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in developing countries: new  
firm level evidence from Brazil  
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**ICT adoption and productivity in developing countries:  
new firm level evidence from Brazil and India<sup>1</sup>**

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*Abstract*

This paper uses a unique new data set on nearly a thousand manufacturing firms in Brazil and India to investigate the determinants of ICT adoption and its impact on performance in both countries. The descriptive evidence shows that Brazilian firms on average use ICT more intensively than their Indian counterparts but changes over time have been rather similar in both places. ICT intensity is strongly related to size, ownership structure, share of administrative workers and education. The econometric evidence documents a strong relationship between ICT capital and productivity, even after controlling for several other factors, including firm-specific fixed-effects. The rate of return of ICT investment is much larger than usually found in more developed countries. Firms report several constraints to ICT investment in both countries and power disruption seems to significantly depress adoption and returns to ICT expenditures in India.

JEL Codes: J2, E20, L20, L60, O33

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## 1. Introduction

There is now a large – and growing – literature on the impact of ICT and associated changes in working practices on productivity. It is now widely accepted that ICT has had important and positive implications for both productivity and output growth. Yet most of that literature is concerned with the developed economies. The extent of adoption and the consequences for firm and economy-wide performance in developing countries remains largely *terra incognita*. Yet, as the price of computing has fallen dramatically and the availability of ICT technology has diffused, we would expect adoption rates in developing countries to have increased. To what extent and with what effectiveness this has happened remains, however, much of a puzzle. This paper is an attempt to begin to redress this imbalance in focus.

The principal objectives of the paper are to use new and unique firm level information from two major developing countries – Brazil and India – to understand better what types of manufacturing firms have been adopting ICT, with what timing and with what variation across countries and sectors. Having done that, the paper then focuses on the consequences of adoption – including allied investments – on the performance of the adopting firm. The analysis is done using a dataset that we have collected which contains nearly a thousand firm-level observations for several points in time for Brazil and India. Firm level analysis allows taking into account heterogeneity in investment and productivity that are likely to be particularly important in the case of ICT. It also allows us to account for differences in organisational capital and skill structure across firms. The data cover six three-digit manufacturing branches located in multiple regions of these two large countries.

Using this rich dataset, the picture that emerges is indeed one of considerable heterogeneity in both adoption and performance. Not only do we find that there are significant differences in the timing of adoption and the resulting patterns of ICT usage across the two countries, but that there are also differences within the countries themselves. We also find strong and robust evidence that ICT usage has a large and positive impact on performance. These effects cut across sectors and countries and seem to be related to organisational changes and to regional constraints.

There is a growing consensus that the widespread adoption of ICT in the developed countries has been associated with significant improvements in performance<sup>2</sup>. The

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<sup>2</sup> There are exceptions, see, for example, Gordon (2000).

evidence also suggests that there has been considerable variation across countries, with European economies experiencing far lower increases in productivity linked to ICT than in the USA where the strong acceleration in productivity growth since the mid-1990s has been associated with improvements in both ICT producing and ICT using sectors<sup>3</sup>. While much of this analysis has been done using growth accounting<sup>4</sup>, firm level analysis has also mostly confirmed the strong and positive association of ICT with productivity. Such work has also thrown light on why this has been the case with the focus less on adoption per se than what adoption can facilitate. In particular, the complementarity between computer investment and other forms of allied investment - such as organisational change - has been emphasised<sup>5</sup>. Examples of complementary investments involve the use of new business processes, teamwork, decentralisation, or changes in monitoring and hierarchies. Such organisational complements - leading to improvements in intangibles, such as new or better quality goods, improved service speed and greater customisation - have been found to be important in explaining why particular firms have reaped productivity benefits and others have not<sup>6</sup>. Indeed, it has also been argued that incomplete implementation of complementary organisational changes can lead firms to be less productive than those that had not implemented any reforms<sup>7</sup>. Measures of management practices have also been found to be positively correlated with a range of performance indicators. For example, Bloom, Sadun and Van Reenen (2006) find that for firms operating in the UK the productivity of ICT capital has been significantly higher in US owned establishments than in other firms. Finally, implementation of organisational and management changes can themselves impose substantial learning and adjustment costs. This argument, for example, has been used to explain differences in returns to ICT across countries<sup>8</sup>.

Turning to the developing countries, the evidence on both ICT adoption and its consequences remains scant. The level of income appears to be a major determinant of ICT adoption and it is clear that there is large variation in ICT adoption across and

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<sup>3</sup> See, inter alia, Oliner and Sichel (2000, 2002), Jorgenson (2001), Stiroh (2002), Bosworth and Triplett (2004).

<sup>4</sup> There have also been a number of industry studies which have largely been inconclusive, mostly, it would seem, due to problems in aggregation and measurement bias, see Stiroh (2004).

<sup>5</sup> See, inter alia, Bartel et al (2005), Bresnahan et al (1999, 2002); Brynjolfsson (2002), Hall and Lynch (2001); Ichniowski et al (1997).

<sup>6</sup> See Bloom et al (2005), Black and Lynch (2001, 2004), Bresnahan et al (2002).

<sup>7</sup> Bresnahan et al (1997).

