Crossing a Chasm:
Technologies, Institutions and Policies for Developing a Regional IT Industry[+]

Nirvikar Singh[*]
Department of Economics
University of California, Santa Cruz
USA

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Abstract

What does it take to build a successful regional IT industry? This paper examines the joint role of technology trends and infrastructure, along with the policy environment and institutions, in developing a robust IT industry. We use the experience of the Indian state of Punjab as a case study, since it is a relatively advanced state that has so far failed to develop a robust IT industry, despite substantial efforts over the last few years. We also evaluate the connection of the IT industry to the broader the structure of the economy and society. For example, it can be argued that Punjab's strength in agriculture and some manufacturing industries must be built on, for a local IT industry to succeed. We suggest that, in fact, ICTs have the potential to be complementary to existing economic activity in Punjab and elsewhere, and can be viewed in the context of an overall economic strategy of diversifying, and increasing the efficiency of, the existing economic base. We discuss policies that are emerging, and prospects for success in the light of current technological and economic trends. We also place the Punjab experience in the overall Indian context of building ICT capabilities.

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[*] Email: boxjenk@cats.ucsc.edu; Fax: 1-831-459-5900

1. Introduction

What does it take to build a successful local IT industry? This paper examines the joint role of technology trends and infrastructure, along with the policy environment and institutions, in developing a robust IT industry. We use the experience of the Indian state of Punjab as a case study, since it is a relatively advanced state that has so far failed to develop a robust IT industry, despite substantial efforts over the last few years. We also evaluate the connection of the IT industry to the broader the structure of the economy and society. For example, it can be argued that Punjab's strength in agriculture and some manufacturing industries must be built on, for a local IT industry to succeed. We suggest that, in fact, ICTs are complementary to existing economic activity in Punjab, and can be viewed in the context of an overall economic strategy of diversifying and increasing the efficiency of the existing economic base. We discuss policies that are emerging, and prospects for success in the light of current technological and economic trends. We also place the Punjab experience in the overall Indian context of building ICT capabilities.

Punjab is a particularly interesting case study, because it is a high-income state with a very good infrastructure as measured by broad based indices (Table 1), yet it has been relatively unsuccessful after India's economic liberalization, including in its efforts to develop an information technology (IT) industry within the state. It is best known as the center and vanguard of India's green revolution, the use of high yielding varieties of food grains, along with complementary modern inputs (tractors, fertilizers, irrigation, etc.) to substantially increase crop yields. In recent years, however, this growth engine has lost steam, and Punjab has also been beset by environmental concerns associated with its current pattern of cropping and resource use.

One alternative that has presented itself as a growth area is the IT industry, which has been an engine of growth for several of the states of southern India, and captured the imagination of policymakers, academics and entrepreneurs. The Punjab government, following this trend, has made substantial efforts to develop an IT industry in the state. Despite these efforts, the state's success in IT has been very limited. Given Punjab's apparently favorable pre-conditions, this relative failure is paradoxical at first sight. We resolve this paradox by arguing that Punjab's policies have not gone far enough in the right direction. We can use the familiar metaphor of needing to cross a chasm in one big leap, not a series of small hops. We therefore discuss what would constitute 'far enough' in terms of institutions and policies to cross the chasm.

Our answer to the paradox also focuses attention on the relationship of IT to the rest of the economy, and its role in broader economic development. Punjab has a range of manufacturing firms in sectors such as textiles, apparel and transportation equipment. What is the actual and potential role of IT in helping these firms to compete more effectively in a liberalized economy? Similarly, what kinds of roles can IT play in improving agricultural efficiency, through better production decisions or improved

market access? Even more broadly, how can IT impact rural development, through improvements in access to local government, delivery of services such as education and health, and general attitudes to social change? Are these benefits significant, and how can they be realized in a sustainable manner?

Table 1: Relative Infrastructure Development Indices, 14 Major States

	1980-81	1991-92	1996-97
Bihar	83.5	81.7	77.8
Rajasthan	74.4	82.6	83.9
Uttar Pradesh	97.7	102.3	103.8
Orissa	81.5	95.0	98.9
Madhya Pradesh	62.1	71.5	74.1
Andhra Pradesh	98.1	96.8	93.1
Tamil Nadu	158.6	145.9	138.9
Kerala	158.1	158.0	155.4
Karnataka	94.8	96.5	94.3
West Bengal	110.6	92.1	90.8
Gujarat	123.0	122.9	121.8
Haryana	145.0	143.0	137.2
Maharashtra	120.1	109.6	111.3
Punjab	207.3	193.4	185.6
All India	**100**	**100**	**100**

Source: CMIE index, taken from Ahluwalia (2002)

The structure of the paper is as follows. In Section 2, we briefly review the state of Punjab's core IT industry, and some of the recent policy efforts, and contrast its experience with that of more successful states. In Sections 3 and 4, we look at two key inputs for the IT sector, telecommunications infrastructure and human capital, and discuss trends as well as policy efforts along these fronts. In Section 5 we examine the possible and actual linkages from the IT industry to sectors that can use IT to improve efficiency or competitiveness, and discuss potential and actual development impacts in industry, agriculture and services. In Section 6, we look in particular at the role of IT in governance in the state, as well as discussing the current policy environment and new policy proposals. Section 7 concludes with an assessment of Punjab's experience, its prospects, and the lessons for India's overall prospects in building ICT capabilities.

2. The IT Industry in Punjab and Government Policies

The success of India's software exports, especially from places such as Bangalore, led other states to try to jumpstart local IT industry clusters. The main focus was on software development, but there were also niches in hardware design. However, despite substantial policy efforts in the late 1990s, Punjab's IT industry remains small. This result is somewhat paradoxical, for several reasons. Chandigarh (the Union Territory that serves as Punjab's capital) and Mohali appeared to be extremely attractive sites for an IT industry. They are close to the nation's capital, the area is pleasant to live in, land is available, and the people of the region have a reputation for being energetic and enterprising. The Punjab government allocated land, a software technology park (STP) was set up, and firms started to move in, from abroad and from other parts of India: major examples included Quark, Infosys, Tata Interactive. Other firms looked seriously at the region as a place for new investment.

