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ICT Adoption and Productivity Gains in Indian Manufacturing*

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INTRODUCTION

Adoption of Information and Communications Technology (ICT) can affect the performance of firms in a variety of ways, including faster processing of information and products, the facilitation of changes in business practices and improved internal organisation and management. Indeed, much of the recent research on developed countries in this area has emphasised less the adoption decision *per se* than what adoption facilitates. In particular, ICT is widely viewed as enabling changes in business and other processes that in turn can generate improvements in performance. It has been argued that the wide variations observed in the estimates of the contribution of ICT to output and productivity are, at least partly, due to differences in co-investments (including those in organizational change) and associated changes in business and other processes. Thus, ICT investment directly affects production processes and permits other productivity enhancing changes, such as customisation, thereby modifying the overall business strategy of the ICT adopting firm.

Based on the literature on developed economies, it is now widely accepted that ICT has a reasonably large and positive impact on both productivity and output growth. However, little is known about the determinants, extent and consequences of ICT adoption in developing countries. The limited descriptive evidence on developing countries has highlighted large variations in ICT adoption across and within countries and sectors.[1] This variation is traced to a variety of factors, including differences in pricing and government policy. Policy shifts in favour of privatisation, lowering of trade barriers and de-regulation have raised investment in communications sectors and improved access to ICT technology, particularly in middle- income countries, such as Brazil. Even so, firm level surveys point to significant constraints on adoption, including those of an institutional nature – such as business environmental constraints – as well as constraints originating from the labour market, most notably relative skill shortages. It also seems that inadequate telecommunications services remain a major problem in several countries. Despite these limitations, the small body of available evidence suggests that ICT adoption has accelerated over the past five years and that ICT may exert a positive impact on adopters' performance. For example, a recent World Bank (2006) study reports correlations between a simple measure of ICT use and a number of performance indicators, including growth in sales, employment and re-investment, suggesting that there is some evidence of ICT use being associated with enhanced performance. More robust econometric evidence on the impact of ICT adoption in developing countries

is not available.

In a recent paper, an effort was made to bridge this gap by analysing the diffusion and impact of ICT in two large developing countries, namely Brazil and India. It used a unique primary survey-based dataset of nearly a thousand firm-level observations for several points in time over a four-year period for the two countries. The data covers six manufacturing branches located in multiple regions of these countries.[2] The study found strong and robust evidence of the impact of ICT usage on performance. These effects cut across sectors and countries and also seem to be related to organisational changes and to regional constraints. However, there was considerable heterogeneity in both adoption and performance. Not only were there significant differences in the timing of adoption and the resulting patterns of ICT usage across the two countries, there were also differences within the countries themselves. This analysis builds on the empirical findings of this study to explore the policy options that can facilitate adoption of ICT by manufacturing firms and thereby enhance their productivity.

COUNTRY CONTEXT

Brazil is well ahead of India in terms of overall ICT adoption and investment. Several indicators, including the index of ICT adoption reported in Figure 1, show this pattern (see also Appendix Table 1).[3] In terms of policy, both countries have seen clear changes in recent years, particularly in India. Telecommunications have been liberalised, with significant entry of new providers, especially for mobile and internet services in India. With respect to the trade regime, in India, un-weighted tariff rates for the six branches fell on average by over 60% between 1999 and 2005. At the start of the period, the average tariff rate was 33.5%, falling to 15% by 2005, except in electronics where it was only 1.9%. In Brazil, the tariff structure has remained basically unaltered since the mid 1990s as most trade liberalization occurred between 1990 and 1995. By 1998, Brazilian tariffs were mostly close to the Indian rates that existed in 2005 and hence were substantially lower than the Indian tariff rates in the late 1990s, with the exception of auto-components that received protection of 46%. In the case of labour legislation, neither country saw significant change in recent years. Thus, broadly, while Brazil has had a fairly liberal regime, India has seen more significant policy induced liberalization processes in recent years.

