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OF FLYING GEEKS AND O-RINGS: LOCATING SOFTWARE AND IT SERVICES IN INDIA'S ECONOMIC DEVELOPMENT

by

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RÉSUMÉ

Ce document propose un cadre analytique permettant de comprendre l'évolution de l'industrie du logiciel en Inde et la place de ce secteur dans l'économie du pays. Les auteurs évaluent ensuite la pertinence de ce cadre par rapport à trois grandes questions : *i)* le secteur des TI a-t-il modifié les performances économiques globales du pays au niveau national et dans les différents États ? *ii)* quel a été l'impact de la croissance du secteur des TI sur la répartition des revenus et la pauvreté ? *iii)* quelles politiques ou quels autres types de mesures pourraient permettre d'améliorer les retombées de cette croissance pour l'ensemble de la population indienne ?

SUMMARY

This paper offers an analytical framework for understanding the evolution of India's software industry and its place in the broader economy. It then considers how well the framework helps to answer three questions: *i)* What difference has the IT sector made to aggregate economic performance, at national and at state level? *ii)* What has been the impact of IT-sector growth on income distribution and on poverty? *iii)* What policy or other measures might enhance the benefits of the sector's growth to ordinary Indians?

I. INTRODUCTION

The spectacular growth performance of India's software sector and, more recently, IT-enabled services (ITeS) has been well-documented (cf. OECD, 2000, chapter 6 by Ashish Arora; also the more recent review in Goldstein and O'Connor, 2002). Salient facts include:

— In 2001, India's IT sector revenues — predominantly software and services — were approximately $8.5 billion, of which exports amounted to $6.3 billion, which makes them 15 per cent as large as total merchandise exports, i.e. roughly on a par with gems and jewellery and bigger than garments.

— Over the previous five years, software exports grew by more than 50 per cent per annum.

— The IT sector's revenues amounted to roughly 2.8 per cent of GDP in 2000-01; the share of value added in revenues is not known, though it is thought to be rather high.

— As of 2001-02, total Indian IT employment (including ITeS) amounted to over a half million people, with a few of the largest firms employing upwards of 10 000 people each. This figure represents, however, a tiny share of total non-agricultural employment — less than half of a per cent.

— About 60 per cent of India's software and service exports are destined for the United States, with the United Kingdom another major customer and Europe as a whole absorbing a quarter of exports; the remainder are spread across dozens of other countries.

— More than 185 of the *Fortune 500* companies outsource some of their software requirements to Indian software houses.

— Software firms are clustered in Bangalore (Karnataka), Chennai (Tamil Nadu), Hyderabad (Andhra Pradesh), Mumbai (Maharashtra), and the Delhi region. Some 84 per cent of NASSCOM's 405 members (as of 1997) were based in these locations.

In part as a response to weak IT market conditions in the United States, India's software and service providers have recently been diversifying strongly into business process management for overseas clients, which involves the outsourcing of functions of whole divisions or departments. In addition, call centres and other IT-enabled services have grown especially rapidly in the past few years: call centre employment doubled in one year, to 16 000 in 2000-01; comparably strong employment growth has been recorded in the area of content development, engineering & design, animation and GIS, with 12 000 jobs added in a year.

Clearly, the IT sector is large enough in terms of export and GDP contribution to make a non-negligible difference to overall macroeconomic performance. At the level of individual states where the IT sector has clustered, the contribution to growth performance is apt to be more noticeable than at national level.

This paper offers an analytical framework for understanding the evolution of India's software industry and its place in the broader economy. It then considers how well the framework helps to answer three questions:

i) What difference has the IT sector made to aggregate economic performance, at national and at state level?

ii) What has been the impact of IT-sector growth on income distribution and on poverty?

iii) What policy or other measures might enhance the benefits of the sector's growth to ordinary Indians?