<sup>8</sup> See Basu et al (2003).

within countries and sectors<sup>9</sup>. These differences can be traced to a wide range of factors, including differences in government policy. For example, shifts in policy – such as privatisation, lowering of trade barriers and de-regulation – can help raise investment in communications sectors and improve access to ICT technology, particularly in middle-income countries, such as Brazil. Even so, some firm level surveys point to significant constraints on adoption, including those of an institutional nature, as well as constraints originating from the labour market, most notably, relative skill shortages. Despite these constraints, 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 some adopters' performance. A World Bank study using data from a number of developing countries reports a positive correlation between a simple measure of ICT use and a number of performance indicators, including growth in sales, employment and re-investment<sup>10</sup>. Motohashi (2005) uses a large panel of Chinese manufacturing firms over the period 1995-2002 and finds that ICT capital contributes significantly to productivity, particularly in foreign-owned firms. However, none of these studies are able to explore the ways in which ICT contributes to productivity growth and, in particular, the possible role of complementary investments and policy.

The paper is organised in the following way. Section 2 provides an overview of the recent literature from both developed and developing country contexts. Section 3 describes the properties of the new dataset that we have collected and analysed. Section 4 then turns to look at the determinants of adoption rates in the two developing countries. Section 5 is concerned with the impact of ICT investment and other co-investments on the performance of firms in our sample. Section 6 examines the constraints on ICT adoption operating at the level of a region, as well as the consequences for the returns to ICT investment. Section 7 concludes.

## **2. Data description and country context**

Our dataset consists of a unique firm level survey of nearly one thousand firms in two major developing countries, Brazil and India. The survey was implemented in both countries between April-May, 2005 through a series of face-to-face interviews. The survey was designed to give detailed responses to a set of questions relating to ICT adoption and its timing, as well as changes to management and organisational features

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<sup>9</sup> See World Bank (2005) and World Economic Forum (2005) for cross country indicators, also Pohjola (2003).

<sup>10</sup> World Bank (2006) and Chapter 4 in particular.

associated with adoption. In addition, changes to the skill and educational structure of employment, firm level constraints to ICT adoption as well as variables capturing key characteristics of the firm in terms of size and performance and the competitive environment were collected.

For most questions, data was collected for either two or three points in time, namely 2003, 2002 and 2001. In each country a target of 500 firms in six 3-digit manufacturing branches - auto-components, soaps and detergents, electrical components, machine tools, wearing apparels and plastic products – was selected. Stratification was by industry, region and size (employment) with quota sampling. In India, firms were sampled in nine states. In Brazil, firms were sampled in seven regions. *Appendix Table 1* gives the distribution of the sample over region and branch and in Brazil, a substantial share of firms was located in two states, Sao Paulo and Minas Gerais, which accounted for over 46% of total firms surveyed. In India, the distribution was less skewed in terms of location. In terms of response rates, in Brazil the ratio of refusals to responses was 3.4 while in India it was 4.5. *Appendix 1* provides more information about the sampling strategy.

*Table 1* provides some basic descriptive statistics for the sample for each country broken down for mean and median values of size (employment), sales, materials and wage shares and capital intensity, as well as the mean rate of growth in sales and employment over the period 2001-2003. There is a good deal of variation in all variables. With respect to employment size, however, the median values are actually very similar across countries, as is the ranking by branch. In both places, employment in auto-components tends to be significantly larger than in other branches. Average employment growth has been quite similar in both countries, although median growth in India was double that in Brazil. In terms of shares, the major difference between the countries is with respect to labour. In India the mean and median wage shares were only 30-40% of those in Brazil. Capital intensity was also higher in Brazil but by a far smaller margin.

The six branches of manufacturing that have been sampled were picked not only because they provide significant variation in their production processes – and hence in their likely adoption of ICT – but also because they comprise a significant component of output and employment in manufacturing in both countries. *Appendix Table 2* provides a breakdown by branch of the respective shares in employment and value added, as well as growth rates in employment and value added over 1998-2003. The level of the average wage and its change is also reported. In India, it can be observed that these six branches

account for nearly 17% of total manufacturing employment and over 20% of value added. In Brazil these shares were around 30% and 32% respectively. In terms of growth rates in the period from 1998-2003, there are major differences for both employment and value added within and across countries. In India three out of the six branches actually saw declines in employment, while this was only true for electronics in Brazil. Generally, Brazilian employment growth was far stronger over this period than in India. Turning to value added, the story is reversed. In all branches growth in net value added was negative in Brazil, while in India growth averaged over 6.7%. Growth in labour productivity was positive in all Indian branches, except wearing apparels. In Brazil, the picture was more varied, electronics and plastic products saw declines of over 12%, wearing apparel grew by under 3% and the others grew in double digits. The wage data also show substantial differences across branches. In India wages in the apparels sector are less than half those in plastics, machine tools or electronics and this pattern is similar in Brazil. There are, however, clearly different rankings and relativities across countries, with auto components and soaps and detergents reporting the highest mean wages in Brazil. There, the ratio of the highest/lowest wage sector was 2.8 as against 2.2 in India. Nominal growth rates of wages show similarly high variation across branches and countries.

Turning to the broader policy and performance indicators for these two countries over the reference period, there have been significant differences. In India, GDP growth exceeded 6% over the period, while in Brazil average growth was around 2%. While this decreased the income gap between the two countries, by 2004 Indian per capita income was only around 13% of Brazil's, with notably lower literacy, schooling enrolment and other social indicators as well

In terms of ICT indicators, *Appendix Table 3* shows major disparities in almost all indicators whether relating to access, quality, efficiency or expenditure. ICT expenditure as a share of GDP was 6.7% in 2004 in Brazil as against 3.7% in India. Access to communications was vastly lower in India than in Brazil, whether for fixed line, mobile or Internet and broadband coverage. In terms of ownership and market structure, in Brazil private ownership of telecoms has been associated with greater competition in provision. In India, by 2004 ownership remain mixed with limited competition, except for internet service providers.<sup>11</sup> Quite clearly, by these indicators, Brazil remains well ahead of India in terms of overall ICT adoption and investment.