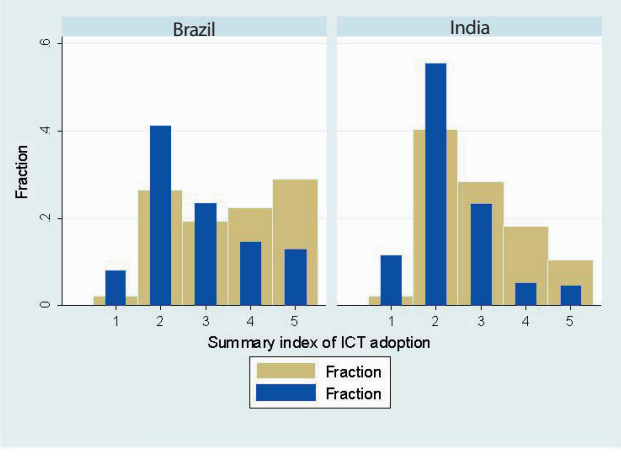

Figure 1: Summary index of ICT adoption, 2001 and 2003

Source: Basant, Commander, Harrison and Menezes-Filho (2006).

Notes:

1. Thin bars are for 2001, thick bars for 2003.
2. Index: IT is not used at all=1; IT is used only for some office along with accessing the Internet, e mailing =2; IT is used for some advanced applications. Most processes are automated but there is no integration into a central system=3; Most processes are automated and some of them are integrated into a central system=4; Almost all processes are automated and integrated into a central system=5

ICT ADOPTION AND PRODUCTIVITY

In line with some of the evidence from developed countries, returns to ICT investments in India and Brazil are very high. These high returns persist even after including skills, occupation, management practices and other controls such as complementary changes (e.g., organisation of work practices).[4] The evidence also suggests that this positive effect of ICT adoption only takes off above a certain threshold level of adoption. Low intensity users of ICT – still a major share of firms in both Brazil and India - receive little or no positive impact. For example, in the case of India, returns to ICT investment become significant only when IT is used for some advanced applications and most processes are automated – adoption level 3 in Figure 1; for Brazil productivity gains are significant only after firms cross the 'threshold' of level 4.

CONSTRAINTS ON ICT ADOPTION

Given such large returns, why do firms not invest in ICT and, if they do, remain low intensity users instead of crossing the "threshold" (e.g., adoption level 3 for Indian firms) critical for reaping higher returns? A weak institutional environment that often exists in developing countries can constrain IT adoption. For example, in the context of ICT adoption and use, the level and predictability of taxation/trade policy, availability of skill generation/up-gradation systems or labour legislation can potentially affect not only adoption but also the subsequent impact on performance.

Table 1 summarizes firm responses to get a better sense of how such institutional barriers might come into play and prevent firms from investing in ICT to their desired level. The proportion of firms in each state covered in the two countries (7 in Brazil and 9 in India) reporting that they are constrained by a particular factor is used as a variable to cap-

Table 1: Constraints on ICT Adoption – A Summary						
	Brazil			India		
	Mean	Median	S.D.	Mean	Median	S.D.
Power disruptions						
Mean days disrupted	-	-	-	21.76	16.71	7.86
Median days disrupted	-	-	-	9.09	2.00	11.35
Proportion of Firms Reporting Constraints						
Availability of skills	0.54	0.50	0.13	0.44	0.30	0.23
Unions	0.20	0.21	0.09	0.14	0.08	0.16
Labour regulations	0.40	0.37	0.10	0.30	0.18	0.27
Internet availability / price	0.45	0.40	0.08	0.49	0.40	0.28
Low internet usage	0.47	0.41	0.11	0.51	0.44	0.16
Lack of government support	0.52	0.56	0.10	0.39	0.28	0.25