The next section presents the analytical framework, which combines eclectically elements of different theoretical literatures. Section III then considers the evidence for the IT sector's contribution to economic performance. Section IV looks at distributional questions, addressing the criticism that the IT sector is largely an enclave economy that generates few benefits — either directly or indirectly — to the wider population and, in particular, to the uneducated and unskilled. Section V concludes with a discussion of policy implications.

II. MAKING SENSE OF IT ALL

Historically, the Indian software industry relied heavily on what is known as "body shopping", *viz*. Indian software houses flying their professional staff to the sites of their overseas clients to work on software jobs before returning to home base. Hence, the term in the title, "flying geeks"[1]. By this term, however, I intend not simply to denote this aspect of the Indian software industry's market entry strategy, but also to suggest a possible kinship between the Indian software experience and the so-called "flying geese" pattern of East Asian development. In this case, however, it is India that takes the place of lead goose, with other countries in the region aspiring to follow its flight path.

Flying Geeks and Market Penetration

An interesting question for understanding the history of Indian software success is whether the flying geeks were indispensable to effective penetration of US and other OECD markets. Could Indian software houses have achieved the same early success if they had simply done all the software development work from their Indian base? It seems very unlikely, for a couple of reasons. First and most importantly, software development is an informative-intensive activity and some but not all of the relevant information can be readily codified and digitised. Software code is one thing, but understanding deeply the functions of the software within the context of a specific organisation — *viz*. the client firm — is quite another. This is especially true if, as was the case when the Indian software export boom began, much of the installed software base was still firm-specific customised software run on mainframes or minicomputers, not shrink-wrapped PC software packages. For the effective transmittal of such information, a telephone or data link is a very imperfect substitute for face-to-face (F2F) contact (see Leamer and Storper, 2001 for an argument on the enduring importance of F2F in the internet age). A second reason why it is hard to imagine Indian software success without the flying geeks is the central role of trust in the business relationship between client and software service provider. For the outsourcing of software services to be effective, the client has to willing to share confidential business information with the software house, which means that the former must trust the latter not to divulge such information to competitors. As the internet era has made plain, building such trust is no mean feat in a world of anonymous long-distance transactions. Normally, reputation associated with an established brand name goes a long way towards instilling trust in prospective customers, but when companies are new entrants to an industry they cannot ride on reputation. Again, face-to-face

1. According the Webster dictionary definition, a geek is "a person who is single-minded or accomplished in scientific or technical pursuits but is felt to be socially inept".

contact and interaction are vital to building trust. This need not involve prolonged periods of residence on clients' premises, but it must involve sufficient F2F contact and interaction for clients to be able to assess both the technical and the managerial capabilities of prospective contractors. Once reputation is established, as it is for many leading Indian software houses, this function of F2F contact diminishes in importance[2].

In sum, the "flying geek" has figured centrally in the market entry strategies of Indian software exporters. The reliance on "body shopping" in the early days of the industry, with its generally higher costs and lower profitability than India-based work, can be viewed as a kind of market-entry-pricing strategy. Profits foregone in the near term laid the groundwork, through the establishment of trust and reputation effects, for reaping higher profits in the longer term.

Clustering

There is another, less formalised aspect of F2F contact that can help explain an important feature of India's software industry, viz., its tendency to cluster in a handful of locations. This is the "Silicon Valley" effect of intensive exchange of ideas among like-minded people working in the same trade that is greatly facilitated by their close physical proximity and frequent social interaction. *That* such an industry clusters is a virtual certainty; *where* it clusters is partly a matter of chance, partly of design. Hence the interest of policy makers not only in India but throughout the world to identify the combination of factors under their control most likely to attract "desirable" (read "high-tech) industries. (We return to this question in the final section of the paper.)