However, in 2002, the total size of the IT industry in the region is still tiny, and much of the activity comes from struggling small firms. Some firms have even left, and the main new development project for the STP has not got beyond laying the foundation stone. What went wrong? Interviews with policy makers and people in industry suggest that, aside from the problems created by the global slowdown, as well as Chandigarh's lack of an international airport and a few other amenities, the policy environment was just not right. As we discuss later in the paper, Punjab was able to overcome some initial constraints in terms of local human capital and telecommunications infrastructure. However, other, less direct or tangible components of policy did not fall into place.

The issues were not ones of lack of direct financial incentives, which were indeed offered for greenfield investments in the state. Given the parlous state of Punjab's government finances, such financial incentives can be too costly. They may also be counterbalanced by higher costs down the road. For example, the huge subsidies provided to agricultural users of electric power have been one factor in high industrial power costs (less the case in Punjab), as well as poor quality power supplies. The latter, in particular, was mentioned by firms as a serious constraint on operations. To some extent, the power problem is severe all across India, but Punjab has been distinguished by the degree of deterioration in its power situation over the last decade. A survey of ten states (Goswami et al, 2002) certainly found a correlation between the power situation and the perceived investment climate in those states. The electric power example illustrates a more general point, that the IT sector cannot be looked at in isolation of the rest of the economy. We will provide other illustrations later in the paper.

Even given the constraints on electric power supplies, the government might have compensated by doing more to create a hassle-free environment for business, both in starting up and in continuing operations. Field interviews yielded stories of government-as-usual, including delays, corruption, and policy inconsistencies. When there are other location options, such an environment can be fatal in getting momentum going. In

particular, the National Capital Region, comprising Delhi, Gurgaon (Haryana) and NOIDA (Uttar Pradesh) has presented a formidable rival as an IT destination in North India. It also appears that the Union Territory of Chandigarh did not initially approach the issue of attracting IT investment with much alacrity. As a result of these factors, not a single firm made a big enough investment in the region to get the ball rolling, and there was never a critical mass in Punjab's IT industry. Employment directly associated with IT remains tiny. We also found that there was limited interest in IT at the northern region headquarters of the Confederation of Indian Industry (CII) in Chandigarh.

Having noted the negatives, we also note that several things seem to have changed since five years ago. First, there are some firms that are based in Mohali and doing reasonably well, so there is a base that did not exist earlier. Second, the telecommunications infrastructure for the STP has improved considerably, so that bandwidth is much less of a problem than it was a few years ago. Third, as we discuss in more detail in Section 4, the local availability of technically trained manpower has improved, though there are some remaining gaps. Fourth, higher costs in and around Delhi, plus some recent efforts on the part of the Chandigarh administration, may improve Punjab and Mohali's relative attractiveness as an IT destination. Finally, government policy appears to have progressed, at least in the conceptual stage. Whereas earlier efforts were somewhat ad hoc, there is now an effort to devise a comprehensive plan for the IT industry. As we discuss in Section 6, if new policies make it to the stage of effective implementation, Punjab may be able to do better in the future in developing a local software industry.

3. Telecommunications Infrastructure

As discussed in the introduction, Punjab is a relatively advanced state, with one of the highest per capita incomes, and also the highest infrastructure index among the states. Nevertheless, in practice, we found that the state of the telecommunications infrastructure was inadequate, especially for Internet use in rural areas.

Initially, in the 1990s, there were problems with the bandwidth required for software exports. Policy initiatives at the state and national level have gone a long way toward reducing the constraints of bandwidth through new investment in infrastructure, though firms suggested to us in interviews that there were still occasional problems with availability, and that bandwidth costs are significantly higher than in some other parts of India. From the state's leading ISP, we also learned about overcharges for leasing lines, and other operational obstacles that were consistent with descriptions of the state's policy environment in other areas such as electric power provision and land use regulation.

The problems of rural Internet access were of the kinds that do not show up in official statistics. An immediate problem (based on observations in Bathinda district) faced by semi-commercial efforts to provide rural Internet access and services was the poor quality of telephone connectivity. While phone lines might be available or installed

specifically for an Internet kiosk, the quality of service turned out to be so poor in most cases that potential Internet-based services were undermined. While IT-based services that do not rely on the Internet or telecommunications are valuable, their financial sustainability is much harder to achieve without good telecommunications links.

Many of the problems with telecommunications infrastructure have to do with central government regulatory policies, so a state government has limited room for maneuver. Nevertheless, awareness of the constraints is important in order for the state government to be able to lobby the center to relax unnecessary constraints, or to formulate its own policies that work around the constraints.

In particular, India's telecoms infrastructure needs must be understood not just as providing high-quality, high-speed international data links for its premier software firms, and independently providing basic local voice calling capabilities for poor villagers. While clearly what is provided is closely linked to ability to pay, the value of being part of a well-functioning network must not be underestimated, even for the bottom rung. For example, the average annual revenue per line of village public telephones (VPTs) is estimated at $16 without long distance, and $760 with that capability.[1] The essence of a network is connectivity, and the domestic network and international gateways, fixed and wireless service, and voice and data must all be built out in a coordinated manner to maximize the value of the network to its users. The government's role should be to ensure this coordination, without stifling competition and innovation. We next discuss innovations that potentially provide cost-effective voice and data telecom access to rural and semi-rural populations. To the extent that such access can stimulate demand for IT products and services geared to the domestic market, there is a positive link between widespread telecom access and the domestic IT industry.[2]

Some of the key work on innovation for Indian telecoms has been done by teams led by Ashok Jhunjhunwala, of IIT Chennai.[3] He realistically frames innovation needs in the context of economics. Affordability is critical to making widespread provision of telecoms services economically viable. Jhunjhunwala gives the example of cable services in India, which are priced at $2 to $4 per month, and have 35-40 million

[1] See Telecom Regulatory Authority of India (2000). Yale Braunstein has pointed out to me that this wide spread partly reflects an inefficient tariff structure, with domestic long distance and international calling being priced significantly above cost.

[2] An example from field research in Bathinda district of Punjab in December 2001 can illustrate: a farmer told us he had taken computer lessons, bought a home computer, and signed an Internet service contract so that he could exchange email with his brother in Toronto, Canada. All three IT-related products and services depended on basic telecom availability. See also Prahalad and Hart (2002).

[3] See Jhunjhunwala (2000), as well as numerous presentations available on his web site, at www.tenet.res.in/ashok.html. The overall group is called the Telecommunications and Computer Network (TeNeT).

subscribers. At this kind of price point, however, a telecom operator in India cannot recover set-up costs for access which are about $800 using conventional technologies.