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<sup>11</sup> World Bank (2006)



In terms of policy, both countries have seen clear changes over our reference period, particularly in India. Telecommunications have been liberalised, with significant entry of new providers particularly for mobile services and internet service providers in India. With respect to the trade regime, in India, unweighted 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, we only have comparable tariff data for 1998, but the tariff structure has remained basically unaltered since then 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 at the start of the period, with the exception of auto-components that received protection of 46%. In the case of labour legislation, in neither country was there significant change over our reference period.

### **3. Correlates of adoption**

There is a large literature that is concerned with diffusion of new technology, including ICT. Much of this literature tries to account for the *S*-curve shape for adoption over time<sup>12</sup>. In what follows our emphasis is less on a detailed look at the diffusion process per se than on the characteristics of firms adopting particular ICT forms and usages in Brazil and India, mainly at one point in time. For the analysis that follows, our leading adoption indicator is constructed from responses to a question regarding the degree of ICT in a given firm. These ranged from IT not being used at all to all processes being automated and integrated into a central system<sup>13</sup>. Each response was scored for each firm and responses were given for two points in time, 2001 and 2003.

*Figure 1* plots the distribution of responses for both years using the 1-5 scale that was applied (the thin bars are for 2001 and the thicker ones are for 2003). Several things stand out. First, the share of Indian firms with little or no adoption (scores of 1 or 2) is higher than in Brazil in both years. In 2001 over 60% of Indian firms were using ICT in a minimal way, as against 45% in Brazil. Second, there has been a rapid increase in the share of firms using ICT in both countries. The share of firms with minimal use

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<sup>12</sup> For a survey, see Geroski (2000)

<sup>13</sup> The possible responses and their scores were: 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

had declined substantially by 2003 while the gap between Brazil and India had remained roughly constant. Third, it is still the case that by 2003 a far smaller share of Indian firms had the highest adoption scores (4 or 5) than in Brazil. At the top end of the distribution (5) nearly 30% of Brazilian firms had automated almost all processes with ICT integrated into a central system, as against only 10% of the Indian sample. The picture that emerges is thus one of significant difference across countries.

*Figures 2 and 3* go on to provide adoption curves for PCs and servers at the time of first introduction in both countries. By 2003 98% of firms in both countries had adopted PCs, while 90% of Brazilian firms had adopted servers at that time as against only 63% of Indian firms. The plotted densities show that there is relatively little difference across the two countries with respect to the timing of adoption. The peaks of the kernel densities are both around 1997 for PCs and around 1998 for servers. The fact that the Indian distribution is not shifted to the right suggests that it is not lagging on the extensive margin. For servers, it suggests that there is a longer tail of late adopters in India than in Brazil.

*Tables 2 and 3* provide some further descriptive statistics for a set of indicators of ICT for both the level in 2003 and the change over 2001-2003. Aside from the adoption index, mean and median scores and standard deviations for a usage index are also reported. This index was put together from a question regarding the intensity of use for ICT for four functions: accounting services, inventory management, marketing and product design and the production process<sup>14</sup>. While the adoption index can be seen as an indicator of the depth of ICT use in a given firm, the usage indicator gives a sense of the breadth of ICT use in a given firm. In addition, the tables report measures of ICT capital (normalised by either sales or employees) and shares of non-production workers using either PCs or ICT controlled machinery.

For the levels, both the summary measures and hardware usage are always higher for Brazil, but so is their standard deviation. In terms of workforce use, there are particularly sharp differences, since on average nearly 70% of non-production workers used a PC in Brazil in 2003 as against 54% in India, while for the proportion of production workers using ICT-controlled machinery the share was around 23% in Brazil against 15% in India. In terms of the changes, the differences are less marked. For usage and non-production workers using PCs, the average rate of increase was larger in India and for most of the other indicators the difference was rather small.

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<sup>14</sup> Possible responses were: Firm did not use any ICT=1; Used ICT for some processes=2; Used ICT for most processes=3; Used ICT for all processes=4. Possible scores thus ranged from 4-16.

*Table 4* provides multivariate examination of the correlates of ICT adoption at the firm level in 2003 for six different measures of ICT intensity: Column 1 is the summary index of ICT adoption; Column 2 is our summary index of ICT usage; Column 3 is the share of non-production workers using PCs; Column 4 is the share of production workers using ICT controlled machinery; Column 5 is the logarithm of ICT per worker and the last – Column 6 - is the logarithm of ICT per unit of sales. In the case of the two summary indicators (Columns 1 and 2) estimation is by Ordered Probit, while all other columns use OLS. All regressions reported in *Table 4* include industry and region/state dummies.

The measures of adoption are related to a set of variables capturing the size of the firm, its age and ownership type, the share of employees belonging to a union and a set of education and occupation shares. In the case of size, the omitted category is 1-29 employees; for occupation shares the omitted category is production workers; for education shares the omitted category is less than upper secondary (US) for both production and administrative & clerical workers and for age the omitted category is more than 20 years old.