If there really are significant benefits to clustering of software development or other high-tech activities, these should be measurable. In short, there should be above-normal returns to firms and industries that are able to reap economies of agglomeration (geographic concentration). In addition to the intensive interchange of ideas and know how, these economies can also derive from other sources, e.g. lower transport and logistical costs from being close to suppliers and customers, and the lower search costs and better job matching from a large local talent pool. The relevant question for empirical investigation — though one not easily answered — is whether a set of software firms widely dispersed geographically would show a significantly different average labour productivity from an identical set of firms geographically concentrated in one area. To wit, does concentration itself boost industry-wide productivity?

Rauch (1993) and Ciccone and Hall (1996) both find evidence from the United States of significant positive productivity and income effects associated with spatial density, i.e. a large amount of capital and labour per square metre. This is a more diffuse sort of agglomeration effect than that associated with the geographic concentration of a specific industry like software. It does suggest, however, that the productivity benefits of agglomeration extend rather widely across occupational groups, not being confined to high-skilled workers or high-technology sectors. If true for India as well, it would suggest that agglomeration yields positive spillovers even to the unskilled, but only to those employed locally. (We return to this in Section IV.)

2. Nevertheless, Indian software companies still face the problem of maintaining credibility in the eyes of customers due to the high turnover of skilled staff (Arora and Athreye, 2002).

Lall *et al.* (2001) have attempted to estimate the importance of agglomeration economies for Indian manufacturing. They distinguish three sources of economies: reduced transport costs and improved market access; benefits from industry-specific concentration such as sharing of a pool of skilled labour, improved information and technology flow among firms, more efficient subcontracting, and low-cost specialised intermediate input supply; benefits from urban density such as well-developed infrastructure, a diversified range of services, and inter-industry information flows. Offsetting costs of agglomeration include congestion and bidding up of rents and wages. The net effects of agglomeration are tested empirically and prove to be decidedly mixed. In general though, urban density *per se* involves more diseconomies than economies for manufacturing activities, though this result does not necessarily carry over to services like software.

O-rings

Thus far, we have been considering evidence of productivity benefits from geographic concentration of economic activities. There is another possibility, suggested by the "O-ring" theory of development (Kremer, 1993), that — within a single production process involving multiple interdependent sub-processes — workers can boost their productivity by matching themselves with other workers of comparable skill. A failure or defect in any single sub-process or component (like the Challenger's O-ring) would render the value created by others null and void. Hence, to maximise the returns to one's own skills, one seeks out others able to match one's skills, i.e. to produce inputs of requisite quality. This is a sort of skill-clustering that may or may not — but often does — have a geographic dimension as well (see Florida, 2000, for a geographic interpretation). Software development would appear to fit well this process description, where any individual who writes faulty code at any stage in the development of a programme threatens to devalue the entire product.

In its original formulation, Kremer proposes the O-ring theory as a possible explanation for the wide skill and income gap between rich countries and poor countries. Yet, as the Indian case makes plain, skilled labour is also plentiful in some developing countries. The O-ring theory may provide a useful lense through which to view the skill matching that is evident in India's software industry. On the one hand, the creation of a pole of attraction for highly skilled individuals within India diminishes somewhat the pull of emigration to the United States or other OECD countries. On the other hand, it provides an environment within which such individuals can combine their skills with those of others to maximise their joint productivity, rather than face the prospect of employment in low-productivity jobs elsewhere in India[3]. Thus, given these two alternatives, the matching of skilled workers in a high-productivity industry like software may yield the largest possible benefit to the Indian economy. Apart from the static returns to skill in agglomerations like Bangalore, Chennai or Hyderabad, there is the question of whether the high private returns to human capital in such locations stimulate a greater investment in human capital than would otherwise have occurred. If so, then this could have dynamic income effects.

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3. While a software professional in India earns only about one-fifth to one-half what s/he would in the United States, that is still about 20 times the national average wage.

III. THE SOFTWARE/IT SERVICES SECTOR AND INDIAN ECONOMIC PERFORMANCE

What difference has the software and ITeS sector made to India's economic performance? A few macroeconomic aggregates were mentioned above, but here we explore the question in greater detail.

