The Internet in India and China

Larry Press,[a] William Foster,[b]
Peter Wolcott,[c] William McHenry[d]

a.
lpress@csudh.edu
Information Systems
California State University
Dominguez Hills, CA, USA

b.
wwfoster@asu.edu
Management Information Systems
Arizona State University
Tempe, AZ, USA

c.
pwolcott@mail.unomaha.edu
Management Information Systems
University of Nebraska
Omaha, NE, USA

d.
wm@uakron.edu
Management Information Systems
University of Akron
Akron, OH, USA

Abstract

With our colleagues in the Mosaic group, we have done several studies of the state of the Internet in India and in China beginning in 1998. These studies were conducted using a six-dimension framework we have developed for characterizing the state of the Internet in a nation. In 1999, we published a comparison of the state of the Internet in China and India. At that time we found that China had a clear lead in each of our six dimensions. This paper updates the comparison. We compare China and India on our six dimensions and find that China continues to have a substantial lead. We also see that India has made significant strides since our 1999 comparison. After examining the six dimensions, we turn to determinants of the values of those dimensions. What has led to China's lead and the progress that both nations have made recently? We conclude that the following factors were important in shaping China's lead over India. (1) Although Indian universities undertook Internet experiments before those of China, China decided to make the Internet a priority and began building it in earnest before India. (2) Chinese economic reforms, which began in the late 1980s, provided both capital for and openness to the Internet. (3) The pre-Internet Chinese decision to invest in telecommunication infrastructure and information technology industries provided complementary infrastructure and human resources for the Internet. (4) The Chinese ability to execute by decree rather than consensus building followed by legislative and regulatory reform accelerated the diffusion of the Internet. (5) The Chinese were able to create competition among government-owned organizations without taking time for legislative change and the raising of private capital. (6) The Chinese were able to establish competitors to the incumbent telephone company relatively rapidly. Although these factors jump-started the Chinese Internet, and will continue to work in its favor, market forces and openness of access and content may serve India well in the long run. Furthermore, there are also great similarities between the two nations, and we hope they will learn from each other and lead other developing nations.

Introduction

The world cannot ignore India and China—with almost 40% of the world's population, with growing middle classes (larger than most nations) that are important consumers in the global market as well as increasingly important global producers, and with aspirations to super-power status, these two nations are forces to be reckoned with. This is as true in information and communications technology (ICT) as it is in strategic or demographic terms. Although these two contiguous countries have very different political and economic systems, both have assigned high priority to information technology (IT) and the Internet. It is likely that these new

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technologies will come to play a pivotal role in their internal developments and their relations with the rest of the world. But the role each assigns to ICT development within their borders is distinctive. These differences can be considered as a huge cross-national natural experiment, shedding light on Internet diffusion and development in general, and the relative strengths and weaknesses of each nation's approach.

In this article we extend some of our earlier comparative work on China, India, and other nations in several ways. (This article is a revised and extended version of our more limited essay in *First Monday,* an electronic journal.) First, we revisited both nations (Wolcott and Goodman 2002; Foster and Goodman 2000),[1] and updated our earlier 1999 empirical material. Second, we extend our earlier MOSAIC analyses by devoting greater attention in this article to the underlying drivers of national differences between the two countries. We point to fundamental macroeconomic conditions such as rates of capital investment and trade patterns that differ between the two countries and that help explain their different ICT performances. We also analyze more sector-specific conditions such as China's accelerated rate of infrastructure build-out and India's dynamic and successful software export promotion program.

This article also points to some institutional and political implications of the two nations' contrasting ICT strategies. For example, our findings run against some of the conventional wisdom that assumes democracy will contribute more to the spread of the Internet than autocracy. In the cases at hand, we find that the less democratic country has had greater success in Internet diffusion than the more democratic country, outcomes that have to do with the relative ease or difficulty of trying to implement reforms under Indian democracy, in contrast to the Chinese authority's ability simply to command.

Finally, we conclude by pointing to the trajectory that each country's Internet has taken to reach its current performance status. In brief, India began with a headstart in the late 1980s but was overtaken by China in the 1990s. Today, the gap continues to grow in some areas but in others the Indians have started to improve their performance relative to the Chinese.

Our approach employs a comprehensive, six-dimension framework we developed for characterizing the state of the Internet in a nation (Wolcott et al. 2001). There is a now a robust repertoire of models that analysts can employ to compare and contrast the ICT conditions of countries around the world, each with its own strengths and weaknesses. These approaches, including our own, have been reviewed and categorized in several works, including bridges.org and by Dutta and Jain (2003) in the *Global Information Technology Report 2002–2003.* We believe our approach, which we term *MOSAIC*, has the advantage of analytic depth and has been consistently and widely applied in more than 30 national case studies and three surveys.[2] We believe that it captures the core performance dimensions of Internet diffusion and the most critical causal determinants of performance. It consists of six dimensions, along which we assign one of five ordinal values ranging from 0 (nonexistent) to 4 (highly developed), summarized in Table 1. Note that several of the dimensions have explicit subcomponents.