The results are broadly plausible while also bringing out some interesting differences across countries. In both countries, the size of the firm is generally positively and significantly associated with the indices of adoption and usage, as well as the worker shares. Interestingly, size is not important for the share of production workers using ICT-controlled machinery in Brazil, but the coefficient is both very significant and large in India. This suggests that larger Indian firms use more ICT intensive production processes relative to smaller Indian firms. The age of the firm mostly does not matter, except in Brazil, where older firms have higher ICT per worker and per unit of sales. The unionisation variable mostly enters insignificantly, except with regard to the usage index where it is significant and positive in both countries. This could obviously be interpreted in a number of ways and we return to this issue in more detail later in Section 5.

In terms of ownership, the multinational (MNE) firm dummy is positively signed and significant for Brazil but this is not the case in India, except for non-production workers using PCs. In addition, there is clear evidence that foreign joint ventures (jvf) use more ICT in India. This is not the case in Brazil. The difference may in part be explained by the limits on MNE operations in India which have led to greater use of joint ventures than in Brazil. Taking this into account, the results do suggest that firms

with foreign ownership or participation are more likely to have higher ICT use or adoption.

As regards the association between our ICT measures and the occupation shares, we find that in Brazil more ICT intensive firms tend to have more administrative and other workers, although this is not generally the case for India. For the education shares, in Brazil the two ICT indices are strongly related to the share of upper secondary (US) and college educated production workers. The association is notably weaker in India. Further, in Brazil the share of non-production workers using PCs is very positively and significantly related with both the share of upper secondary (US) and college educated administrative workers. The share of production workers using ICT controlled machinery is also very strongly related to the share of educated production workers in Brazil. In India, we also find a positive association but one that is only strongly significant in the case of college educated production workers. These results suggest that ICT adoption has probably been associated with more skill-bias in Brazil than India<sup>15</sup>.

Finally, picking out the branch and region effects, we find that in both Brazil and India none of the branch dummies were significant<sup>16</sup>. In Brazil where the omitted region was Sao Paulo, we found that Minas Gerais was positive and significant at the 5% level, while Norde was negative but significant only at the 10% level. In India where the omitted state was Maharashtra, all other states were negatively signed with four – Andhra Pradesh, Delhi, Gujerat and West Bengal - all significant at the 1% level.

#### 4. ICT adoption and productivity

We start by estimating some augmented Cobb-Douglas revenue functions estimated separately for Brazil and India. Revenues,  $r_t$ , is a function of physical capital,  $K_t$ , Labour,  $L_t$ , ICT capital,  $ICT_t$  and a set of variables for observable firm heterogeneity given by  $Z_t$ .

$$r_{it} = Z_{it} K_i^a L_i^b ICT_i^p \quad (1)$$

where the exponents give the elasticities of revenues with respect to the individual components.

Taking into logs with a normally distributed error term,  $e_i$

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<sup>15</sup> These findings are explored in more detail in a complementary paper by Harrison (2006) using this dataset to look at the impact of technology adoption on skill shares and bias.

<sup>16</sup> This reports results from the adoption estimate.

$$\ln(r_i) = \ln(Z_i) + a \ln(K_i) + \beta \ln(L_i) + \gamma \ln(ICT_i) + e_i \quad (2)$$

Introducing organisational change as an interaction with ICT capital gives:

$$\ln(r_i) = \ln(Z_i) + a \ln(K_i) + \beta \ln(L_i) + \gamma \ln(ICT_i) * (Org) + e_i \quad (2')$$

*Table 5* reports the results. All results include industry, region/state and age dummies unless otherwise specified. The estimations use the information available for 2003. Note that the number of observations in the Brazil sample has dropped to just below 200 due to the fact that many Brazilian firms only reported ranges rather than levels for key financial variables<sup>17</sup>. (*Appendix Table A4* reports descriptive statistics for the variables used in the production function analysis).

The results reported in *Table 5* appear to be robust and reasonably similar for the two countries. Column (1) reports the basic production function with the addition of an ICT capital stock variable. All base variables are highly significant. The coefficients on materials are quite close to the median materials share in both countries. The coefficients on labour are, however, larger than the salary and wage shares. More importantly, the ICT capital stock is also highly significant in both cases, with a larger elasticity in Brazilian sample<sup>18</sup>.

We also use other measures of ICT. In particular, Column (2) of *Table 5* replaces the ICT capital stock variable with dummy variables for the extent of ICT adoption, where the reference group is firms that only use desktop applications or do not use ICT at all. In Brazil the main impact is from firms using ICT in an integrated fashion (groups 4 and 5), which on average are about 50% more productive than other firms. In India the main effect is from groups 3 and 4. This is consistent with the information on adoption patterns reported in the previous section. Column (3) then uses the ICT capital stock

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<sup>17</sup> We have corrected this limitation by matching most of our firms to the data in the Brazilian PIA or Industrial Census. This has allowed us to retrieve values for the main financial variables used in the analysis. However, as of late October 2006 we are still waiting for IBGE to release the results. Looking at means for in and out of sample firms, we find that there are some significant differences with respect to the share of workers using PCs and, in Brazil the share of administrative and clerical workers in total employment. However, in general, there are not large differences between in and out of sample firms.

<sup>18</sup> We also experimented with the use of imputation and without, as well as the sensitivity of our results to dropping outliers and lower intensity users. We found that the results we get with imputation are similar to those we get without. Dropping firms with low usage indicators predictably and significantly lowers the return to ICT in both countries. Dropping outliers has the opposite effect while increasing the precision of the estimate. Results are available on request.

variable as well as the dummies for usage at the same time. Interestingly, the latter still contain a significant amount of information even after controlling for ICT capital stock.