While the beginnings of Indian software contracting date back at least to the early 1980s, the sector achieved a critical mass only in the mid-1990s (exports approached $500 million in 1994/95)[4]. Thus, in understanding software's contribution to growth, we will be concerned essentially with the period since 1990. The reforms that helped lay the groundwork for the take-off of India's IT sector date to the mid-1980s, when the government partially liberalised computer hardware imports with its 1984 Computer Policy. Economic reforms gained momentum only after the balance-of-payments crisis of 1991, but they remain far from completion. Historically, the software sector was not severely handicapped by the generally inhospitable business environment precisely because its links to the domestic economy are so limited. Its infrastructure requirements consist of reliable satellite links to major markets in the United States and Europe and a reliable electricity supply for the computer installations. Provision for both has been made either by the companies themselves or by dedicated software industry parks modelled on the hardware-oriented export processing zones of East and Southeast Asia. Since 1993, the Software Technology Parks of India (STPI) have offered the only alternative international connectivity to the state telecoms monopoly, VSNL, *via* earth-to-satellite links to Intelsat; as of 1999, STPI had earth stations in 13 cities, catering mainly to software exporters and a few other corporations (Wolcott 1999).

This combination of benign neglect and targeted provision of key infrastructure has supported the software boom, which has also benefited until now from the sector's limited linkages to the rest of the economy. Even with few forward and backward linkages, the dynamism of this sector has noticeably affected growth performance in the states where it is concentrated. The states with the fastest growth in real state domestic product (SDP) from 1990/91-1998/99 were, in descending order, Karnataka (7.9 per cent p.a.), Maharashtra (7.5 per cent), Gujarat (7.4 per cent), West Bengal (6.8 per cent) and Tamil Nadu (6.6 per cent)[5]. Three of these states have heavy software concentrations,

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4. For software export figures dating back to 1980 (when they registered only $4.0 million), see website of Richard Heeks at University of Manchester: http://idpm.man.ac.uk/ipdm/isiexpt.htm.

5. These SDP data can be downloaded from: http://www.statesforum.org/DATA/GSDPTOT.XLS. Incidentally, Andhra Pradesh's SDP growth rate was slightly below the national average over this period.

though clearly this does not mean that software development has been the major contributor to above-average growth.

Any effort to establish the role of software and ITeS per se in growth of state domestic product requires a more detailed disaggregation of sectors than was available at the time of writing. Pending verification, we assume that software and ITeS are classified as “Other services”, which is defined to include “business services”. In the data available from statesforum.org, however, this category would appear to include as well a variety of other important services (e.g. education and research, and medical and health services) that when combined tend to dwarf software services and, given their generally slow rate of growth, account for a low overall growth rate of “other services”.

Over time, with the further liberalisation of India’s economy, other sectors could expect to enjoy the relative ease of doing business that until recently has been largely the privilege of the software sector. The telecommunications and internet service sectors are now also benefiting from deregulation, which should provide a strong boost to their development. In the next few years, at least the major cities of India should be linked by high-speed fibre optic networks that should stimulate internet applications and demand. To sustain its software industry’s international competitiveness, India also needs to upgrade international bandwidth; by one recent comparison, China’s is five to seven times greater than India’s[6].

Ensuring the continued international competitiveness of the software industry has provided impetus to the reform of public utilities at the state level, in particular in the telecoms and power sectors. The serious power bottlenecks experienced by industry because of the virtual bankruptcy of state electricity boards has forced many enterprises to invest in their own costly diesel generators to ensure a reliable electricity supply[7]. In states where the software industry has come to constitute a significant economic force, it has had some success in lobbying government to accelerate liberalisation in the interest of financing capacity expansion. Other sectors should enjoy the cost reductions and productivity gains from a more reliable power supply.