Source: Basant, Commander, Harrison and Menezes-Filho (2006).
Notes:
1 Reported constraints variables are the proportion of firms in each region/state reporting that the relevant constraint has prevented them from investing in ICT to their preferred level.
2 The estimates relating to availability of skills is an average across four types of workers.
3 Standard deviations (S.D.) are for the variation in the mean values across 7 Brazilian regions and 9 Indian States.

ture the extent of constraint faced by the firms in the state. In Brazil the mean and median scores are generally closer together than in India, indicating much greater state/region level variation in the latter. Interestingly, skills availability, unions and labour regulations are actually perceived as more constraining on average in Brazil than in India. Around 54% of Brazilian firms reported skills availability as a constraint. Skills were also one of the most important constraints in India. But at 44%, the share of firms reporting this constraint was lower in India than in Brazil. This is broadly consistent with other evidence on labour supply and its quality. With regard to unions, industry specific data shows that – with the notable exception of machine tools – unionisation rates in Brazil are indeed higher than in India.[5]

Interestingly, additional analysis of the survey data suggests importance of skill availability in both countries. It finds skill biases in ICT adoption for both production and non-production workers. (Harrison, 2006) In Brazil, there is strong evidence that ICT adoption has been associated with a higher share of educated workers at the firm level. In India, the positive association between ICT adoption and education exists, but in more attenuated form. Moreover, ICT adoption is positively associated with the supply of educated workers in a region. Also, within each nation, adoption is negatively associated with a region's (state) mean relative wage of more educated workers, a measure of relative supply of skills. Thus, the availability of skills remains an important factor for ICT adoption in both countries.

The scores for the availability and pricing of Internet services and the level of Internet use for suppliers/customers are very similar for both countries, while lack of government support is perceived as more of a constraint in Brazil. This may appear surprising given the large investments in connectivity and the like made by the Brazilian government. However, it may also signal the link to expectations. In India, firms may have a low expectation of government support and discount it appropriately. Finally, for India, we have an additional variable – the number of days that a given firm experienced problems with power supply. The mean number of days – nearly 22 - with power supply problems is indeed quite high. In the case of India, where data on power disruptions is available, there is clear evidence of lower adoption in states more affected by power disruptions, when other factors that can affect adoption are controlled for. The impact of power constraints on performance of firms that adopt ICT is also negative. Not only do firms in more power-disrupted states invest less in ICT, they also get a lower return. In fact, estimates show that all the South Indian states – with the exception of Karnataka - have relatively high rates of return to ICT adoption that are closer to the Brazil estimates, while the Northern and Eastern states (plus Karnataka) have low estimated returns.

What is the link between power availability and ICT adoption? Power shortages may raise the cost of ICT adoption due to requirements like power back-up. Besides, power deficit regions may also have low spare funds for IT, reducing thereby the chances of firms crossing the 'threshold' of adoption. But it is quite likely that power shortage is capturing the impact of other institutional and infrastructure factors. Table 2 shows that the power disruption variable is generally

Table 2: Correlations between Power Disruptions and Constraints Across States						
	Days disrupted	Skills	Unions	Labour laws	Internet availability/ price	No. using the net
Days disrupted	1.0000					
Skills	0.6383	1.0000				
Unions	0.3853	0.8593	1.0000			
Labour laws	0.6116	0.9527	0.9336	1.0000		
Internet avail./ price	0.5539	0.9380	0.9055	0.9825	1.0000	
No. using the net	0.6791	0.9478	0.7913	0.9476	0.9653	1.0000
Lack of government support	0.6226	0.9101	0.9332	0.9839	0.9569	0.9188

Source: Basant, Commander, Harrison and Menezes-Filho (2006).

highly correlated across states with other reported individual constraints on ICT adoption. These constraints, reflecting a wide variety of institutional and infrastructural problems, are even more highly correlated with each other. This raises the possibility that there are a cluster of states with poor institutions that are correlated with each other. This seems to be consistent with evidence from other sources.[6] Instead of using power disruptions, if other constraints are used individually, they provide similar results for India; all constraints except unions and internet access have a significant negative impact.[7] An analysis of the role of such constraints in Brazil suggests that only unionization has a mildly significant impact on ICT adoption and its impact. Overall, the estimates suggest that in India weak institutions do indeed result in lowering ICT adoption as well as the returns from ICT adoption. Interestingly, however, the best Indian states look quite like the main Brazilian regions.