An important feature to note from these specifications is that the coefficients on ICT capital correspond to extremely high median rates of return of about 2200% in Brazil and 2900% in India (from Column (1)). This compares to more reasonable median rates of return of 65% and 72% for normal capital. While high returns to ICT investment have also been found in developed countries<sup>19</sup>, we still need to explain these apparently very high returns in our dataset. Although it is possible that a high cost of ICT capital due to depreciation and obsolescence may provide a partial explanation<sup>20</sup>, this is unlikely to be the whole story. More likely candidates are omitted observable and unobservable factors that may be correlated with ICT as well as measured or unmeasured complementary investments.

#### **4.1 Controlling for omitted variables**

One possible explanation for the very high returns to ICT capital that we find is that ICT is itself correlated with other omitted variables, such as skills and other firm characteristics, as suggested by the results reported in *Table 4*. To probe this in more detail, *Table 6* reports the baseline production function (Column (1)) and then splits employment up by occupation (Column (2)) and skill types (Column (3)). In addition, we augment (3) with a set of other controls for many important firm characteristics, including management practices, ownership, joint ventures, listed status and unionisation<sup>21</sup>. For the India estimates, we also have a measure of software that is not available for the Brazilian firms and we hence control for investment in software as well. In Brazil the coefficients on labour of the different occupational groups are roughly in proportion to their employment shares. When production and administrative workers are split into college and non-college education, the coefficients are roughly equal across the four groups. In India, only the management and administrative occupation groups have positive coefficients and management is the only group with a consistently significant coefficient.

However, the results also suggest that these previously omitted variables can explain only a part of the high returns to ICT. They serve to reduce the coefficient on ICT by no more than 20-30% in both Brazil and India. Interestingly, when we introduce

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<sup>19</sup> See, for example, Brynjolfsson and Hitt (2003); Stiroh (2002)

<sup>20</sup> Stiroh (2004)

<sup>21</sup> The coefficients are not reported but are available on request

the stock of software as an additional regressor (Column (5) for India) this reduces the coefficient on ICT by over 55%. Software is extremely correlated with hardware ( $\rho = 0.82$ ) and the two are jointly significant at the 5% level. Even so, the implied median rate of return on ICT in India still remains very high at around 1100%.

To eliminate other unobservable fixed effects that may be correlated with ICT, in *Table 7* we proceed to estimate the same specifications in first differences using the change over a two-year period from 2001-2003. We then control in a similar way for occupation, skills and other controls. Column (1) in *Table 7* is a levels specification on the same sample as the difference specification in Column (2). For Brazil the coefficient on ICT capital loses significance in the levels but is highly significant and large in the differences specification. For India, both coefficients are significant but there is decline in the change estimate. However, the estimated coefficient in India is still very large. These results mean that firm-level fixed effects were not biasing the estimates of the levels specifications in both countries. Controlling for omitted occupation, skills and other controls has little, if any, effect on the ICT capital coefficient in either country. Software is not significant in India<sup>22</sup>. Our finding that using first differences does not lower the ICT coefficients is indeed quite striking<sup>23</sup>.

#### **4.2 Complementary organisational changes**

As indicated in Section 2, one approach to understanding how ICT has an impact on performance is to focus on complementary investments, particularly with respect to the reorganisation of working practices and firm management. We now turn to investigating whether complementary organisational changes can help explain the high measured returns to ICT and the possible contribution of such changes to performance. We use three measures of organisational change in the analysis that follows. The first is whether a firm “removed a level of hierarchy or reduced the number of reporting levels” and whether such change was explicitly related to IT over the past three years. This question was asked with regard to the working practices of three groups of employees: production workers as a whole; clerical and administrative workers and managers and its value could therefore range between 0 (no change) to 3 (change across all three occupation types). The second was whether a firm had “improved monitoring of individual workers or groups of workers” related to IT. The third was whether a firm had “improved management decision making based on up-to-date information”. This third question was

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<sup>22</sup> The change in software is less correlated with the change in hardware ( $\rho=0.38$ ) than in the levels.

<sup>23</sup> Stiroh (2004) does a meta-analysis and finds that estimates in first differences tend to be lower.]

only asked with respect to changes in the working practices of managers and its value is either 0 or 1.

The results presented in *Table 8* show that in Brazil a reduction in hierarchy or flattening has no effect either directly or in the interaction for the full sample. However, once we exclude firms that make minimal or no use of ICT, we find a very strong and positive interaction (Column 4). For Brazilian firms that use ICT more intensively, the return to ICT capital stock is only significantly positive if they also undertake organisational change at the same time. In India there is again no effect from our measures of organisational change on the full sample, but when we exclude low-adopters we again find a significant direct effect of this type of organisational change on productivity growth<sup>24</sup>.

*Table 9* performs the same exercise this time using the improved monitoring measure of organisational change. In neither country we find any effects. This suggests that the results from flattening reported above have not been driven by unobserved heterogeneity that is correlated with the propensity to undertake organisational change per se. Finally, *Table 10* uses the management measure of organisational change. In Brazil there is no effect, while in India there is a significant direct effect, particularly for the high adopters.

In short, we find that organisational change linked to IT can have a significant impact on performance but that this depends on the type of organisational change as well as the degree of IT adoption. There is also some interesting variation across the two countries. In particular, reduction in hierarchy exerts both a direct and indirect effect in Brazil, but only for firms that are using ICT for more complex functions. Improved monitoring is insignificant in all cases and improved management only comes in positively and significantly for the Indian sample.