Arora and Athreye (2002) argue that the software sector has contributed to Indian economic performance well beyond the macroeconomic indicators of GDP share, employment and foreign exchange earnings. In particular, they argue that software companies have come to represent models of good corporate governance that other Indian enterprises can and increasingly do emulate. This creates productivity spillovers to other sectors. Among the practices the authors cite are: *i)* increased investment in staff training; *ii)* incentive pay linked to corporate performance; *iii)* flat hierarchies and team organisation, designed to encourage knowledge sharing. An important alleged effect of the sector’s stellar performance has been to cause technical personnel to look more favourably upon entrepreneurship and, in many cases, to venture on their own. As with Fairchild in the early days of Silicon Valley, the Indian IT giant, Wipro, has been an especially prolific progenitor of start-ups by former employees.

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6. *Dataquest India*, 11 March 2002.

7. A CII/WB survey of 1 099 manufacturing enterprises finds that, averaged across states, some 70 per cent invest in their own generator sets (Goswami *et al*., 2002).

Arora and Athreye make the further claim that the rapid growth of the ITeS sector in the last few years has depended heavily on copying the software industry business model. To the extent that is true, it would suggest another sort of positive externality of the software industry's development, one moreover that would tend to have positive distributional consequences insofar as the average employee in a call centre or other ITeS operation is likely to have a somewhat lower education and skill level than the typical software engineer. Evidently, the call centre worker must have command of the English language and be highly trainable and therefore is unlikely to come from the poorest stratum of the population. Still, the expansion into ITeS would appear to represent a move down the skill ladder in terms of average employee profile, though admittedly this sector covers a broad range of activities from very high-skilled (engineering design) to less-skilled (data entry).

Thus far, the Indian software industry has been heavily export-oriented. As of 2001-02, the domestic software market was only about a third as large as exports[8]. Domestic software sales are, however, growing rapidly. As the Indian economy continues to liberalise and domestic enterprises are faced with growing competitive pressures, information technologies will play an increasingly important role in rationalisation and cost-cutting. Singh (2002) emphasises the potential for IT to increase efficiency across the Indian economy, suggesting that in a latecomer like India it is possible for firms to leapfrog over costly EDI systems directly to web-based procurement, inventory, and supply chain management. Along with Desai (2000), he stresses the need for broad labour law reform if the productivity benefits of IT are to be fully realised. In short, workers' concerns over retrenchment need to be addressed in a more flexible manner than currently.

8. Based on data from NASSCOM website: www.nasscom.org.

IV. SOFTWARE DEVELOPMENT, INCOME DISTRIBUTION AND POVERTY REDUCTION

Sceptical observers of the software sector's development are quick to note that the benefits accrue largely to a small educated elite, mostly consisting of graduates from India's institutes of science and of technology. There is certainly an element of truth in this view, since the overwhelming share of skilled software engineers, programmers and systems analysts come from the tiny segment of the Indian population that has a tertiary education. So, the first-order benefits of above-average wages are enjoyed by a privileged few. Naturally, one can point to multiplier effects of these salaries on local goods and services industries that, to varying degrees, employ low-skilled workers. Few estimates have been made of how large those multiplier effects are, and even those fail to quantify the share of the poor in associated income gains. Moreover, there is some evidence from the United States at least that even relatively low-skilled workers in a geographic area rich in human capital benefit in terms of higher wages than comparable workers elsewhere. (Assuming a close association between of wages and productivity, this would suggest that more talented — hence productive — low-skilled workers are selected into jobs working for or alongside people with high human-capital endowments.) If this is the case in India as well, it would seem to suggest that the social returns to human capital exceed the private returns, but that those social returns dissipate rather quickly with distance from the agglomeration of high-skilled activities. So, while the growth of this sector, with its high-paid professionals, may be widening income inequality, the effects are muted at the local level to the extent that the less-skilled also benefit from higher incomes.