Table 2 summarizes our findings when we first compared India and China in 1999. India joined the Internet in 1988, six years before China.[3] Knowing only that, we might expect India to have attained a commanding lead in 1999, but instead China led on nearly all of our dimensions, and India led on none.

We attributed China's relative success at that time to several factors. Overall Chinese economic performance was considerably stronger than India's, and the Chinese had decided to modernize aggressively their telecommunication infrastructure and to focus on IT long before the Internet became a consideration. China became aware of the Internet in the mid-1990s, and after taking a time to weigh the economic benefit of a controlled Internet against its

1. For our recent studies of India and China, see Wolcott and Goodman (2002). Many assertions and conclusions in this paper are supported in these reports, and we do not explicitly reference them beyond this point.

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

3. For dates of the first Internet Protocol (IP) connectivity of these and other nations, see www.nsrc.org/oclb/msg00048.html.

Table 1. Dimensions of Internet Diffusion

Dimension	Description
Pervasiveness	Our primary indicator of *pervasiveness* is the number of Internet users per capita. Although 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 Internet service provider (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 such as public exchanges, ISP industry associations, and emergency response teams.
Connectivity Infrastructure	*Connectivity infrastructure* 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	Although widespread access is desirable, the payoff is in use of the Internet. This is accounted for in *sectoral absorption,* a measure of the degree of Internet use 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 such as 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.

political and cultural risks, China decided to move forward.[4]

After our introduction in section 2, we compare the current state of the Indian and Chinese Internets on our six dimensions. In section 3 we examine the determinants of the levels of those dimensions in the two nations. In the conclusion we summarize the key factors that have led to different diffusion patterns between India and China and note the similarity in the challenge that awaits both nations.

Comparison Along Our Dimensions

This section compares India and China along our six dimensions and their constituent subdimensions. (Impatient readers may want to jump to Table 12, which summarizes the comparisons for 1999 and today.)

Pervasiveness

Table 3 shows estimates of the numbers of Internet users in India and China. 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% of the Indian population versus 3.7% in China.

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

4. 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. As in China, the Cuban government decided to proceed with a controlled Internet. For a discussion of this "dictator's dilemma," see Press (1998).

Table 2. Summary of 1999 Comparison

Dimension	Summary
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 more than 200 cities representing all Chinese provinces, whereas India has Internet points of presence (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% 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. Although interconnecting network competition is beginning in India, the ministries that operate China's commercial interconnecting networks, the Ministry of Electronic Industries (MEI) and the 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 2 mbps 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%) in China, but fewer than 400 businesses are connected in India. Although connectivity is almost nonexistent in primary and secondary schools in both nations, more than 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 because 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.)

Geographic Dispersion

ChinaNET, China's dominant Internet service provider (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 more than 200 cities.

At the time of our 1999 comparison, China had a clear lead as India had points of presence (POPs) in only 70 cities in 17 (of 32) states and union

Table 3. Number of Users (Millions)

Nation	ITU December 2001	CNNIC July 2002	CIA December 2002 (estimate)	Netsizer, August 2002
India	7.0		16.6	10.2
China	33.7	45.8	47.8	41.0

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

Table 4. Host Counts (Thousands)

Host	NW January 2002	CNNIC July 2002	Netsizer July 2002
Chinese Hosts		161	194
.cn Domain Names	89	126	119
Indian Hosts			96
.in Domain Names	83		68

Note: NW: Network Wizards Internet Domain Survey, www.isc.org/ds/WWW-200201/index.html. Netsizer: Telecordia Netsizer, www.netsizer.com/. China Network Information Center (CNNIC): www.cnnic.net.cn/develst/2002-7e/index.shtml.

territories. But, by 2002, India had POPs in 140 cities in 22 states and union territories, and today there are POPs in more than 450 cities representing 27 (of 35) states and union territories. China still has a lead in geographic dispersion, but India is rapidly adding POPs.

In spite of China's lead in POPs and percentage of connected provinces, coverage in both nations remains concentrated in urban areas. For example, 31% of *www* Web sites in the *.cn* domain are in Beijing or Shanghai, and 29.4% 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.[5] 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 ("State Council Approves" 2001). According to Pan of the *Information Gatekeepers* newsletter, this restructuring is complete, and by the end of the year, the two networks will be interconnected and optimized.