The economics of widely available telecom services in India is therefore very different from the US, where revenue per connection will be several hundred dollars per year: innovation in the US focuses on increasing revenue through upgrading services, rather than reducing the cost of providing access. The goal of innovations by Jhunjhunwala's team, therefore, has been to bring the cost of access down below $300 per line, and as close to $200 as possible. The latter figure would make access affordable to 50% of Indian households at current income levels. On the other hand, without such innovations, targets of increasing India's teledensity fourfold (from 4 to 15 per hundred), or Internet access tenfold are empty rhetoric.

With the cost of fiber-based backbones falling rapidly, it is the access component of the network that accounts for as much as two thirds of the per line cost. The IIT Chennai group and spin-offs started by alumni have developed several key innovations that can dramatically bring down the cost of access. These innovations include developments in hardware as well as software, and address issues of network management and deployment as well as pure access issues.[4] They help bring both affordable voice and Internet access to rural areas of India.

The benefits of this suite of technologies are not restricted to rural users, but also extend to middle class and working class urban users. Current access costs using these new technologies are estimated at $400 per line, but are likely to fall with further innovation. Pilot projects in rural and urban areas appear to have been very successful, and adoption is finally gaining some traction, despite bureaucratic and policy hurdles.

An alternative technology, which bypasses the local network entirely, and is particularly suited for rural Intranets connecting nearby villages, is that of high-powered Wi-Fi networks that travel long distances.[5] These versions of wireless networks using the Wi-Fi, or 802.11b, standard create a wireless zone of up to 12 miles long, far beyond the usual 300-foot-radius range that Wi-Fi typically achieves. The new products can achieve long distances by boosting the power inside access points--the radios that create the network, and by adding additional antennas to the access points so signals can be beamed directly to a user's location, rather than creating a cloud of access. While the technology is in its infancy, it is already being implemented in the U.S. and the main issue for use in India will again be cost and regulatory hurdles.

[4] The innovations are described in more detail in Jhunjhunwala (2000). They include some wireless components, combined access to voice and Internet connections, and low-cost access devices.

[5] See the news article, "Wi-Fi stretches its boundaries", By Ben Charny, Staff Writer, CNET News.com, September 27, 2002,

The bottom line is that bringing down the cost of access through innovation targeted at the domestic market is a critical component of any dramatic increase in telecoms connectivity in India. Economically combining Internet and voice access also has the benefit of increasing the value of connecting to the network. The benefits accrue not just to the poor, but also to the tens of millions of lower middle class households who are currently outside the affordability radius. What was striking was that Punjab, while it leads in

4. Human Capital

Advanced technical and managerial education is an essential input into the development of an IT industry. From the perspective of an individual state, it might be argued that local educational facilities are not important, since labor, especially skilled labor, is mobile within the country. However, the evidence suggests that there are mobility barriers, in the form of language, culture, and substantial costs of moving. Even in the United States, which is culturally and linguistically much more homogeneous than India, proximity to educational facilities (universities in particular) has been an important factor in developing IT industry in various local regions – Silicon Valley being the most prominent of them, of course.

The case of Punjab is interesting since, while it has been a relatively prosperous state for some time, the extent of technical education it provided tended to lag behind its ostensible level of development, and behind several of the southern states in India.[6] To some extent, this reflected educational policy decisions taken at the center, but also substantial periods of political turmoil, as well as a political focus on agriculture as the dominant sector of the state's economy.

In the late 1990s, some catching up began to take place, as part of a nationwide effort by the central and state governments to ride the wave of the IT boom. Punjab has significantly increased the number of engineering colleges, as well as non-degree granting technical institutes. A significant step was the establishment by the state government of the Punjab Technical University (PTU) in 1996-97. The PTU acts as an independent provider of technical education, as well as an umbrella for technical education in pre-existing universities and colleges in the state. Its decentralized model, including the use of small entrepreneurs at the rural or small town level, is well suited to making a basic level of IT education available to a broad cross-section of the population. In particular, the costs of shifting to a city for education can often be a substantial barrier to less-well-off rural youth. Education closer to home is also particularly attractive for

[6] This was partly a North-South imbalance. For example, the four southern states of Andhra Pradesh, Kerala, Karnataka and Tamil Nadu, together with the Union Territory of Pondicherry, accounted in 1997 for about half of engineering college seats, though they had only about a quarter of the population of India. See Palit (1998).

girls, where social norms might otherwise not permit them to go to a city for further education.

Thus, the past five years have seen a significant broadening of Punjab's local supply of technical education geared toward IT and related knowledge industries. What is probably missing from Punjab is a top-notch institute at the level of the Indian Institutes of Technology (IITs). While the IITs are elitist in some respects, and a significant proportion of their graduates contribute to the brain drain, they also can act as a source of high-level technical skills that are important for innovation. The IIT Chennai group discussed in the previous section is an example of the possible positive role that more advanced institutes can serve. IITs are also important in enabling faculty of regional engineering colleges to upgrade their skills by acquiring doctorates.

A similar quality gap lies in the field of management education, where Punjab, despite its long tradition of entrepreneurship, has no world-class management institute. Rankings differ, but the only management institute in the region that appears regularly in such lists is the University Business School, Chandigarh, which had ranks of 56, 18 and 28 in three different lists.[7] Of course Chandigarh, while the shared capital of the state, is not in Punjab. In some respects, this gap may be more serious than in the case of engineering education, where the best regional engineering colleges are close in terms of quality.

Despite the increase in technical training within Punjab, it seems that the vast majority of engineering and other technical graduates go beyond the state's boundaries for jobs. To some extent, this is to be expected, since places such as Bangalore are well established, and offer the most attractive opportunities. In general, however, the problem is that the number of IT jobs in Punjab is tiny, as we have noted earlier. Nevertheless, a supply of high quality local graduates can be an important factor in the future, since firms seeking to invest in the state will be less concerned about having to attract workers from elsewhere in the country.

5. Forward Linkages and Development Impacts

In addition to requiring educated manpower as an input in production, the IT sector itself can play an enabling role in education delivery: this is an example of what is termed a "forward linkage."[8] Low-cost digital processing, storage, transmission and printing

[7] The Punjab School of Management Studies, Punjabi University, Patiala, appeared at 49 in one list, at www.rbeindia.com/topbschools.htm. Other lists were available at www.geocities.com/shanmugavelbabu/50bschool.htm, and www.namasthenri.com/Education/b_schools.htm.