Except via the overall GDP growth stimulus provided by this dynamic sector, it seems doubtful whether its rapid expansion has been particularly auspicious for poverty reduction. As there is little in the way of empirical evidence bearing directly on this question, one must approach it indirectly by considering differential growth performance across Indian states, how well those differences are explained by the presence or absence of a dynamic software industry, and what difference growth in a particular state makes to nation-wide poverty reduction. The first and third links in the chain we have from the work of Datt and Ravallion (2002). The second we need to provide ourselves.

First, let us consider the evidence on state-level growth and national poverty reduction. Based on a headcount index of poverty for 1993/94, Datt and Ravallion (2002) identify the states whose percentage shares of national poverty are highest[9]. The top four (in descending order) are: Uttar Pradesh (17.8), Bihar (16.7), Maharashtra (10.8),

9. In that year, the national average poverty headcount was 39.1 per cent (Datt and Ravallion, 2002).

and Madhya Pradesh (9.2). Based on data from 1960 to 1994, they also calculate, state-by-state, share-weighted elasticities of poverty with respect to changes in non-agricultural output per capita. The higher the elasticity, the more output growth in that state contributes to reducing national poverty. The five highest elasticities are: Uttar Pradesh (-0.12), Madhya Pradesh (-0.059), West Bengal (-0.056), Maharashtra (-0.054), and Bihar (-0.043). Even though Bihar has a rather high share of people living in poverty — indeed the highest headcount index in India at 60.3 per cent in 1993/94 — non-agricultural output growth there over the past several decades has had a relatively weak effect on poverty reduction.

What is the relevance for our discussion of the software/IT services sector? Clearly this sector counts in the figure for non-agricultural output growth, though it is by no means the only — or even necessarily the most important — source of such growth in most states. It is noteworthy that, among the states where non-agricultural output growth contributes most to poverty reduction, only Maharashtra is among those hosting an important software agglomeration (Mumbai). Andhra Pradesh (with Hyderabad) has a share-weighted poverty elasticity of -0.017, Karnataka (with Bangalore) -0.035, and Tamil Nadu (with Chennai) -0.032. Of course, even if their poverty elasticities are relatively low, a high non-agricultural output growth rate could still substantially reduce poverty. A ranking on this measure does suggest that some of the “high-tech” states are indeed growth leaders, with Tamil Nadu enjoying a 58.9 per cent increase in non-agricultural output per capita (1993/94-1999/00), second only to Kerala’s 73.5 per cent. Karnataka enjoyed the third highest non-agricultural output growth per capita (53.4 per cent), followed by Rajasthan (44.3 per cent), then Andhra Pradesh and Punjab (both with 43.2 per cent). Among the large states, the slowest growth was registered in Madhya Pradesh (18.1 per cent), followed by Orissa (26.3 per cent), Maharashtra and Bihar in close succession. If we compare the poverty reducing effects (1993/94-1999/00) of per capita non-agricultural output growth in Bihar (with the highest poverty headcount at the beginning of the period) to that in Tamil Nadu, we find that the latter’s estimated contribution to reducing the national poverty rate was roughly double the former’s. In short, despite a below-average poverty headcount of 34.9 per cent in 1993/94, and a relatively low share-weighted poverty elasticity, Tamil Nadu’s exceptionally strong non-agricultural output growth ensured a large contribution to poverty reduction. Even in Karnataka, with its slightly slower growth than Tamil Nadu and very slightly higher poverty elasticity, non-agricultural output growth made a somewhat larger contribution to poverty reduction than in Bihar. Similarly in Maharashtra, where non-agricultural output growth was among the lowest, the high poverty elasticity made for a marginally higher contribution to poverty reduction than in Bihar. Among the “high-tech” states, only in Andhra Pradesh has non-agricultural output growth in the 1990s made a relatively minor contribution to poverty reduction (smaller that is than in Bihar).