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.[6] The task force released a 108-step IT Action Plan in July 1998; an IT Action

5. India's Mahanagar Telephone Nigam Limited provided local telecommunications service in Delhi and Mumbai.
6. For the description of the Taskforce and its history and reports, see it-taskforce.nic.in/vsit-taskforce/.

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; Lakshminarayanan 2003).

India sought telecommunication liberalization by appointing an IT task force that has generated visible, publicly debated action plans; China did the same by central control and state-owned competitors. Although the incumbents remain powerful, there is growing competition in both nations.

Table 5. Implementation of India's Initial Information Technology Action Plan

Implementation	Number
Implemented	56
Not Implemented	27
Ongoing	22
Not Accepted	3
Total	108

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% of international bandwidth, indicating that they remain the dominant ISP.[7]

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

India's Department of Telecommunication has issued Class A (all India) ISP licenses to 68 organizations, and 44 of these had started service as of July 2002.[8] Five 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.[9] Although 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; therefore, we rate them *even.*

Table 6. Interconnecting Networks, March 2002

Network	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

Source: CNNIC: www.cnnic.net.cn/mapinfo/english/cnnic-english.html.

In addition to Class A licenses, India has granted 336 licenses for access in limited regions or local areas, but only about 90 financially pressed ISPs are in operation (Mahanta 2001). 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.

Table 7. Chinese Contracted Link Capacity, March 31, 2002

	Mbps	Percentage
Bilateral Agreements with China Telecom	20,435	53%
Bilateral Agreements Among Others	1,155	3%
Beijing NAP	16,973	44%
Total	38,563	100%

Note: China Network Information Center: www.cnnic.net.cn/mapinfo/english/cnnic-english.html. NAP = Network Access Point.

7. 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.
8. www.dotindia.com/isp/ispindex.htm.
9. www.dotindia.com/ip/ipindex.htm.

We did not explicitly report on international gateways in 1999, but India has moved to diversify this market, having granted 24 companies permission to operate 55 international gateways in 17 cities. At least 9 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 satellite (V-SAT) connections to the Internet. (V-SATs played a major role in India in 1999 because there was little international cable connectivity.) The situation is more competitive than in 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.

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, V-SAT, paging, and so on.

Voice Over Internet Protocol (VOIP) is a critical technology for developing nations with low teledensity and income and large expatriate populations (Rao 2001), but until recently, VOIP was banned in India 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 (ITU 2002a). China Netcom had roughly $60 million in VOIP revenue in 2002, representing about one third of its revenue. (H. Pan, March 7, 2003, phone interview). VOIP revenue has also been instrumental in funding competitors to China Telecom, strengthening our assessment of the Chinese lead in access-provider competition; however, now that VOIP is legal in India, it is becoming a significant source of ISP revenue. It may be that China's early lead will erode over the next few years.

Industry organizations constitute the final component of organizational infrastructure. India and China each have several Internet and e-commerce organizations; therefore, we rate the two nations as *even* on this component.

Connectivity Infrastructure

China's aggregate international bandwidth was roughly twice India's (Table 8) in October 2001, the latest time for which we have comparable data (Packet Geography 2002). Although 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 such as the United States or Japan. The combined international capacity of India and China was only 11% of U.S.-Asia capacity and 3% 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.

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.[10] (It is also interesting to note that the percentage of Chinese link capacity to the United States rose from 50% to 79% between October 2001 and March 2002.)

Table 8. International Link Capacity

China		**India**	
Nation	Mbps	Nation	Mbps
U.S.	1640	U.S.	1166
Hong Kong	654	Singapore	145
Japan	388	Italy	76
Taiwan	257.3	United Kingdom	60
Rep. of Korea	155	Hong Kong	22
Australia	151	Japan	16
Singapore	51	Germany	8
Others	1.5	Austria	8
		UA Emirates	8
		Switzerland	1.5
Total	3297.8		1510.5

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 and links to POPs in

10. CNNIC: www.cnnic.net.cn/mapinfo/english/cnnic-english.html.

more than 420 cities. This may be compared with China Telecom's 16 trunk lines (8 east-west and 8 north-south) with capacity of 2.5 Gbps each. University networks remain stronger in China, but the domestic backbone gap is closing, 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 (Ji 2001/2002; H. Ji, July 24, 2002, personal interview). As shown in Table 9, the IX and domestic bilateral exchange points have the capacity to handle 84% of Chinese traffic, indicating that China has weaned itself from the U.S. and other backbones.

VSNL has established an exchange point, and exchange points are part of the NIB plan. The Internet

Table 9. Chinese Contracted Link Capacity, March 31, 2002

	Mbps	Percentage
International Links	7,553	16%
Beijing IX	16,973	37%
Domestic Bilateral	21,590	47%
	46,116	100%

Note: China Network Information Center: www.cnnic.net.cn/mapinfo/english/cnnic-english.html.