### **4.3. Variation across regions in ICT adoption**

A feature of many developing countries is often a weak institutional environment. For example, in the context of ICT adoption and use, we can think of constraints - such as the level and predictability of taxation or the role of labour legislation - as potentially affecting not only adoption but also the subsequent impact on performance. To get a better sense of how such institutional barriers might come into play, our survey

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<sup>24</sup> This is, of course, also consistent with complementarity between ICT adoption and organisational change, even though we find no significant interaction effect.



specifically asked whether – and to what extent – particular constraints had prevented firms from investing in ICT to their desired level over the last three years. *Table 11* provides the descriptive statistics using region or state level averages. The constraints variables are defined as the proportion of firms in each state reporting that they are at all constrained by that factor. In Brazil the mean and median scores are generally closer together than in India, indicating much greater state/region level variation in the latter. The table also shows that skills availability, unions and labour regulations are actually perceived as more constraining on average in Brazil than in India. It is striking that just under 55% of Brazilian firms reported skills availability as a constraint. This is broadly consistent with other evidence on labour supply and its quality. With regard to unions, branch data show that – with the notable exception of machine tools – unionisation rates in Brazil are indeed higher than in India<sup>25</sup>.

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 in both 2001 and 2003 that a given firm experienced problems with power supply – that has the advantage of being exogenous<sup>26</sup>. The mean number of days – nearly 22 – with power supply problems in 2001 is indeed quite high. Exploiting this information on the variation in constraints across regions to investigate the impact of external conditions on the adoption of ICT – and subsequently the qualified return to ICT adoption – can help identify policy choices.

Using such measures of constraints in explaining performance can obviously be problematic given the need to control for potential endogeneity, particularly as the performance variables have been gathered simultaneously.<sup>27</sup> With our dataset, this is a

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<sup>25</sup> 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 branches was 26%. In Brazil, the range was from 22-47% with the average at 35%.

<sup>26</sup> It could be argued that this variable is not strictly exogenous in that the frequency of power cuts could have affected the location decision. However, as the great majority of our firms were not established recently and the frequency of power cuts has varied substantially over time, it seems unlikely that this is a major hurdle.

<sup>27</sup> For how to do this with subjective survey data, see Commander and Svejnar (2006). A possible alternative would be to use an instrumental variable, such as the ratio of workers with university and secondary education. If production is Cobb-Douglas, the firm is a profit maximiser and a price taker for inputs, then the ratio of input prices (wages) can be considered exogenous

serious challenge as, for example, using lagged values is not feasible. To mitigate these problems, we use regional/state average values for the constraints in our estimations.

We start by using the India data and the power supply measure to look at the impact of mean state level days in 2001 affected by power disruptions on ICT adoption (*Table 12*). All the variables used in *Table 4* are also included as controls but not reported. All standard errors in this section are adjusted for clustering at the state/region level. Panel A reports results for the level of ICT adoption in 2003. As before, Columns (1) and (2) are estimated with Ordered Probit, while all the others are estimated using OLS. We find some clear evidence of lower adoption in states more affected by power disruptions, particularly for the overall adoption index and the log of ICT per unit of sales. Both variables are negative signed and significant. Panel B reports results from the changes. Again, there is some evidence for smaller increases in usage, but surprisingly we get a small positive - but insignificant - coefficient on the change in the log of ICT capital intensity.

#### **4.4 Variation across regions in the returns to ICT**

We now look at the impact of constraints on performance. *Table 13* allows the elasticity with respect to ICT capital to vary by interacting it with the power supply variable, both mean and median values. The interaction is strongly negative. Not only do firms in more power-disrupted states invest less in ICT, they also get a lower return. Not only are the elasticities lower but so are the implied rates of return. *Figure 4* allows the elasticity to be different for each state and plots the state-specific estimated elasticity against the state mean number of days in 2001 with power-related problems. The fit is very good with an R-squared of 0.80<sup>28</sup>. It can be seen that all the South Indian states – with the exception of Karnataka - have relatively high elasticities that are closer to the Brazil estimates, while the Northern and Eastern states (plus Karnataka) have low or zero estimated elasticities.

An obvious question that arises is whether we are actually identifying the impact of power shortages or the fact that our measure is just correlated across states with other institutional and infrastructure factors. *Appendix Table 6* shows that the power disruption variable is generally highly correlated across states with the state means of the individual constraints. These constraints are even more highly correlated with each other. This raises the possibility that there are a cluster of states with poor institutions that are

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<sup>28</sup> In a bi-variate regression (with clustered standard errors) of the elasticity on the disruption variable the coefficient (standard error) is  $-0.009$  ( $0.001$ ), very similar to the interaction term in column (1) of *Table 13*.

correlated with each other. This seems to be consistent with evidence from other sources<sup>29</sup>. However, at this stage, we are probably not able to identify exactly which factors are important since we only have observations from nine different states.

*Table 14* extends this discussion by showing that we get similar results to those in *Table 13* if we enter the constraints variables individually, instead of using the power disruption variable. For India, only unions and internet access are not at all significant<sup>30</sup>. 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.