[8] In the case of technical education for employment in the IT industry there is a "backward linkage" from IT to its inputs. A similar backward linkage exists in the case of telecommunications. These linkages are among the most obvious, and national and state government policies all over India have been geared toward relaxing the constraints of telecoms infrastructure and IT skills.

together lower the costs of developing and delivering educational materials. There is no reduction in the role of human capital, except to the extent that interactive materials can substitute partially for human teachers. On the contrary, there is a need for precisely the kind of human capital that can be produced by technical institutes, since the preparation of IT-based educational materials now requires IT skills as well as knowledge in the discipline in which the educational content lies. In the case of IT-education, of course, the two overlap.

There is evidence that broad-based delivery of nontraditional education can be enhanced by the use of IT. For example, fieldwork in Bathinda in studying TARAhaat suggests several general points. First, in all attempts to introduce IT to rural India in a manner that promotes development, financial sustainability is a key issue. The TARAhaat franchisee model offers important promise in this regard with respect to incentives and scalability, though there have been difficulties in implementation. Second, the experiment validates the idea that IT costs have come down sufficiently to make rural IT services financially viable. This is an example of the force of technological change, since a basic desktop system now costs less than $700.

Third, there is the issue of complementarities, both technological and pecuniary. To elucidate this point, note that one major roadblock for TARAhaat has been the poor quality of existing telecoms infrastructure. This has severely limited the scope of services that its franchisees could offer. On the other hand, the provision of complementary inputs such as financing and physical infrastructure, through subsidized loans from nationalized banks and the use of local government buildings, have been important in reducing startup as well as operating costs. The most important complementarity emerged when the Punjab Technical University (PTU) quickly piggybacked on TARAhaat's efforts, enhancing the franchisees' initial financial viability through its own offerings of college-level IT education.[9]

Fourth, the scope of potential educational services is quite broad. While ventures such as this cannot be financially self-sustaining in providing basic education or adult literacy classes, they fill several gaps in the educational offerings available in rural and small town India. For example, TARAhaat offers classes in Tally accounting software, and some local small business owners have taken these. Going beyond IT education, it is also developing classes in rural retailing and in personality development. Again, these are not 'basic needs', but they raise the level of human capital outside the big cities, and without the costs of travel to those cities.

[9] Subsequently, TARAhaat has chosen to forbid its franchisees from offering PTU courses, in an attempt to solidify its brand and quality control. Whether this is the optimal strategy requires a separate analysis.

The key inputs provided by TARAhaat are educational content and organizational capital. Our observations suggest that both these are scarce in rural areas, and any efforts to create and leverage such resources are likely to have a positive impact.

The use of IT in agriculture, industry and services creates forward linkages from IT to those sectors. To the extent that IT can have significant effects on the efficiency of operations in other sectors, there are complementarities between the IT sector and the rest of the economy. Examples of areas where increased efficiency may be possible include accounting, procurement, inventory management, and production operations. These are all examples of forward linkages, since IT adoption has positive impacts on operations. This is, of course, the standard argument in developed countries such as the U.S. for the virtues of the "new economy" based on IT. In a developing country such as India, the use of IT is still scattered, but falling costs and homegrown solutions may provide some promise. We would argue that, ultimately, the linkages between IT and the rest of the economy are critical for the success of a regional IT industry.

Agriculture

The forward linkages from IT to agriculture are varied in nature. In the case of farming itself, good and cheap telecommunications access can enable farmers to access market information. Interestingly, in the case of Punjab, the role of the Internet appears to be currently limited by the existing institutional structure and physical infrastructure. In other parts of India, where infrastructure is less well developed, information about market prices and conditions allows individual farmers to make more beneficial decisions on where to sell their crop. In Punjab, the good network of roads and market towns makes the benefits of the Internet more marginal. Better-off farmers, for example, use cell phones to gather market information as needed. In other cases, the existence of dominant intermediaries, who, in addition to providing credit, have pre-purchased the farmer's crop, make the Internet redundant.

One aspect of agriculture where there may be potential for use of IT is in providing information to farmers. The Punjab Agricultural University, Ludhiana, is well known for its research and extension services. These include training programs, farmers' fairs, and telephone help lines. However, the use of IT does not appear to go beyond the posting on the Web of some basic information about scheduled events, and locations and contact information of district offices. All this information is in English. Email contact possibilities are restricted to a single, general address. Hence, the potential of the Internet and Web as a medium for farmers to pull in useful information about inputs and techniques has not been tested.

To summarize the discussion so far, the benefits that could flow from linkages from IT to agriculture include improvements in the working of input and output markets, and improvements in the quality of decision-making in productive activities. Interestingly, in Punjab, immediate and obvious benefits from improved market information via the

Internet did not appear to be available. In general, this could be understandable as a consequence of the relatively good infrastructure of markets and roads (and to some extent voice telecommunications) in Punjab, in contrast to more backward areas such as Dhar (Madhya Pradesh) and Bundelkhand (Uttar Pradesh), where Internet access seemed to make a dramatic improvement relative to the status quo.

However, further analysis also suggests that existing market institutions may have a lock-in effect, preventing the benefits of improved information from being realized. Fieldwork in Bathinda district suggested the importance of "commission agents", intermediaries who provided credit as well as pre-purchasing farmers' crops. In such circumstances, information of spot market opportunities that the Internet could provide is made irrelevant.

On the input market side, our interviews with government officials suggested that input traders constitute a strong political lobby. Hence, direct purchases of inputs from manufacturers, which might be aided by the Internet, in a straightforward example of disintermediation through improved information, were precluded by lobbying-influenced policies.

In terms of using the Internet to reach new markets, especially abroad, we did not find any strong evidence for this taking place, though it was being discussed in policy-making circles. To some extent, the problem was again lock-in to an existing institutional structure, which determines with some rigidity the cropping patterns, market channels, and prices paid. It is also true that the complementary physical infrastructure is available for the existing institutions, but not for newer efforts that might take more of IT.