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. India's Telecommunications Regulatory Authority has also acknowledged the need for Internet exchange and has called for the establishment of a national Internet exchange. In the meantime, Indian ISPs must choose between a limited number of closed exchanges and the cost and latency of international round-trips for domestic traffic. At the present time, China is leading in IX capacity and the capacity to handle domestic traffic domestically.

China has a clear lead in broadband[11] access with 3.5 million digital subscriber lines (DSLs) (H. Pan, March 7, 2003, phone interview) and 3.15 million integrated services digital network (ISDN) users, as compared with only 73,000 broadband users (72% of which are corporate) in India ("Broadband" 2002). Conflicts between the State Administration for Radio, Film and Television and the MII have slowed cable deployment, but a new organization with authority over both has now emerged; therefore, the cable alternative is expected to pick up steam. Another 16.6 million Chinese users connect via a local area network (LAN) with a leased line.[12] China Telecom has made "large investments in fiber metropolitan area network (MAN) and high-speed access networks" for fiber to residence, fiber to building, and fiber to curb (Cisco 2001). 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 United States, with companies such as Yipes and Metromedia Fiber Networks filing for bankruptcy.)

Sectoral Absorption

Both nations have assigned high priority to commercial Internet application. We found that 192,340 Chinese enterprises have registered in either the *.com* or *.com.cn* domains, and 78.4% of *.cn* Web sites are *.com.*[13] China has some e-commerce in support of trade, and India has a $10 billion software industry, but commercial use is not widespread in either nation (see the Sophistication of Use subsection).

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. Although 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 more than 10 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 (Wu 2002). The number of PCs in all levels of schools is shown in Figure 1. Few or-

11. We consider broadband *to be access from home by other-than-analog modem.*

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

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

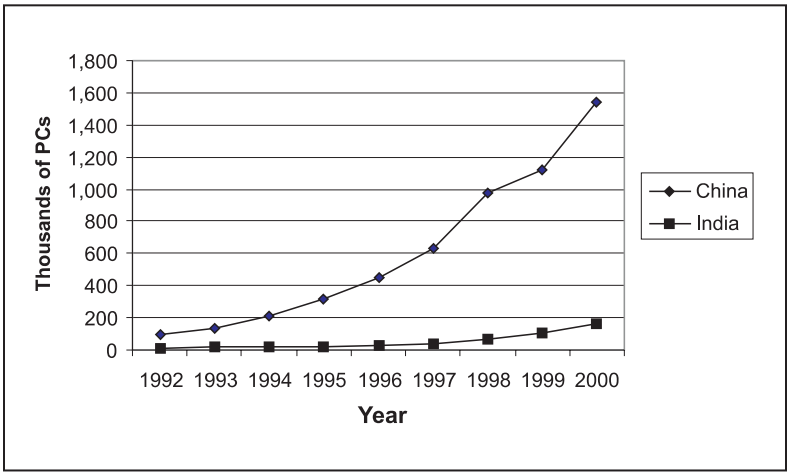

Figure 1. Personal computers installed in education.

ganizations in the health sector have an Internet presence as evidenced by always-on connectivity or a significant Web site; therefore, we rate China and India 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 10 shows the numbers of national government agency Web sites analyzed by the Cyberspace Policy Research Group (CyPRG). (Note that these totals are far below the numbers of domain names registered to government agencies in the two nations.)

CyPRG examines 23 characteristics indicating Web site transparency and 22 characteristics indicating interactivity.[14] As Table 11 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.

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 (Press et al. 1998). 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.[15]

Table 10. National Government Agency Web Sites

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

Note: Cyberspace Policy Research Group: www.cyprg.arizona.edu.

Sophistication of Use

This dimension focuses on the extent to which deployed applications alter the lives and behavior of individuals and organizations. E-mail, game playing, chat, and such 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 because of 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% of those with working Web sites[16]

Table 11. Cyberspace Policy Research Group's Average of Total Scores

Nation	Transparency	Interactivity
China	2.4	1.0
India	5.6	1.7

14. 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, and so on.

15. www.gujaratindia.com/it/itp1.html.

16. It is indicative of the situation that 29% had invalid or nonexistent uniform resource locators (URLs).

do e-commerce. Thatcher's (2002) study of international business-to-business e-commerce in China finds:

> There is relative agreement that active use of websites, 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 websites 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.

