. More than 30,000 state security employees are currently conducting surveillance of Web sites, chat rooms and private e–mail messages — including those sent from home computers. Thousands of Internet cafes have been closed in recent months, and those remaining have been forced to install 'Internet Police 110' software, which filters out more than 500,000 banned sites with pornographic or so–called subversive content. Dozens of people have been arrested for their online activities; in 2001, eight people were arrested on subversion charges for publishing or distributing information online." [67]

While this sort of constraint may seem to promise attractive stability to some potential investors, it may have unintended side effect of slowing applications in education, entertainment, commerce and other areas.

Sophistication of use

Nearly forty percent of the world population lives in rural areas of nations with low–income economies [68]. In India the rural population is over 70 percent [69]. China has 900 million rural residents, and has recently liberalized restrictions on movement from rural to urban areas [70]. If necessity is the mother of invention, these nations are in a good position to innovate in discovering and deploying applications that are of value to rural populations. If the Internet can improve rural education, health care, entertainment, news, economy, etc., the flow of people to crowded cities, a major demographic trend of the last century, may be diminished.

We would welcome innovation in small PCs and Internet appliances, satellite and terrestrial wireless systems, solar energy systems, understanding rural IT requirements, etc. [71] India has several projects pursuing village connectivity [72], but there has not been widespread deployment as of this time. In anticipation of a proliferation of Internet devices and multimedia applications, China has been developing equipment for and deploying IP v6. This experience and infrastructure may lead to innovative applications, as may their experience with VOIP.

Conclusion

Indian universities joined the Internet in 1988, six years before Chinese universities [73]. Knowing only that, we might expect India to have a commanding lead in Internet diffusion today; however that is only a small part of the story.

The Internet was very different in 1988 than it is today. Few outside a small group of researchers and technicians knew of the Internet, and they used it primarily for sharing technical information and facilitating the development of standards and networking technology. In 1995, when China seriously considered the Internet, the wider public, including policy makers and politicians, were aware of its implications and the World Wide Web protocol was beginning its rapid proliferation. In some sense, the race did not really begin until the mid 1990s.

After a delay to consider the economic opportunity afforded by the Internet and the cultural and political risks of open access, the Chinese made the Internet a priority, and rapidly overtook India's early lead [74]. This success was due in large part to reform that began in the late 1980s, with no consideration of the Internet. Under Deng Xiaoping, China instituted market reforms and liberalized trade policy. The success of these reforms provided resources for and an openness to Internet diffusion.

At the same time, China focused its industrial policy on infrastructure and high technology. This led to dramatic expansion of telecommunication infrastructure, personal computer manufacturing and adoption, awareness of the Internet and information technology applications, and a pool of trained demanding users and the managers and technicians to serve them. These resources were all available when the Chinese decided to connect to the Internet and make it a priority. We saw the simultaneous impact of Chinese economic, trade, and industrial policy of the 1990s in Figures 2, 3, and 4.

India was not as well prepared or as quick to act when it became clear to politicians and policy makers that the Internet could be important infrastructure. Their response was a series of publicly visible action plans with high–level industrial and political support. In a sense, India joined the experimental Internet before China, but did not assign high priority to the modern Internet until the first IT Action Plan in 1998.

The political systems of the two nations have also led them to different approaches to the Internet. China is attempting to maintain control over access and content, while India's Internet is open. While the incumbent telecommunication companies and their government supporters remain strong in both nations, India has moved toward an open market with licensing of telecommunication and Internet service providers. Privatization has gone more slowly in China, where a strategy of competition among government owned enterprises has been pursued in the large ISP market. Pressure from the WTO and market forces may dilute this policy, bringing the two closer together.

For the time being, China has a solid lead over India. However, China is no longer leading or equal on every dimension, as they were earlier, and, when considered on a per–user basis, India is not as far behind as it first appears to be. Table 19 lists some of the key determinants of this lead.

Table 19: Key determinants.

Determinant	Dimensions primarily affected	Comments
Government priority	P, GD, SA, CI, OI, SU	China began first, but India is now committed. Some Indian states are innovators.
Democracy and transparency	P, SU	India has clear lead on UNDP indices, but China acts more decisively.
Rule of law, governance, effectiveness and corruption	OI, CI	China has edge on UNDP indices.
Government control over content and access	P, GD, SA, SU	China has much stronger restrictions on content and access than India.
Trade policy	P, CI	China is more open historically, has a large lead, and is now a WTO member.
Telecommunication policy	P, OI, CI	Different approaches to similar goals.
Economic productivity	P, GD, SA, CI, SU	China leads.
Health	P, SA	China leads.
General education	P, GD	China leads.
General literacy	P, GD	China leads.
Technical, managerial, professional education	P, CI, SA, SU	India has strong universities and trade schools.
Expatriate entrepreneurs and technicians	SA, CI, SU	India leads in the U.S. and China has Hong Kong and strong ties to Taiwan and Singapore.
University networking	P, CI, SA, SU	China leads.
Language	P	English advantage to India and diversity to China.
Software industry	P, SU	India leads.
IT hardware industry	P, CI, SU	China has large lead.
Telecommunication infrastructure	P, GD, CI	China leads.
PCs	P, SA	China leads in installed base and manufacturing.