The lack of any noticeable efforts or impacts with respect to IT and Punjab agriculture is, to some extent, the consequence of needing to change a set of complementary institutions and policies in tandem. However, large players, such as the state government or corporations with agricultural interests (e.g., agro-processing), can make a difference through coordinated implementation, as illustrated by the ITC effort in several southern states. Their annual report (ITC 2002) states:

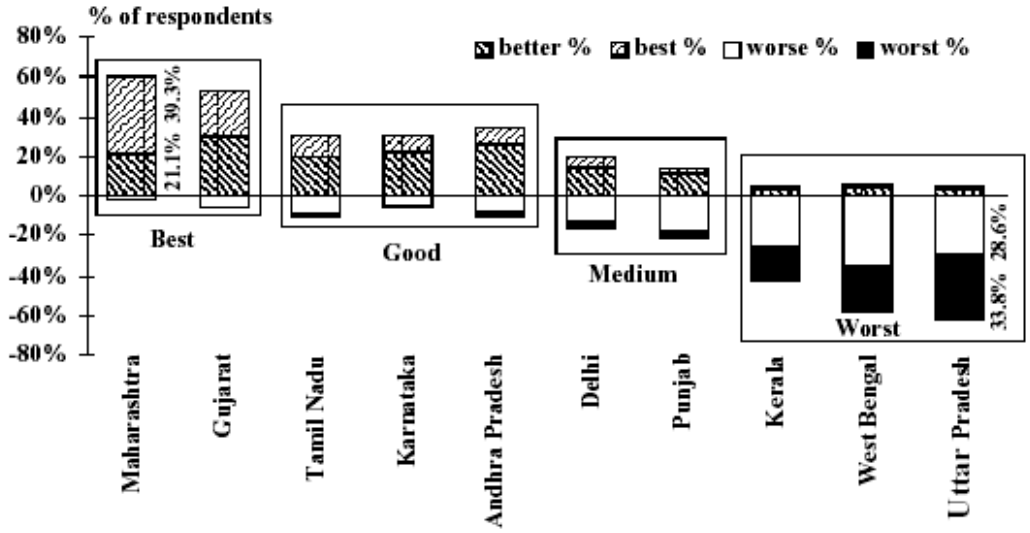
> Project 'e-Choupal'…links the Indian farmer with domestic and international markets …It already reaches out to more than half a million farmers to provide web-enabled real-time information on the weather, best farming practices and commodity prices. Through virtual clustering, these 'e-Choupals' are conferring the power of scale on even the smallest of individual farmers. This…e-infrastructure will dramatically enhance efficiency in the purchase and sale of agri-inputs and farm produce, with direct benefits to the farmer. 770 'e-Choupals' are already operational, covering 4,500 villages across four states in India.

Of course the Punjab case requires some major changes in the thrust of future agricultural development in the state for the benefits of IT use to be realized, and this presents a larger challenge than the ITC example.

Industry

In the case of industry, the general picture that emerged from discussions with policymakers, industry group representatives and IT managers was that the use of IT was not a front-burner issue. The general industrial investment climate in India appears to be poor, with the financial sector carrying a significant amount of non-performing assets, and unwilling to engage in much new lending. Equity markets in India remain in their infancy as well. Other hurdles are the difficulty of exit from any industrial activity, over-regulation in general, and corruption that accompanies such regulation. It was also suggested to us that the loss of guaranteed markets in the former Soviet Union continued to weigh negatively on Punjab's woolens and light manufacturing industries.

Figure 1: Firms' Perceptions of Investment Climate



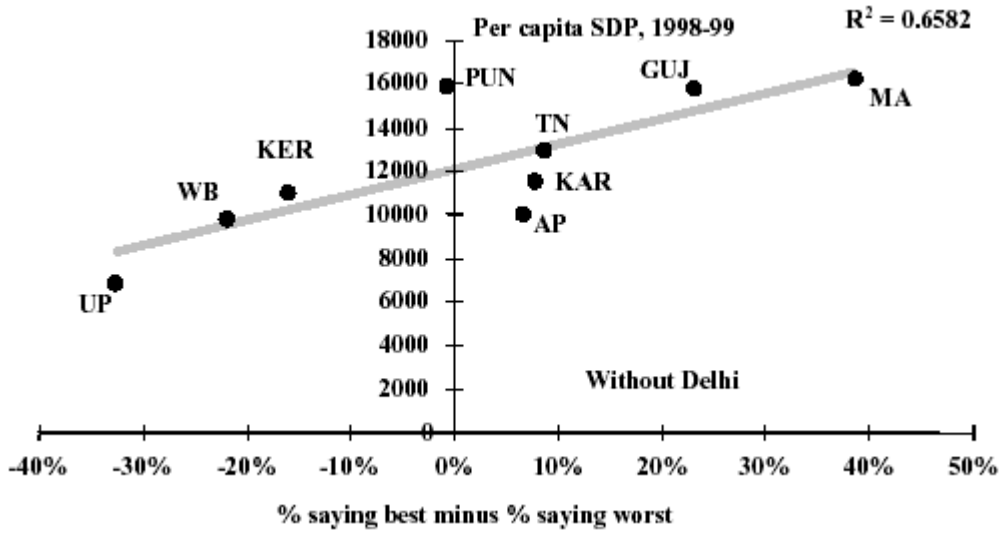
Source: Goswami et al, p. 10, Chart 1.

While these problems exist nationwide, they do so to varying extents. For example, Dollar, Iarossi and Mengistae (2002) and Goswami *et al* (2002) have examined the quantitative impact of state-level variations in policy on manufacturing productivity. Using a survey of 1000 manufacturing establishments across 10 Indian states (including the National Capital Territory of Delhi), they find that states that are poor performers, and identified by survey respondents as having a 'poor investment climate', have total factor productivity (TFP) that is 26 percent lower than the high-performing states. About a tenth of this gap is found to be due to a higher regulatory burden (specifically, labor

market regulations such as factory inspections) in the worse states. Punjab is in the lower half of the states surveyed, as shown in Figure 1.

The situation of Punjab, in the bottom half of the "league table" of perceptions of investment climate, is most strikingly illustrated by plotting a particular measure of perceptions of investment climate against per capita SDP. This is shown in Figure 2, where Punjab is the only clear outlier among the nine states that were surveyed, excluding Delhi. Clearly Delhi would also be an outlier if it was included, and this might suggest that the problem is overstated, since Delhi is a successful IT destination (as is NOIDA in Uttar Pradesh). To some extent this caveat is warranted, but Delhi is a single high-income urban region, and therefore is distinct from the nine states in the sample.