Because China has encouraged VOIP whereas VSNL successfully fought it until April 2002, 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 Internet Protocol version 6 (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 12 shows that India did not lead China on any dimension or subcomponent in 1999. Although China retains a clear lead over India, India has closed the gap in a few places. This section looks at

Table 12. 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

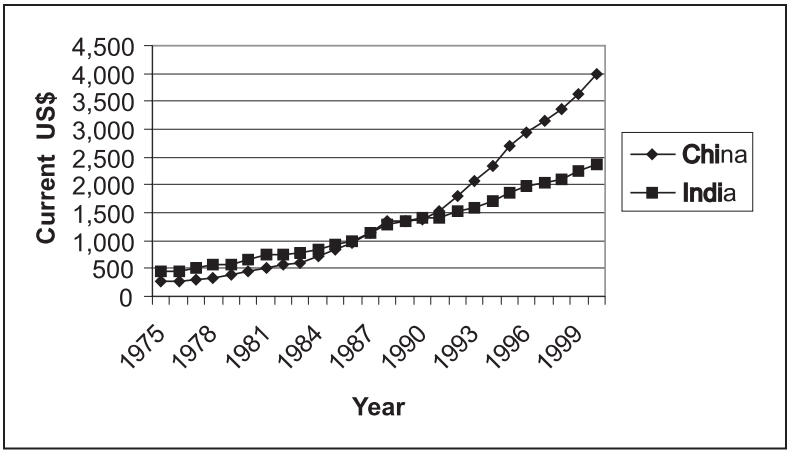

Figure 2. Purchasing-power parity gross domestic product per capita.

some of the key determinants—factors underlying the levels of Internet diffusion. Again, we consider our six dimensions.

Pervasiveness

Minges and Gray (2002) cite seven determinants of Internet pervasiveness: affordability, complementary infrastructure (PCs, telephone lines, and electricity), literacy, education, awareness, computer literacy, and language. Let us look at each of these.

Affordability is a function of income and the cost of Internet access. Although 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 purchasing-power parity gross domestic product (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.[17] (Unfortunately, Chinese air and water pollution have also surged, bringing them to second place behind the United States. 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 13 shows dial-up tariffs.

Part of China's relative advantage in access cost reflects dramatic improvement in telecommunication since it decided to invest in this area in 1990.[18] 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 14). In 1990, India and China had the same teledensity: 0.6 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 (ITU 2002a). This growth parallels growth in the general economy; the Chinese made the decision to invest in telecommunication, and they were able to afford it.

China also has a commanding lead in PCs. The ITU estimates approximately 25 million PCs in China versus 6 million in India, and the *Computer Industry Almanac* estimates 34 million versus 5.2 million (ITU

Table 13. 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

Note: PSTN = Public Switched Telephone Network; ISP = Internet service provider.

Table 14. Teledensity, 1990–2000

	Teledensity		National Rank	
Nation	1990	2000	1990	2000
China	0.6	17.8	159	95
India	0.6	3.6	160	145

17. China's sustained growth since 1990 has lifted 150 million people out of poverty (World Bank 2002).
18. China's early focus on informatization was due in part to the influence of U.S. futurist Alvin Toffler.

2002a). Using either estimate, the gap is growing rapidly (it was 3.7 million versus 1.1 million in 1996) because of greater affordability in China and a domestic PC manufacturing industry that produced 7.5 million PCs and 6 million personal digital assistants (PDAs) in 2001 (Mainland China 2002). Lower PC cost makes Internet access even more affordable in China than in 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 per capita versus 384 kwh in India (ITU 2002a).

China also leads in education and literacy indicators (Table 15). Text is the dominant data type on today's Internet (especially in a low-bandwidth developing nation); therefore, literacy is very important.

Table 15. Education Indicators

Nation	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 because Internet access in public schools is not widespread.

Language is a 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.[19] This advantage is offset by greater language diversity in India. India has 387 living languages and China has 201. Their respective language diversity indexes are 0.48 and 0.93, respectively. (The higher the value, the less likely it is that two people will speak the same language.) This is due in part to the fact that 70% of the Chinese population speaks Mandarin whereas only 50% speak Hindi in India.[20] 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 such as 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 the Pervasiveness subsection presents a larger problem in rural areas than in cities. There is also significant variation in Internet diffusion among regions and states in both nations. For example, Table 16 shows the percentages of China's 742,000 villages that have telephone service (H. Yufu, personal communication based on rmyd.cnii.com.cn/20020201/ca16330.htm). As shown in Table 16, eastern China is better served than the west. (Such regional differences are generally more pronounced in developing nations than in industrial nations.)

Table 16. Village Telephone Availability

Region	Percentage 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 finds 4,373 households with 21,465 people sharing 12 public and 27 private phones (Press 1999).

19. Global Reach estimates that 40.2% of Internet content is English and 9.8% is Chinese (www.glreach.com/globstats/index.php3). Note that China has embarked on a program to teach English to technical workers.
20. Language data is from Ethnologue (www.ethnologue.com/). Cantonese (Yue) uses the same character set, and many people in other nations including Indonesia, Malaysia, Singapore, Taiwan, the United States, and Vietnam speak both languages.