*Table 15* does the same exercise for Brazil. In this case, we get much less traction. Only the interaction of unions and ICT is mildly significant but this is in fact driven entirely by just three observations from one – Centro – of the regions. *Figure 3* shows that when we drop these observations, there is no association. Further, given that over 60% of our observations are in the Sao Paulo and Sul regions that have very similar elasticities, we are unlikely to be able to identify regional variation in constraints as playing any significant role in explaining returns to ICT in Brazil<sup>31</sup>.

In sum, the novel use of constraints measures to look at both the consequences for adoption and performance, suggests 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. Aside from indicating far less variation in regional institutions in Brazil than in India, our analysis also picks out the way in which this state-level variation in India translates directly into weaker adoption and performance. For example, comparing firms of comparable dimensions in the same branch but located in states with different institutional features, 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 – Tamil Nadu – is, moreover, quite similar in both intensity

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<sup>29</sup> See, for example, the World Bank's Doing business reports

<sup>30</sup> Note that in all cases if we also include an interaction with the disruptions variable this always dominates and the constraints interaction becomes insignificant.

<sup>31</sup> We also experimented with a more restrictive use of the constraints variables to see whether the perceived intensity of the constraint mattered. We ran the same estimations for when the constraints score was either 3 or 4 (viz, to some extent and to a large extent). The results were very similar, although the point estimates were predictably higher.

of ICT use and in its rate of return to ICT to Brazilian states, such as Minas Gerais and Sao Paulo.

## **5. Conclusion**

This paper uses a unique, new dataset that we have collected on a thousand firms in manufacturing in two important developing countries, Brazil and India. The data allow us to look at the extent of ICT adoption at the firm level, to examine the characteristics of firms adopting ICT and the consequences of adoption for performance. In addition, we are able to relate adoption and the return to adoption to region or state level institutional features in both countries. In terms of adoption, we find that size and foreign ownership tend to be associated with higher adoption. In Brazil, we also find that there is strong evidence that ICT adoption has been associated with a higher share of educated workers. Interestingly, Brazilian firms also report skills availability as a constraint; a finding that is in keeping with other observations about the shortcomings of the Brazilian educational system. In India the positive association between ICT adoption and education exists, but in more attenuated form. The evidence shows that Brazilian firms have on average adopted more ICT than their Indian counterparts and use that ICT more intensively. However, firms operating in states with good institutional arrangements in India tend to have adoption rates similar to their Brazilian comparators. Certainly, the variation between countries in adoption is far smaller than the aggregate data would suggest.

With respect to the association between ICT and productivity, our analysis suggests that – in line with some of the evidence from developed countries – there have been very high returns to ICT. We investigate possible reasons for the very high returns that we report for both Brazilian and Indian firms. We find that these high returns persist even after including skills, occupation, management practices and other controls. We also look at the way in which complementary changes – such as in the organisation of work practices – might have affected the returns to ICT. We find robust and positive evidence that there is complementarity between some – but not all – of our organisational change measures. In particular, reducing hierarchies appears to be associated with higher returns to ICT in Brazil, and is directly positively related to productivity growth in India. The evidence also suggests that this positive effect only kicks in 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.

Finally, our survey allows us to throw new light on the way in which institutional features of a region or state may affect both ICT adoption decisions and returns to ICT adoption. We find that the combination of weak institutions and infrastructure result in lower adoption and lower returns, particularly in India. The regional variation in Brazil is 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 at state level of these inefficiencies and institutional weakness.

## **Appendix 1: Design of the survey**

The survey was administered to 500 firms each in Brazil and India on a face-to-face basis in April and May, 2005. The firms were selected in six branches of manufacturing: electronic components, plastic products, soap and detergents, auto-parts, machine tools and wearing apparel. In India the sampling frame comprised the Prowess and First source databases of firms. Stratification was by branch and region. In India, the Prowess dataset contains extensive financial data on each firm, so this was used as the primary source for sampling. For branch, quotas were set relative to their size. The Prowess universe comprised 437 firms of which 175 were sampled. The remaining 325 were taken from First Source. The order used to achieve these quotas was thus from industry or branch to Prowess and First Source (in that order) and then by region. Within the final regional quota cell, firms were selected randomly. In terms of regions, sampling was organised in 14 regional centres located in nine states in India. In Brazil, the sampling frame was the Industrial Census (PIA). Stratification was by branch, region and employment size. Sampling occurred in five regions of the country comprising 13 states.

## **Appendix 2: Variable definitions**

*ICT adoption index*: takes integer values from 1 to 5 according to answers to the question 'how would you describe the degree of ICT usage in your firm?' where the options are as follows: (1) ICT is not used at all; (2) ICT is used for some office applications along with accessing the internet, emailing etc.; (3) ICT is used for some advanced applications, most processes are automated but there is no integration into a central system; (4) most processes are automated and some of them are integrated into a central system; (5) almost all processes are automated and integrated into a central system.

*ICT usage index*: takes integer values from 4 to 16. For each of four functions (accounting services; inventory management; marketing and product design; production process) firms were asked to chose from the following four options: (1) do not use any ICT; (2) use ICT for some processes; (3) use ICT for most processes; (4) use ICT for all processes. The variable is the sum of these answers across the four different functions.

*ICT capital stock*: constructed using a perpetual inventory method from information on ICT capital investment in 2001, 2002 and 2003. The assumed depreciation rate is 0.315 and the price of ICT capital is assumed to fall by 20% per year (both following Stiroh, 2004). For the initial stock real ICT capital investment is assumed to have been growing by 50% a year for both countries, which is close to the median growth rate in the sample during the 2001-2003 period.

*Admin*: the proportion of the workforce in 2003 that were administrative and clerical workers.