Figure 2: Per Capita SDP and Perceptions of Investment Climate



Source: Goswami et al, p. 10, Chart J.

In any case, there is limited use of IT in Punjab industry. Perhaps the best example is the case of accounting and inventory software. Two strong domestic competitors exist here. One is Bangalore-based Tally Solutions, a private company that makes Tally accounting software. Fieldwork interviews in Punjab suggested that Tally is a market leader for small business accounting software, and that even small shopkeepers are interested in acquiring it and learning to use it. For larger businesses, Tally has recently introduced a server version, which fits the needs of businesses with multiple locations or offices. The second product is E.X. from Tata Consultancy Services (TCS), which is the oldest of India's IT services companies, currently the largest exporter, and a firm with a substantial presence in the domestic business software market. The two companies' products are priced similarly, and in each case one can find all the features of distribution channels, after-sales support, marketing, and product versioning that exist in competitive US markets.

Another example of IT use was that of CAD software in manufacturing firms such as Hero and Punjab Tractor. Unlike the case of accounting software, the products here were not domestic, but made by the U.S. and global market leader in design software, Autodesk. The software is distributed through local resellers, but demand is not very high. Companies tend to purchase limited amounts of software, upgrade infrequently, and demand little customization or maintenance support. Thus, the market for such software is not very strong as yet. The reseller also identified piracy as somewhat of a problem. It may be noted that the small local market also means that the manufacturer appears uninterested in a pricing strategy that would build volume in small country markets, thus perpetuating limited adoption.

In the case of design and other higher-end software, it appears that the structure of Punjab industry may also act as a barrier to IT adoption. Smaller firms are less likely to be able to afford the fixed costs of IT adoption, and this problem is compounded by the lack of competition (partly due to over-regulation), which reduces incentives to modernize production.

On the positive side, as we have noted, accounting software and CAD software were two examples of use of software to enhance productive efficiency, and these are natural ones in the context of Punjab's industrial structure, with many smaller manufacturing firms. More complex uses of software, including networked applications, or more sophisticated logistics or production management, seem to be far away. The thinness of IT use suggests that its development impacts in practice have been limited. The situation reflects the weakness of Punjab's manufacturing industry, as discussed earlier.

It should be emphasized, however, that even at India's level of development, there is tremendous scope for the use of IT. For example, Miller (2001), who surveys the potential for B2B e-commerce in India, gives the example of Reliance Industries, which, though still quite diversified, is now heavily into production and distribution of chemicals. In this area, of the company's 20,000-plus customers in India, about 3,000 are major buyers, accounting for over three quarters of total sales. These major customers are electronically linked to a Reliance-controlled Internet-based market exchange. Using leased- lines, customers can process orders, and Reliance can communicate dispatching details, better manage inventory, carry out invoicing, and provide customer support. Using this system, Reliance has reduced receivables from 310 days to 90 days. General cost improvements have come from an overall tightening and acceleration of processing within the company, and between the firm and its customers. The speed of order delivery has greatly improved, and inventories reduced. A shift from leased lines to the Internet will provide further cost savings.

Reliance is one of the largest firms in India, as well as being one of the most dynamic. The absence of firms like this from Punjab may be partly responsible for the lack of any

discernible impact of IT on the functioning of firms in Punjab. Specifically, both the size distribution of Punjab firms (skewed toward smaller firms), and their focus in more traditional industries may reduce the adoption of IT in Punjab industry. One emerging exception may be in pharmaceuticals, where a more knowledge-based industry cluster might be developed. Otherwise, in general, the sophistication and scope of Punjab's industry does not seem to provide an attractive place for IT use to make an impact, despite Punjab's relatively high per capita income levels and good traditional infrastructure.

Services

One area where higher-end software may be more likely to be adopted is in the financial sector, where the inherent possibilities for digitizing financial information are stronger. This takes us over to the services sector, however, in exploring forward linkages. Large financial institutions, such as ICICI, State Bank of India and Bank of Punjab appear to be adopting IT for internal business processes as well as customer interfaces, but this is a nationwide phenomenon, and Punjab is neither a leader nor a laggard in this respect.

The financial sector in India in general is not in good shape, with the banking sector in particular being overstaffed and subject to political compulsions in making loans. New private banks are somewhat free of these problems, but their role in the sector is still limited, and is overshadowed by the continued dominance of public sector banks and other lending institutions. Government-controlled lending institutions, because of their own financial problems, are unlikely to be leaders in IT adoption, though some progress is being made.

Interestingly, in the case of finance, there is also an important opportunity at the other end of the spectrum. The use of IT in rural banking and micro finance can impact a much broader cross-section of the population. The evidence of pilot schemes such as the SKS InfoTech Smart Card project is encouraging. Handheld computers and smart cards can substantially reduce the costs of making loans, as well as monitoring them. Reducing these transactions costs may turn out to be critical for the scalability and sustainability of micro finance schemes. On the other hand, as in the case of market information for farmers, the relative benefits for Punjab may be lower, since it has entrenched credit institutions that serve the majority of farmers, and the scope for micro finance may be more limited.

The best hope for Punjab in terms of the use of IT in the services sector is the opportunity that is currently exciting many Indian firms. IT-enabled services (ITES) have shown the strongest growth among IT-related sectors in the last two years. They include a variety of types of service, ranging from customer call centers, to accounting services and other business process outsourcing, to GIS and engineering services. Thus the required degree of technical sophistication of the workforce and the level of use of IT can vary widely. In fact, the three categories mentioned make up most of India's ITES exports, with the first

two showing high growth and representing over 60% of the total of Rs. 71 billion. The list of ITES segments constructed by NASSCOM displays ample scope for specialization within the category (Table 2), and it is clear that individual firms are already trying to capture niches. For example, Daksh has a 90% concentration on customer service, whereas HCL Frontline (a division of HCL) is 100% focused on technical support (*Dataquest*, 2002, p. 134).

In the case of Punjab, the draft government IT policy makes ITES a priority, and lists the strengths of the state in this respect. These are said to include a large and technically competent English-speaking workforce and high quality infrastructure. We have already discussed some of these issues earlier. We will also return to a discussion of the policy environment in Section 6. However, here we note that a concerted effort will be required if Punjab is not to miss the boat again. For example, the data on the location of ITES companies from NASSCOM shows that Punjab (and Chandigarh) is nowhere in the current ITES picture (Table 3). Furthermore, the region did not even make the survey of promising ITES cities, in which the cities were assessed on factors such as manpower availability, real estate, telecom infrastructure, policy initiatives, power infrastructure, city perception and entrepreneurial history. Thus Punjab still faces an uphill battle in establishing a niche in this sector.