Ostensibly, each of these villages had telephone service, but it was clearly insufficient to support Internet connectivity.

These are large, geographically diverse nations,[21] 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 (Wellenius 1997).

Low-earth-orbiting IP satellite technology may one day solve this problem, but rural connectivity is a daunting challenge in both India and China. Although 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 such as 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[22] that issued a report in October 2000 recommending 56 actions in infrastructure and service, electronic governance, education, and raising mass IT awareness. 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 United Nations Development Programme (UNDP) surveys five measures of democracy in a nation, and India has a clear lead over China on each of them (UNDP 2002). 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 it to formulate policy and execute plans than it is for China. During the 1990s, China's industrial policy focused on infrastructure and high technology (Pangestu 2002). 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 V-SAT. India set the same goal in 1998 but has yet to achieve it.

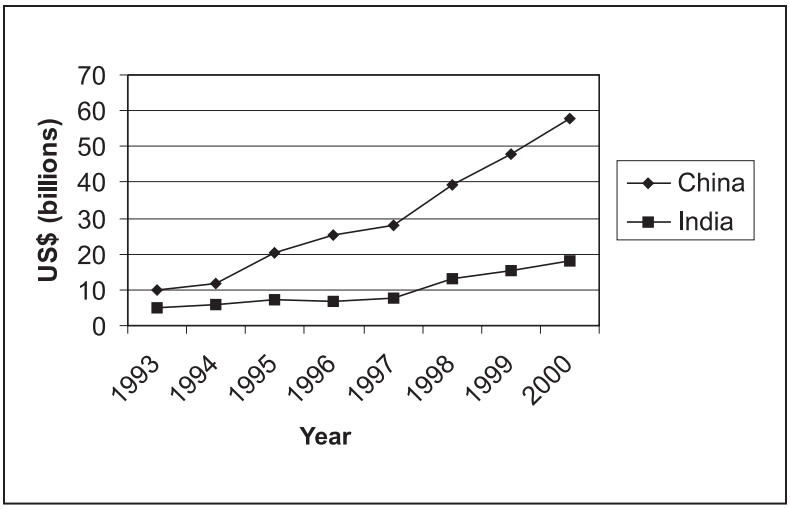

Figure 3. Total information and communication technology expenditures.

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. It has continued the strategy of competition among government-owned enterprises, and thus far, it has succeeded. We have observed this pattern of

21. The area of China is nearly three times that of India.
22. itformasses.nic.in.

government planning combined with competition among partially or wholly government-owned organizations in Singapore, Vietnam, and Cuba as well as China (Press 1998, 2000; ITU 2002b). The ITU also observes the efficacy of this strategy 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 (ITU 2002a).

The UNDP (2002) also reports six indicators of the rule of law, governance effectiveness, and corruption, and China outscores India on each. This also contributes to China's ability to execute and to bolster 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, it has made significant competitive progress.

Connectivity Infrastructure

In addition to factors 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 in India (Figure 4; China is shown with a diamond symbol; India has the square symbol.) This parallels the growth in GDP 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 (2002) finds that "China has [already] used the process of WTO accession to stimulate and make irreversible substantial trade liberalization and more broadly based reforms."[23] We expect this pressure to continue.

At the same time, India will see increased trade as it continues implementation of its 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 it has allocated resources suboptimally, 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% vs. 25% in India; World Bank 2002), but India has excellent technical universities and a vibrant trade school industry. Chinese telecommunication employees may also be more efficient—the number of main lines per employee is 159 in China and only 77 in India.

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

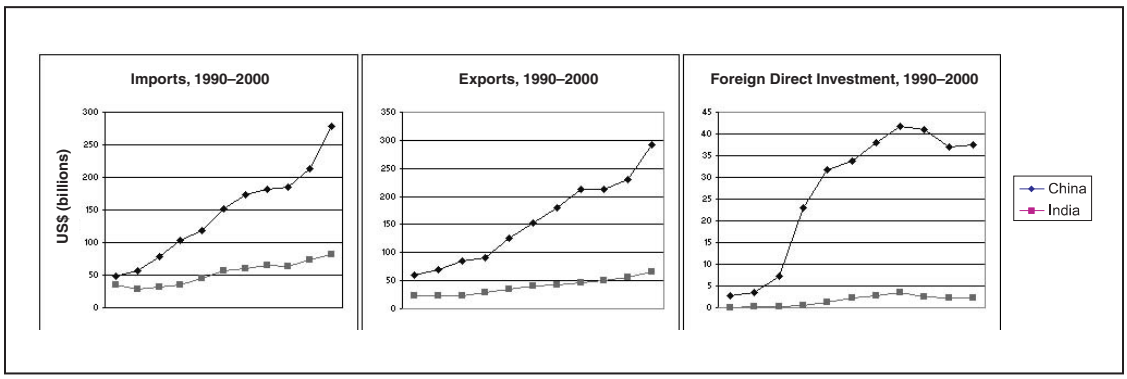

Figure 4. Imports, exports, and foreign direct investment in China and India, from 1990 to 2000.