Electricity	P, GD	China leads.
Geography	P, GD	Both have large populations in remote villages with poor roads and transportation.
Rural connectivity policy	P, GD	India has a plan and several relevant research projects in this area.
VOIP	P, CI	VSNL was successful in stalling VOIP until recently, while China has encouraged it.
IPv6	P, CI, SU	China is investing here with an eye toward non–computer access and multimedia.

Yoshio Utsumi, Secretary General of the ITU, has pointed out that "1.5 million villages in the world still lack a basic telephone connection," and "the time has come to add information to the list of basic human needs," along with food, clothing and shelter [75]. To be a success, the Internet must succeed in India and China. FM

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Notes

1. By *China*, we mean Mainland China, less Hong Kong and Macao.

2. In his thorough treatment of the context surrounding the Internet and its political implications in India and China, Marcus Franda suggests that "IT — and especially Internet–related aspects of economics, technology and communications — is likely to have a major, perhaps crucial, impact on how this massive Asian power rivalry evolves in the future."

3. Center for Information Strategy and Policy, "Asian Giants On–Line," December 1988. This report includes chapters on India (http://mosaic.unomaha.edu/Asian_Giants_India.pdf) and China (http://mosaic.unomaha.edu/Asian_Giants_China.pdf).

4. Larry Press, Grey Burkhart, Will Foster, and Sy Goodman, "The Internet in India and China," INET '99, San Jose, Calif., June, 1999, at http://www.isoc.org/isoc/conferences/inet/99/proceedings/3a/3a_3.htm.

5. Peter Wolcott, Larry Press, William McHenry, Seymour E. Goodman, William Foster, "A framework for assessing the global diffusion of the Internet," *Journal of the Association for Information Systems*, November 2001, volume 2, article 6, at http://jais.aisnet.org/articles/2-6/article.pdf.

6. For case studies see, http://mosaic.unomaha.edu/gdi.html, and for surveys and background, see http://som.csudh.edu/cis/lpress/gdiff/index.htm.

7. For our recent studies of India and China see: Peter Wolcott and Seymour Goodman, "Is the elephant learning to dance? The diffusion of the Internet in the Republic of India," Center for International Security and Cooperation (CISAC), Stanford University and Georgia Tech University, 2002, at http://mosaic.unomaha.edu/India_2002.pdf. Many assertions and conclusions in this paper are supported in these reports, and we will not explicitly reference them beyond this point.

William Foster and Seymour E. Goodman, "The diffusion of the Internet in China," Center for International Security and Cooperation (CISAC), Stanford University, November 2000, at http://www.public.asu.edu/~wfoste1/chinainternet.pdf.

8. China Network Information Center, at http://www.cnnic.net.cn/develst/2002-7e/index.shtml; International Telecommunication Union (ITU), *World Telecommunication Development Report 2002*, at http://www.itu.int/ITU-D/ict/publications/wtdr_02/index.html; Telecordia Netsizer, at http://www.netsizer.com/daily/TopCountry.html; and, Computer Industry Almanac, at http://www.c-i-a.com/.

9. NW: Network Wizards Internet Domain Survey, http://www.isc.org/ds/WWW-200201/index.html; Netsizer: Telecordia Netsizer, http://www.netsizer.com/; and, CNNIC: http://www.cnnic.net.cn/develst/2002-7e/index.shtml.

10. India's Mahanagar Telephone Nigam Limited provided local telecommunications service in Delhi and Mumbai.

11. *People's Daily*, "State Council approves China Telecom's north–south split Plan," 12 December 2001, at http://english.peopledaily.com.cn/200112/11/eng20011211_86402.shtml.

12. For the description of the Taskforce and its history and reports, see http://it-taskforce.nic.in/vsit-taskforce/.

13. http://www.mit.gov.in/atrnt.htm.

14. CNNIC, http://www.cnnic.net.cn/mapinfo/english/cnnic-english.html.

15. A ninth network (Great Wall) belongs to the People's Liberation Army, which is in a class by itself and is different from the other interconnecting networks.

16. CNNIC, http://www.cnnic.net.cn/mapinfo/english/cnnic-english.html.

17. CNNIC, http://www.cnnic.net.cn/mapinfo/english/cnnic-english.html.

18. http://www.dotindia.com/isp/ispindex.htm.

19. http://www.dotindia.com/ip/ipindex.htm.