Apart from indicating far less variation in regional institutions in Brazil than in India, the analysis also highlights the way in which this state-level variation in India translates directly into weaker adoption and performance. For example, comparison of firms of comparable dimensions in the same industry group but located in states with different institutional features provides interesting results. A firm located in a state with good institutions – Tamil Nadu - could expect to have almost three times higher ICT intensity and almost twice the rate of return to its ICT investment when compared with a firm in West Bengal - a state with relatively weak institutions. The state with better institutions (covering infrastructure, skill provision, state support etc.) – Tamil Nadu – is, moreover, quite similar in both intensity of ICT use and in its rate of return to ICT to Brazilian states, such as Minas Gerais and Sao Paulo.

POLICY IMPERATIVES

Weak institutions and infrastructure together result in lower adoption and lower returns to ICT adoption, particularly in India. The regional variations in Brazil are far smaller. However, firms in India located in states with better institutions and infrastructure have returns to ICT that are close to those obtained by Brazilian firms. This suggests that much of the policy challenge in India consists of addressing the sources of these inefficiencies and institutional weakness at the state level. Given the critical importance of power and skills, policy initiatives to relax constraints in these two areas would be critical to enhance use of ICT. Insights from the case studies suggest that training costs of firms rise with ICT adoption (Basant, 2006). Since required skills are not so easily available in the market, firms have to internalise training costs.[8] The problems associated with power disruptions have already been highlighted. As in the case of training, power generation is also being increasingly internalised by several firms in India. Given the high cost of in-house training (and the associated externalities) and power generation, not all firms are able to afford it and ICT adoption and the related productivity gains suffer in the process.

The skill constraint is emerging as a major constraint across several labour segments. There are not enough trained people for ICT implementation and even those who are formally trained are not equipped to adequately handle tasks on the job. This calls for additional training in the short run and curriculum modifications and increased scale of training in the long term. Both industry and government (especially at the State level) will have to think of innovative methods to tackle this problem. The idea of 'finishing schools'[9] floated by NASSCOM recently seems to be a decent short term solu-

tion but will have very limited effect unless it is scaled up. State governments will have to take active interest in the scaling up process. Despite significant growth in recent years, IT infrastructure remains limited in its reach. Low overall IT penetration was reported as a major constraint on ICT adoption by firms. An improvement in this infrastructure may have an indirect effect on skills availability as more exposure might enhance trainability.

Despite significant reduction in hardware and software prices, many firms (especially SMEs) find the costs of ICT adoption to be high. Besides, maintenance and up-gradation costs may be a more important bottleneck to IT adoption than initial costs. In addition, specialized tools that are not available in standard packages need to be developed separately and integrated with the standard package. The extent of such need also seems to be higher for SMEs and adds to the cost of IT adoption (Basant, 2006). In fact, many IT solutions are found to be inappropriate by SMEs for their needs. A continuation of policy of trade liberalization and reduction in tariff rates for hardware and software would certainly help. In fact, if the results discussed above hold, tax revenue gains from higher profitability (productivity) through ICT adoption may (at least partly) compensate for revenue losses from custom duties.

The key to reduce prices, however, is to rapidly increase the market base. Well formulated temporary incentives for ICT adoption by manufacturing firms may be useful but will have to be thought through. Some recent estimates suggest that growth in domestic market for ICT and related services may enhance the role of domestic IT firms, especially SMEs. Domestic market has so far been dominated by MNCs but Indian firms are gaining ground with a growing share of smaller deals (NASSCOM, 2007). As more and more SMEs adopt ICT, the share of Indian firms may grow more rapidly and prices may come down further as such adopters are much more cost conscious and often require modular and customized solutions. In any case, more appropriate IT solutions for the domestic firms, especially SMEs, would emerge as this market expands.