23. 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 Special Administrative Region of the People's Republic of China (SAR) stock exchange.

India was an early mover in software export (Press 1993), 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% of Indian GDP.[24] Although 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 (Manu 2001).

China enjoys a clear lead in IT hardware manufacturing. Chinese companies produced $23.9 billion in computer products in 2001, an increase of 24% over 2000 (Mainland China 2002). Thirty nine percent of Chinese exports are high- and medium-tech products versus 16.6% 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 it to close this gap.

Expatriate workers in Europe and the United States are also playing a role in the growth of IT development in both India and China. Saxenian surveyed 2,273 first-generation immigrants who are members of Silicon Valley high-tech professional associations and finds:

> 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. (Saxenian 2002)

Saxenian's (2002) survey included 1,271 first-generation immigrants from China, Taiwan, and India, and it finds many had either been involved in founding or running a start-up company (Table 17). Because 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.

Table 17. Percentage Founding or Participating in a Start-up

Participation Rate	China	Taiwan	India
No Participation	68	49	40
Part-Time	17	17	17
Full-Time	16	34	49

China's close commercial relationship with Taiwan and the Hong Kong handover provide similar sources of capital and expertise for the People's Republic of China. 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% of China's switched, outbound telephone minutes were to Hong Kong and another 8.02% were to Taiwan. Hong Kong ranks second to the United States in Internet connectivity from China; Staples 1997.) There are also ties to the Chinese in Singapore. For example, Shanghai Venture Capital has allied itself with Venture TDF Company in Singapore (Franda Forthcoming).

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 universities that will trickle down to lower levels of school. Both nations have plans to wire schools, but that does not ensure 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.

24. www.nasscom.org/articles/annual-result.asp.

The expatriate communities mentioned earlier 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.[25] 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. (Qiang and Beach 2002)

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

Sophistication of Use

Nearly 40% of the world population lives in rural areas of nations with low-income economies (World Bank 1997). In India the rural population is more than 70% (World Bank 1997). China has 900 million rural residents and has recently liberalized restrictions on movement from rural to urban areas ("Residence" 2001). 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, and so on, 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, and so on.[26] India has several projects pursuing village connectivity,[27] but there has not been widespread deployment. In anticipation of a proliferation of Internet devices and multimedia applications, China has been developing equipment for and deploying IPv6. This experience and infrastructure may lead to innovative applications, as may China's experience with VOIP.

Conclusion

At this time, China has a solid lead over India. However, China is no longer leading or equal on every dimension, as it was earlier, and, when considered on a per user basis, India is not as far behind as it first appears. Table 18 lists some of the determinants of this lead, and we conclude with a discussion of key factors.

Since Indian universities joined the Internet in 1988, 6 years before their Chinese counterparts, we might expect India to have a commanding lead. But the race did not really begin in 1988. The Internet was very different then than it is today. Early university networks were run by and run for a handful of technicians. The race began in earnest in the mid-1990s when policy makers, politicians, the IT industry, and the middle-class public became aware of the Internet. After a delay to weigh the economic opportunity afforded by the Internet against the cul-

25. www.mit.gov.in/itmasses/repg3.htm.

26. The Simputer (www.picopeta.com/) is an example of a low-cost Internet appliance being developed in India, and Teledesic (www.teledesic.com/) may bring IP connectivity to rural villages at reasonable cost if it achieves its goal of being up by 2005.

27. Example projects are Drishtee, which hopes to install 50,000 kiosks serving 500 million people over the next six years (www.drishtee.com/index.htm); Gyandoot, with rural kiosks for e-governance and other applications in Madhya Pradesh (gyandoot.nic.in); and the M. S. Swaminathan Research Foundation Information Village Research Project (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 Press 1999).

Table 18. 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 indexes, but China acts more decisively.
Rule of Law, Governance Effectiveness, and Corruption	OI, CI	China has edge on UNDP indexes.
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 United States, 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, whereas China has encouraged it.
IPv6	P, CI, SU	China is investing here with an eye toward non-computer access and multimedia.

Note: P = pervasiveness; GD = geographic dispersion; OI = organizational infrastructure; CI = connectivity infrastructure; SA = sectoral absorption; SU = sophistication of use; UNDP = United Nations Development Programme; VOIP = Voice Over Internet Protocol; VSNL = Videsh Sanchar Nigram Limited.

tural and political risks of open access, the Chinese made the Internet a priority. One can argue that India began working toward a modern Internet several years after China with the IT Action Plan of July 1998.