The next question we would like to be able to answer is what contribution the software and IT services sector has made to the strong non-agricultural output growth in states like Karnataka and Tamil Nadu. The answer can only be approximated through indirect evidence. Historically, Tamil Nadu has been one of India’s most industrialised states, with industry representing 29 per cent of state GDP, several points higher than the national average. Major industries include textiles, leather goods, engineering, petrochemicals, motor vehicles and railway stock (Maclay, 2001). So, there are multiple potential contributors to non-agricultural output growth. In actual fact, however, manufacturing grew rather slowly in Tamil Nadu during the 1990s, by a mere 2 per cent p.a. in real terms, while services grew by 10 per cent p.a. (based on statesforum.org data).

A final consideration in assessing how widely the benefits of the software industry's growth have been shared is the heavy reliance of many software firms on equity markets to raise capital and the rather broad participation of the Indian public as equity investors (Arora *et al.*, 2001). Of course, in the last few years, the Indian stock market has not been immune from the global malaise, and technology stocks have faced rough sailing, so any wealth effect from holding software stocks has been greatly reduced.

V. POLICY TO SPREAD THE BENEFITS OF IT-BASED GROWTH

From a policy perspective, there are a few implications of the preceding analysis. The first is that, even if strong growth in states like Karnataka and Tamil Nadu, driven in part by the software and ITeS sector, contributed significantly to national poverty reduction, stronger growth in some other states would have far more dramatic impacts, given their higher poverty elasticities. In particular, stronger non-agricultural output growth in Uttar Pradesh could have contributed more strongly to poverty reduction than was actually the case with the 37.3 per cent growth observed 1993/94-1999-00. Likewise for Madhya Pradesh, with its high poverty elasticity but very slow non-agricultural output growth (only Assam having had slower growth). The actual contribution of that state's non-agricultural output growth, 1993/94-1999-00, to national poverty reduction was even lower than Bihar's. It is perhaps not surprising that, of the 10 states ranked by companies in terms of investment climate in the recent CII/World Bank survey, Uttar Pradesh ranked worst (Goswami *et al.*, 2002). The same survey shows UP firms to have by far the highest mean blended electricity costs (considering both public grid and private generators), also the highest median cost of all 10 states. This does not bode well for attracting software firms that depend heavily on affordable and reliable electricity. One element of the poor investment climate in UP (severe delays in customs clearance) is not likely be as serious an impediment to software investment as to manufacturing investment.

Limitations of physical infrastructure and regulatory impediments help to explain why some states of India attract so much less investment than others (at least in manufacturing but probably also in software and ITeS). The dearth of investment in turn helps to explain the slow rate of non-agricultural output growth, at least in UP. Datt and Ravallion address another question, *viz*. why a given rate of non-agricultural output growth can have a significantly different poverty impact from one state to another. They identify several initial conditions that are associated with stronger poverty-reducing effects of such growth. These include: high female literacy, low infant mortality, low rural landlessness, low urban-rural income/consumption disparity, and a high agricultural yield per hectare. The first of the five variables is estimated to have the largest and statistically most significant effect on poverty reduction. While not tested by Datt and Ravallion, it seems highly plausible that the initial literacy rate of a state's workforce would make an important difference to the possibility of attracting investment in the software and ITeS sector (and other human capital intensive sectors) in the first place. Tamil Nadu's female literacy rate (at roughly 65 per cent) is among the highest in India, exceeded only by Kerala and Maharashtra[10]. In contrast, female literacy in Andhra Pradesh is only 51 per

10. Based on 2001 census data reported at: http://www.censusindia.net/maps/femaleliteracy.html.

cent, which goes some way towards explaining the low poverty elasticity of non-agricultural output growth in that state.

As Desai (2000) argues, a key consideration for Indian policy makers ought to be to ensure that the boom in the IT sector not only raises India's growth rate so long as it lasts but that it also has a lasting effect on the economy's growth potential. For the latter to happen, the policy environment needs to encourage the more widespread adoption of IT by traditional industry as well as within the service sector. The need for greater flexibility in reallocating labour is mentioned by Desai as one of a list of measures that would need to be put in place to accelerate growth. Most of the others relate to broad macroeconomic management, but labour market flexibility relates specifically to the conditions for more rapid IT diffusion.