Table 2: IT-Enabled Services Types

- Customer Interaction Services
- Business Process Outsourcing / Management; Back Office Operations
- Insurance Claims Processing
- Medical Transcription
- Legal Databases
- Digital Content
- Online Education
- Data Digitization / GIS
- Payroll / HR Services
- Web site Services

Source: http://www.nasscom.org/it_industry/spectrum.asp

Even if Punjab is successful in establishing a niche in ITES, the overall employment impacts may be relatively small, in the order of tens of thousands additional people employed (the official target is 50,000 jobs over the next two years). Nevertheless, given the severity of youth employment problems in the state, even marginal impacts will be useful.

Table 3: ITES penetration and ranking of cities

City/Region	Number of Companies	Survey Rank
National Capital Region	53	8
Mumbai	45	7
Bangalore	35	6
Chennai	35	3
Kolkata	29	4
Hyderabad	24	1
Kochi	10	2
Ahmedabad	9	5
Pune	6	9
Others	32	
Total	**278**	

Source: NASSCOM (2002)

6. Governance and Policy Environment

Our discussion so far suggests that the quality of governance in Punjab has been one factor in its failure to take off as a destination for IT investment. Governance is well established as an area where IT can lead to substantial improvements in functioning. There are two broad uses of IT for improved government functioning. First, back-office procedures can be made more efficient, so that internal record keeping, flows of information, and tracking of decisions and performance can be improved. Second, when some basic information is stored in digital form, it provides the opportunity for easier access to that information by citizens. The simplest examples are e-mailing requests or complaints, checking regulations on a web page, or printing out forms from the web so that a trip to pick up the forms from a physical office can be avoided. More complicated possibilities are checking actual records, such as land ownership or transactions. Still more complicated are cases where information is submitted electronically by the citizen, for government action or response.

As in the broader case of using the Internet for communications and transactions, sustainability of e-governance initiatives is a significant issue. Since governments at all levels are financially strapped, the initial investments and ongoing expenditures for IT-based service delivery may act as a barrier to adoption as well as to long-run sustainability. However, a franchise model can be successful here. Low-cost rural Internet kiosks, a tiered franchising model, and a suite of basic government access services for which users are willing to pay, are key components of what Drishtee, an outgrowth of the Gyandoot project in Madhya Pradesh, is implementing in several parts

of India.[10] Cooperation of local governments and subsidized financing have been important elements for Drishtee, as in the case of TARAhaat, with the former being obviously critical in the case of Drishtee. It is important to note that once Internet access is available, its benefits are not restricted to e-governance. Individuals can obtain market information, training, job information, advice on farming techniques, and so on, as discussed earlier in this section.

The Punjab government's implementation of e-governance at the rural level appears to have been very slow, both for reasons of funding and prioritization. For example, TARAhaat explicitly promised e-governance services when it began operations in Bathinda district, but has since abandoned this direction, partly because it perceived a lack of anything to offer. That, in turn, was apparently the result of a lack of progress on the front of computerizing land records. On the other hand, the state government's own sponsored e-governance initiative in Sangrur district appears to have had some success, based on our conversations with state officials in charge of IT policy. Another pilot project that has received attention is at Fatehgarh Sahib, with a Web based Citizen-IT Interface for or services offered by district administration (for example, see http://informatics.nic.in/archive/inf2002apr/e_governance.htm).

IT policymakers in Punjab have developed an elaborate analysis and plan for e-governance, and in some ways have been conceptual leaders among the states, but implementation, as noted, has lagged. To some extent, the elaborateness of the plan, including a statewide identity scheme to manage digital access and exchange of information between citizens and government, has also contributed to delay by substantially raising the setup costs.[11]

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[10] Further details of Drishtee's efforts are in Kaushik and Singh (2002). Drishtee has a pilot effort in Jalandhar, but we did not get much sense of it going forward with any speed. In Jaipur, Rajasthan, it is moving rapidly by piggybacking on the firm Aksh's expansion of a fiber optic cable network.

[11] The 'citizens' database scheme' is described in detail by Nirmaljeet Kalsi as follows: "Almost all transactions with the government require a citizen to prove his identity, the ownership of property as well as his professional credentials. The documents that verify these are typically pre-defined transactions with agencies like the state electricity board, municipal corporation and transport department. If the process of acquiring these documents is automated, the delays in getting such work done will be cut down by 80%. Key services include dissemination of information, billing, handling complaints and grievances, licenses and approvals, certificates, financial transactions or procurements. Therefore the citizens' database, property database and business database along with the departmental databases like Punjab State Electricity Board, old age pensions, food and civil supplies or transport would cover almost all services being provided by the government to the citizens and businesses. The creation of these three authenticated databases will be at the core of our e-governance strategy.

"While Punjab already has the business database in the form of master dealer files (MDF) with the department of excise and taxation, the citizens' database would take some time. We first need to complete the pilot project at Fatehgarh Sahib, the *pro forma* for which has already been finalized. Funds for the door-to-door survey have also been allocated to the deputy commissioner (DC)." From a June 24, 2002 interview with *Dataquest*, available at www.dqindia.com/content/special/102062403.asp.

Areas where some implementation has occurred are in tax collection and information availability. According to Nirmaljeet Singh Kalsi, who has directed much of the effort in this direction: "The results have been very encouraging so far with the improvement in revenue collection by the excise and taxation department. Also, the punjabsewa.gov.in portal offers almost 300 services to citizens." (See footnote 11). Our own examination of this "citizen services portal" suggested limited functionality and available information, although the framework and interface are both attractive and comprehensive. One obvious positive feature of the portal is that its offerings include complete options in the Punjabi language: this contrasted, for example, with the lack of such options on the PAU web based information for farmers (Section 5).

Turning to the broader policy environment, we have noted that Punjab has been a successful agricultural state, and evolved an infrastructure and a set of institutions that provided excellent support for its agricultural economy. At the same time, Punjab's development was very much in line with India's economic policies that emphasized heavy government involvement in all aspects of the economy. In some respects, Punjab's success with agriculture, and its relative success with government intervention in the state economy, have together made it harder to develop the potential of IT in the state. In particular, policymaking remains geared toward traditional crops and the interest groups that benefit from them, including farmers, distributors, input suppliers and other middlemen.