Much of China's Internet success is due to economic reform that began in the late 1980s. Under Deng Xiaoping, China instituted market reforms and liberalized trade policy. During the 1990s, Chinese GDP per capita moved from roughly equal that of India to double, and the gap in imports, exports, and foreign direct investment grew even more rapidly. Deng Xiaoping wrote that "getting rich is glorious," and the success of Chinese economic reforms provided both the resources for and openness to Internet development.

At the same time, China focused its industrial policy on infrastructure and high technology. This led to dramatic expansion of telephone networks, PC manufacturing and adoption, awareness of the Internet and IT 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 made it a priority. We saw the simultaneous impact of Chinese economic, trade, and industrial policy of the 1990s in Figures 2 through 4.

The Indian democracy could not act as quickly as China once it became clear to politicians and policy makers that the Internet would become an important infrastructure. Its response was a series of publicly visible action plans. The Chinese executed their plans more rapidly. Although India published and discussed action plans and began changing laws and regulations, China allocated resources and built infrastructure.

All nations have had to deal with the inertia found in established incumbent telephone companies, but the Chinese economic and political system allowed China to establish quickly competing Internet backbone networks and ISPs whereas the Indian Internet remained under control of VSNL. The Chinese were also able to authorize VOIP without hesitation, whereas several years of black-market activity and haggling were needed to do the same in India. Twenty years after they were established, the regional Bell Operating Companies remain a conservative force in the United States. It will be interesting to watch the evolution of the incumbent telecommunication companies and their descendents in India and China.

The Chinese mixing of competition and communism strikes some as ironic, but there is nothing inconsistent in competition among government-owned enterprises. China could quickly establish competing Internet service providers at all levels, but India first had to enact regulations allowing competition, and then organizations had to decide to compete and raise capital. This competition by decree clearly jump-started the Internet in China.

The strategy of fostering competition among government-owned or -controlled organizations has been pursued with some success in China, Singapore, and Vietnam. China may become stuck with new incumbents, which are slow to adopt new technology. India's market approach may prove superior in the long run, or China may continue to lead. In any case, this strategy seems worthy of consideration in these and possibly other nations, and we will continue to follow the progress.

Although competition can coexist with communism, it is not surprising that privatization has gone more slowly in China than in India. Pressure from the WTO and market forces may dilute this policy, bringing the two closer together. It will be interesting to see how "communist" the Chinese Internet is in 10 years.

Looking to the future, we expect some of the factors we have mentioned to continue to work to the advantage of the Chinese. Their general economy will continue to be stronger than India's, providing internal capital to invest and attracting foreign investment. The lead China has built in telecommunication infrastructure and the manufacture of IT will also continue for some time. The basis for these was laid in policy decisions dating back to the 1980s, and China's advantage will not be overcome quickly.

On the other hand, India's market orientation may help it adapt quickly and overcome some of the initial advantage conferred by China's ability to execute plans quickly. 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, whereas India's Internet is open. Nobel Prize economist Amartya Sen points out that freedom is both a facilitator and constituent of human development and is conducive to economic development. Chinese control may diminish the economic impact of the Internet in the long run.

The contacts and business relationships both have fostered with foreign firms and expatriates will continue to be important, and it is difficult to single out a clear leader here or in human capital. Chinese literacy and general education lead India, but India's English-speaking professional class is an advantage in our increasingly global IT industry. External factors such as pollution, religious conflict in India, conflict with Pakistan or North Korea, and so on also introduce uncertainty into the future of the Internet in these nations.

In spite of the differences in China's and India's approach to the Internet, their similarities may be more telling. Both are developing nations, and the state of the Internet in China is much closer to that

of India than, say, that of the United States or Japan. The expatriate community has been an important source of ideas, expertise, contacts, and funds for both India and China. Most important, with large, unserved populations, they both face the same demographic and geographic problems, and in this they are representative of much of the world.

These are the earliest days of the Internet and modern IT. We are hopeful that both India and China will make significant innovations in the future. If necessity is the mother of invention, India and China are both in a good position to innovate in discovering and deploying applications that are of value to impoverished and rural populations.

Yoshio Utsumi, secretary general of the ITU, points out that "1.5 million villages in the world still lack a basic telephone connection" and states that "the time has come to add information to the list of basic human needs," along with food, clothing, and shelter.[28] If the Internet can improve rural education, health care, entertainment, news, economy, and so on, the flow of people to crowded cities may be diminished and Utsumi's vision may be realized. To be a human success, the Internet must succeed in India and China. ■

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