20. Vinod Mahanta, ";How to survive the ISP shakeout," *Business Today* (23 December 2001), at http://www.hclinfinet.com/pr.html.

21. Madanmohan Rao, "IP telephony to have a dramatic impact on Asian voice, data communications markets," *OnTheInternet*, http://www.isoc.org/oti/articles/0601/rao3.html.

22. International Telecommunication Union (ITU), *2002 world telecommunication development report* (WTDR), at http://www.itu.int/ITU-D/ict/publications/wtdr_02/index.html.

23. Packet Geography 2002, *Telegeography*, Washington, D.C., see http://www.telegeography.com/.

24. CNNIC, http://www.cnnic.net.cn/mapinfo/english/cnnic-english.html.

25. Hongyang Jy, "IX in China," *APIA Newsletter*, number 8 (Winter 2001/2), http://www.apia.org/pdf/nl8.pdf. Also personal correspondence with Mr. Jy.

26. CNNIC, http://www.cnnic.net.cn/mapinfo/english/cnnic-english.html.

27. We consider "broadband" to be access from home by other than analog modem.

28. Note that there is some double counting since some users have more than one mode of access.

29. Cisco press release, "Cisco teams with China Telecom to build information highway" (7 May 2001), http://newsroom.cisco.com/dlls/corp_050701d.html.

30. http://www.cnnic.net.cn/e-sl.shtml. Note that only one Web site is counted per domain name.

31. Jiangping Wu, "CERNET Update," Dante Global Summit (21 May 2002), at http://www.dante.net/conference/globalsummit2002/html/2-4wu/sld001.htm.

32. http://www.cyprg.arizona.edu/.

33. Transparency is a measure of the amount of data an agency makes available through its Web site and interactivity indicates how easy it is for visitors to use the information on the Web site, give feedback to the agency, contact agency officials, etc.

34. Larry Press, Grey Burkhart, Sy Goodman, Arun Mehta, and Arun Mittal, "The role of state government in developing India's Internet," *OnTheInternet* (November/December 1998), pp. 35–37, and at http://som.csudh.edu/fac/lpress/devnat/nations/india/otigovt.htm.

35. http://www.gujaratindia.com/it/itp1.html.

36. It is indicative of the situation that 29 percent had invalid or non–existent URLs.

37. Sherry M.B. Thatcher, "Business–to–business e–commerce: A study of greater Chinese and U.S. electronics and apparel/textile firms," Center for Advanced Purchasing Studies, University of Arizona, 2002, at http://www.capsresearch.org/ReportPDFs/China_eCommerce.pdf.

38. Michael Minges and Vanessa Gray, "The impact of socio–economic factors on Intenet use in South East Asia," *Proceedings of the 2002 International Networking Conference*, Washington D.C., July 2002.

39. China's sustained growth since 1990 has lifted 150 million people out of poverty, World Bank, *World development indicators 2002*, at http://www.worldbank.com/data/wdi2002/.

40. Their early focus on "informatization" was due in part to the influence of U.S. futurist Alvin Toffler.

41. International Telecommunication Union (ITU), *World telecommunication development report 2002*, at http://www.itu.int/ITU-D/ict/publications/wtdr_02/index.html.

42. International Telecommunication Union (ITU), *World telecommunication development report 2002*, at http://www.itu.int/ITU-D/ict/publications/wtdr_02/index.html; *Computer industry almanac*, at http://www.c-i-a.com/.

43. "Mainland China," *Global Sources* (14 January 2002), at http://www.globalsources.com/MAGAZINE/CP/0201/OUTCH.HTM.

44. International Telecommunication Union (ITU), *World telecommunication development report 2002*, at http://www.itu.int/ITU-D/ict/publications/wtdr_02/index.html.

45. Global Reach estimates that 40.2 percent of Internet content is English and 9.8 percent is Chinese, http://www.glreach.com/globstats/index.php3. Note that China has embarked on a program to teach English to technical workers.

46. Language data is from Ethnologue, http://www.ethnologue.com/. Cantonese (Yue) uses the same character set, and many people in other nations including Indonesia, Malaysia, Singapore, Taiwan, the U.S., and Vietnam speak both languages.

47. Huang Yufu, personal communication based on http://rmyd.cnii.com.cn/20020201/ca16330.htm.

48. Larry Press, "A client–centered networking project in rural India," *OnTheInternet* (January/February 1999), pp. 36–38, and at http://som.csudh.edu/fac/lpress/devnat/nations/india/pondyoti.htm. Note that the public telephones in four of the villages were not functioning at the time of the survey!

49. The area of China is nearly three times that of India.

50. Björn Wellenius, "Extending telecommunications service to rural areas — The Chilean experience," *Public Policy for the Private Sector*, Note 105 (February 1997), World Bank, http://www1.worldbank.org/viewpoint/HTMLNotes/105/105welle.pdf.