REFERENCES

Basant, Rakesh (2006), "ICT Adoption, Skills, Organizational Change and Firm Performance: Some Insights from Indian Cases", Indian Institute of Management, Mimeo.

Harrison, Rupert, (2006), "Skill biased technology adoption: firm level evidence from Brazil and India, Institute for Fiscal Studies, May, mimeo

NASSCOM (2007), Strategic Review 2007 – The IT Industry in India.

World Bank, 2006, Information and Communication for Development: Global trends and Policies, Washington DC

Appendix Table 1: Measures of ICT Adoption, 2003

	Brazil				India			
	Mean	Median	S.D.	Obs	Mean	Median	S.D.	Obs.
Summary measures								
Adoption index	3.50	4	1.22	491	2.94	3	1.05	476
Usage index	11.64	12	3.48	461	10.71	10	3.36	473
Hardware								
ICT capital as % of sales	4.18	0.59	17.78	278	3.34	0.44	17.01	379
PCs per employee	0.28	0.20	0.29	379	0.22	0.15	0.25	473
Servers per employee	0.04	0.02	0.07	372	0.02	0.00	0.05	473
Workforce usage								
% of non-production workers using PCs	69.6	90.0	37.9	484	53.9	59	34.6	476
% of production workers using ICT-controlled mach.	23.3	10	31.2	468	15.3	6	23.3	473

Source: Basant, Commander, Harrison and Menezes-Filho (2006).
Notes: S.D - Standard Deviation

End Notes

* This issue brief is essentially based on the insights and empirical findings reported in Basant, Rakesh, Commander, Simon John, Harrison, Rupert and Menezes-Filho, Naercio, "ICT Adoption and Productivity in Developing Countries: New Firm Level Evidence from Brazil and India" (September 2006). IZA Discussion Paper No. 2294 Available at SSRN: http://ssrn.com/abstract=932029. The author is grateful for the comments provided by Simon Commander and Rajdeep Sahrawat. Usual disclaimers apply.

1. See World Bank (2005) and World Economic Forum (2005) for cross country indicators.
2. The six manufacturing groups covered in the study were: electronic components, plastic products, soap and detergents, auto-components, machine tools and garments. For details of the sample design etc. see Basant, Commander, Harrison and Menezes-Filho (2006).
3. See Basant, Commander, Harrison and Menezes-Filho (2006) for other estimates of adoption.
4. Some estimates of returns on ICT investment are extremely high with median rates of return of about 2200% in Brazil and 2900% in India! High cost of ICT capital due to depreciation and obsolescence provide a partial explanation for these high rates but it is more likely to be due to the fact that these estimates are based on specifications which do not control for omitted observable and unobservable factors that may be correlated with ICT as well as measured or unmeasured complementary investments. Interestingly, even after controlling for these factors, the estimated returns do not decline by more than 25-55 per cent and still remain quite high.
5. In India, unionisation rates in 2000 ranged from under 10% in wearing apparel and soaps and detergents to 74% in machine tools. The unweighted average for the six industry groups was 26%. In Brazil, the range was from 22-47% with the average at 35%.
6. See, for example, the World Bank's Doing Business reports. It is difficult to identify exactly which factors are important since only observations from nine different states are available.
7. If we include more than one interaction of constraints, they become individually insignificant but jointly significant, which is hardly surprising given that they are highly correlated. Further, if we also include the power disruption variable it always dominates making the other constraints variables insignificant.
8. This may be one of the reasons why educational profiles of firms adopting ICT does not show as significant a change in India as in Brazil; firms in India undertake in-house training to enhance skills while the formal educational profiles remain similar.
9. Short-term training programme for engineers to enhance their employability in the IT sector.

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