In the late 1990s, as we have discussed in Section 2, there were policy efforts toward developing an IT industry in Punjab. From conversations with people in government and in industry, it appears that implementation lagged substantially behind intentions. Much of the implementation activity within government appears to have been entrepreneurial efforts on the part of a few individuals, with the bulk of the government machinery unchanged in its orientation and approach, and therefore failing to provide an environment for business that was attractive enough to bring in firms with several locational alternatives to choose from within India. The closeness of the Delhi-Gurgaon-NOIDA IT cluster, with better international access and other infrastructure, has been a major factor in this respect. While a few firms did enter Chandigarh and Mohali, major impediments in the allocation of land and the provision of other infrastructure deterred any substantial build-out of a local IT industry.

In 2002, the policy environment appears to have improved in several respects. The government has accumulated substantial experience (its own and that of other states) to help it understand what initiatives are crucial to success. The current policy documents – including the policy on IT and ITES, as well as on industrial policy – are more comprehensive and detailed than earlier ones with respect to the different dimensions of government policy. In particular, there is more of an emphasis on creating a hassle-free business environment, without the roadblocks to startup (e.g., clearances for getting

started) and continuing operations (e.g., various kinds of health, safety and environmental inspections) that have continued to exist. There is also considerable attention being paid to issues of complementary infrastructure, such as housing, social amenities and transportation.

On the input side, technological and institutional changes have worked together to relax the severe bandwidth constraints that earlier hampered growth of the IT sector, though there are still issues of relative cost and reliability. Finally, there is a larger local pool of human capital available than was the case a few years ago, though again quality is an issue, and people with the right technical and organizational skills are still going to be scarce. In order to attract or retain such people, the social infrastructure is crucial.[12]

Of course it remains true that implementation will be the test. Two constraining factors have not changed since the 1990s. The first is what we alluded to earlier in this section, namely, the strength of the societal groups that have a stake in the traditional agricultural economy of Punjab. The second is the continued poor condition of the state government's finances. These two factors are closely connected, of course, through the provision of lavish subsidies for agricultural inputs such as water and electric power.

The state government will have to make several changes in its policy approach in order to overcome its resource constraints. The first is to reallocate its resources toward developing infrastructure for a "new economy" in Punjab. This new economy is not necessarily restricted to software for export, ITES, or even IT alone. It includes IT products and services that can be geared to the needs of the regional economy more broadly. The second is to rely more on the private sector in developing infrastructure. The third is to avoid narrowly targeted financial incentives in an attempt to build up a local IT and ITES sector. Such incentives are typically a strain on the budget, without necessarily overcoming key roadblocks to industry growth.

7. Conclusions

We offer three conclusions in this paper. First, we offer some understanding of the paradox of Punjab's lagging in the development of IT capabilities, despite its being one of the richest states in India in terms of per capita income levels. We have argued that the policy environment was not sufficiently supportive of what was, in fact, a substantially new form of economic activity in the state. In turn, this policy environment has been a function of the state economy's dominance by particular interest groups tied to traditional agriculture.

[12] While these factors are hard to quantify, they came up again and again, in different forms, depending on the profiles of the individuals raising the issues. Among the aspects brought up were clubs for IT professionals with families, entertainment for young single adults, and branded restaurant chains – all these were found to be deficient in Chandigarh. Interestingly, the new IT and ITES policy of the government recognizes such factors explicitly.

Second, we have suggested that some policy shifts are both feasible and can support the regional development of IT and ITES. In particular, policies toward industry that are broadly more favorable, and reduce the costs of starting up and doing business are likely to be more beneficial than narrowly targeted financial incentives. Furthermore, while the direct employment benefits, even with ITES added to IT proper, are likely to be small, the spillover effects can be substantial. We were struck by how little impact the use of IT was having on industry in Punjab, though it is ostensibly an "advanced" state. To some extent, this reflects policies that do not allow successful small firms to expand easily – this is something that has been a problem throughout Indian industry, we believe, since it is the result of policies determined at the national level.

Third, at the micro level, we have been struck by how easily small collaborative entrepreneurial efforts in IT can have an impact on local development. This was most clearly illustrated by fieldwork in Bathinda district. While TARAhaat's efforts in Bathinda district have been fraught with several missteps and implementation problems, they have validated a model of local entrepreneurship that uses IT as an input for a variety of educational purposes. The impacts included new employment created, new services generated, lower cost and broader education delivery, and most importantly, the economic testing of the use of IT in rural areas. Thus, despite the failure of local e-governance to take off (as has been true throughout the state), and mistakes by TARAhaat in strategy and execution, the Bathinda example is indicative of what is possible in terms of developmental impacts.

If anything, the Punjab experience illustrates the importance of policy, but in a nonobvious way. A few years ago, one might have expected that Punjab would easily establish itself as a destination for IT-related investment. It appeared to have very favorable preconditions, in terms of high incomes, good infrastructure, and an enterprising population. Instead, other states and locations have been the ones to thrive. In a sense, they have leapfrogged Punjab in developing ICT industries.[13]

This is not surprising if one believes that local human capital (with technical and organizational skills) by itself is necessary and sufficient to explain the development of ICT industry locations in India, since the southern states had an advantage in this respect. However, it is clear that provision of complementary physical inputs was also critical. Most of all, generally favorable government policies for doing business in a particular state or location have been the crucial ingredient for success. The survey we referenced in this paper was not restricted to IT, but the states that are seen as attractive places to invest in general are also mostly states that have succeeded on the IT front. While specific targeting of policy to remove critical infrastructure bottlenecks is certainly

[13] On the efforts of the government of Andhra Pradesh, see Eischen (2000), and for Tamil Nadu, see Bajpai & Radjou (1999) and Bajpai & Dokeniya (1999). On Karnataka, there are numerous references: see, in particular, the works cited in Saxenian (2001)

necessary, our analysis suggests that a general policy shift is also needed. This is where Punjab took only a short hop, rather than a leap that would be sufficient to cross the chasm to a new economic future. This is what we would suggest is our main conclusion from examining the case of Punjab and comparing it with other Indian states.

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