51. http://itformasses.nic.in.

52. *2002 United Nations Development Programme human development report*, at http://www.undp.org/currentHDR_E/.

53. Mari Pangestu, "Industrial policy and developing countries," In: *Development, trade and the WTO: A handbook*. Washington, D.C.: World Bank, 2002.

54. Larry Press, Larry, "The Internet in Singapore 1997: A benchmark report," Mosaic Group, 2000, at http://mosaic.unomaha.edu/SINGAPORE_2000.pdf; International Telecommunication Union (ITU), *Vietnam Internet case study*, 2002, http://www.itu.int/ITU-D/ict/cs/vietnam/index.html; and, Larry Press, *Cuban computer networks and their determinants* (DRR–1814–OSD), Santa Monica, Calif.: RAND Corporation, February 1998.

55. International Telecommunication Union (ITU), *World telecommunication development report 2002*, at http://www.itu.int/ITU-D/ict/publications/wtdr_02/index.html.

56. *2002 United Nations Development Programme Human development report*, at http://www.undp.org/currentHDR_E/.

57. Constantine Michalopoulos, "WTO accession," In: *Development, trade and the WTO: A handbook*. Washington, D.C.: World Bank, 2002. There has already been some privatization. China Mobile is part owner of several private mobile operators, and Unicom is partially private with its shares traded on the Hong Kong SAR stock exchange.

58. *World development indicators*, http://www.worldbank.com/data/wdi2002/.

59. Larry Press, "Software export from developing nations," *IEEE Computer* (December 1993), at http://som.csudh.edu/cis/lpress/articles/SoftExportFromDevNats.txt. Richard Heeks reports that Indian software export grew at a rate of 42 percent per year from 1990–2001, at http://idpm.man.ac.uk/idpm/isiexpt.htm.

60. http://www.nasscom.org/articles/annual-result.asp.

61. Joseph Manu, "China threatens India eminence," *Wired News* (23 February 2001), http://www.wired.com/news/print/0,1294,41656,00.html.

62. "Mainland China," *Global Sources* (14 January 2002), at http://www.globalsources.com/MAGAZINE/CP/0201/OUTCH.HTM.

63. AnnaLee Saxenian, "Local and global networks of immigrant professionals in Silicon Valley," Public Policy Institute of California, San Francisco, 2002, at http://www.ppic.org/publications/PPIC159/PPIC159RB.pdf.

64. Greg Staples (editor), *Telegeography 1997/98*, Telegeography, Inc., Washington, D.C., 1997, and http://www.cnnic.net.cn/mapinfo/english/cnnic-english.html.

65. Marcus F. Franda, *China and India online: Information technology politics and diplomacy in the world's two largest nations*. Lanham, Md.: Rowman and Littlefield, 2002.

66. http://www.mit.gov.in/itmasses/repg3.htm.

67. Xiao Qiang and Sophie Beach, "The great firewall of China," *Los Angeles Times* (25 August 2002), at http://www.cpj.org/news/2002/China_Firewall25aug02.html.

68. World Bank, *World development report*. Oxford: Oxford University Press, 1997.

69. India was 73 percent urban in 1995; see World Bank, *World development report*. Oxford: Oxford University Press, 1997.

70. "Residence system reform speeds up human resources flow," *People's Daily* (1 November 2001), at http://www.china.org.cn/english/2001/Nov/21457.htm.

71. For example, the Simputer, http://www.picopeta.com/, is an example of a low–cost Internet appliance being developed in India, and Teledesic, http://www.teledesic.com/ may bring IP connectivity to rural villages at reasonable cost if they achieve their goal of being up by 2005.

72. Example projects are Drishtee, which hopes to install 50,000 kiosks serving 500 million people over the next six years, http://www.drishtee.com/index.htm; Gyandoot, with rural kiosks for e–governance and other applications in Madhya Pradesh, http://gyandoot.nic.in/; and, the M.S. Swaminathan Research Foundation Information Village Research Project, http://www.mssrf.org/informationvillage/informationvillage.html, which has conducted in–depth studies of the information needs of villagers in one area and is now attempting to serve them. See Larry Press, "A client–centered networking project in rural India," *OnTheInternet*, volume 5, number 2 (January/February 1999), pp. 36–38, at http://som.csudh.edu/fac/lpress/devnat/nations/india/pondyoti.htm.

73. http://www.nsrc.org/oclb/msg00048.html.

74. We have observed a similar staging in Cuba, which began with the rapid expansion of academic networks (by the standards of the region), followed by a flat period of assessment of the risks and benefits of the Internet, and the emergence of a decision to proceed under the control of the government. See Larry Press, *Cuban computer networks and their determinants* (DRR–1814–OSD), Santa Monica, Calif.: RAND Corporation, February 1998.

75. http://www.itu.int/newsroom/press_releases/2002/22.html.

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