Lal's work (2002) confirms that firms that have the greatest international exposure and technical collaboration with foreign companies have a higher propensity to employ advanced e-business technologies. This suggests that, as India's economy becomes progressively more open and businesses more closely linked to overseas suppliers and clients, the pressures to adopt such technologies should spread more widely. Until now, as Arora *et al.* (2001) note, there has been relatively little synergy between software development for domestic clients and that for overseas clients. As domestic enterprises increasingly seek to sell into overseas markets and source from overseas suppliers, their software needs — notably in the area of e-business and web-based applications — are likely to converge towards their overseas partners'. This could in turn create stronger synergies between the domestic and export software markets, allowing learning in one to be more readily applied to the other.

The intellectual property regime takes on added importance as the Indian software industry — or at the very least innovation leaders — seek to exploit opportunities to move from project-based contract work to the systematic creation of intellectual property that can be copyrighted and/or patented, thereby yielding the prospect of repeat sales and potentially large profits. Moving in this direction creates other challenges for the industry and for policy makers, as it implies heavier up-front investments in R&D with higher risk as well as higher marketing costs and a potentially longer payback period. All of this requires access to substantial sums of risk capital such as had begun to flow into India prior to the bursting of the dotcom bubble. Government liberalisation of regulations on repatriation of profits from venture capital investments was instrumental in facilitating the inflow.

Finally, let us return to the question of the replicability of the "flying geek" model broadly conceived. The is a question of interest not only to national governments in other countries of Asia and the developing world, but it is also of interest to state governments of India other than those that have already succeeded in hosting large players in the software and ITeS industry. Can a Bihar, a Madhya Pradesh, an Uttar Pradesh ever hope to follow in the footsteps of a Karnataka, Tamil Nadu, Andhra Pradesh? There is no clear-cut answer, but the cards are stacked against them in the near term for the reasons alluded to above — poor infrastructure, burdensome regulation, low literacy rates — plus others that have not yet been mentioned but are explored in Florida's 2000 paper on "The Economic Geography of Talent". The harsh reality is that highly-educated individuals do not choose to live just anywhere and cannot be persuaded easily to move to places that lack the amenities they value, at least not at an affordable cost in terms of compensating salary differentials. A location with poor schools and health care facilities, few cultural facilities, few parks and other natural amenities, to name a few, is simply not likely to attract a large highly-educated labour pool. Thus, while rising land, labour and other costs eventually forced many firms in Silicon Valley to expand to lower cost locations, they tended to cluster once more in a few locations with just the sorts of amenities that would attract educated workers, *viz.* Portland, Oregon; Phoenix, Arizona; and Austin, Texas. They did not move to Detroit, Cincinatti, or for that matter Pittsburgh — at least not in large numbers, not yet. Likewise in India, the clustering has spread from Bangalore to Hyderabad and Chennai, but not yet to major cities in India's poorest states — e.g. Patna, Bhopal, or Lucknow. Hence the importance of generating a local talent pool of individuals who have personal attachments to a location not entirely dependent on the quality of amenities.

One development working in favour of a "flying geeks" pattern of development encompassing multiple countries with India in the lead is the growing concern of clients for back-up systems to hedge against security threats. This will gain even greater importance to the extent that Indian software companies succeed in winning "mission critical" business from clients like business process and IT systems management. Since an entire country could be adversely affected by risks like the outbreak of war, diversification of locations will necessarily spill over national borders. Other countries in Asia are likely to see share in the benefits of Indian software companies' decentralisation and risk-spreading efforts. Needless to stay, those locations which pose the lowest political and security risks of there are likely to benefit disproportionately, assuming that the other conditions are in place to attract software investment: a hospitable investment climate, a reasonably large local skill pool, liberal regulations on short-term two-way migration of skilled workers, and reliable and low cost telecommunications and electricity infrastructures.

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