*Managers*: the proportion of the workforce in 2003 that were managers.

*Other*: the proportion of the workforce in 2003 that were not production workers, administrative and clerical workers or managers.

*Prod:US*: the proportion of production workers in 2003 that had completed Upper Secondary but not College.

*Prod:Coll*: the proportion of production workers in 2003 that had completed College.

*Admin:US*: the proportion of admin and clerical workers in 2003 that had completed Upper Secondary but not College.

*Admin:Coll*: the proportion of admin and clerical workers in 2003 that had completed College.

*Union*: dummy variable equal to one if the firm reported that any of its workforce belonged to a union.

*OC (Flattening)*: takes integer values from 0 to 3 according to whether firms reported that they had 'removed a level of hierarchy or reduced the number of reporting levels' for three types of workers (production; admin and clerical; managers) during the years 2001, 2002 or 2003.

*OC (Improved monitoring)*: takes integer values from 0 to 3 according to whether firms reported that they had introduced 'improved monitoring of individual workers or groups of workers' for three types of workers (production; admin and clerical; managers) during the years 2001, 2002 or 2003.

*OC (Improved management)*: takes values of 0 or 1 according to whether firms reported that they had introduced 'improved management decision making based on up-to-date information' during the years 2001, 2002 or 2003.

*Mean days disrupted*: (India only) the State mean number of days in 2001 that firms reported experiencing 'power related problems (power cuts or surges, either partial or total) from the public grid'.

*Median days disrupted:* (India only) the State median number of days in 2001 that firms reported experiencing 'power related problems (power cuts or surges, either partial or total) from the public grid'.

*Reported constraints:* in each case these are equal to the state/region proportion of firms answering that the potential constraint in question had constrained them at all from adopting ICT to their preferred level over the past three years. The only exception is *Availability of skills* which is the average for four types of constraints related to skill shortages: 'lack of production workers with relevant skills'; 'lack of IT technicians with relevant skills'; 'lack of clerical and administrative workers with relevant skills'; 'lack of managers with relevant skills'.



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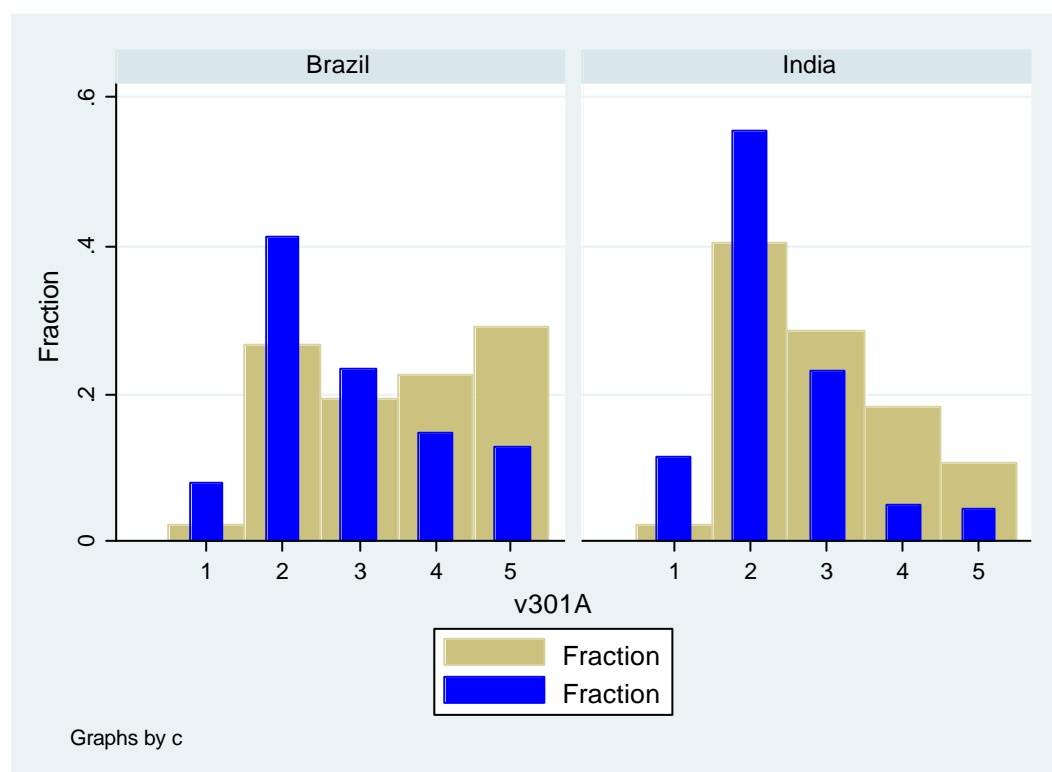
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**Table 1: Descriptive statistics for full sample**

	Brazil				India			
	Mean	Median	s.d	Obs	Mean	Median	s.d	Obs.
<b>Employment</b>	207	70	431	387	367	70	1074	476
<b>% change in Emp</b>	22.0	7.8	63.2	368	19.7	14.3	37.7	471
<b>% change in Sales</b>	57.8	25.0	128.0	294	31.8	23.1	56.5	447
<b>Materials share</b>	0.44	0.41	0.31	194	0.41	0.40	0.25	433
<b>Wage share</b>	0.22	0.16	0.25	195	0.09	0.05	0.14	446
<b>Capital intensity</b>	0.75	0.32	1.19	156	0.56	0.25	1.03	395

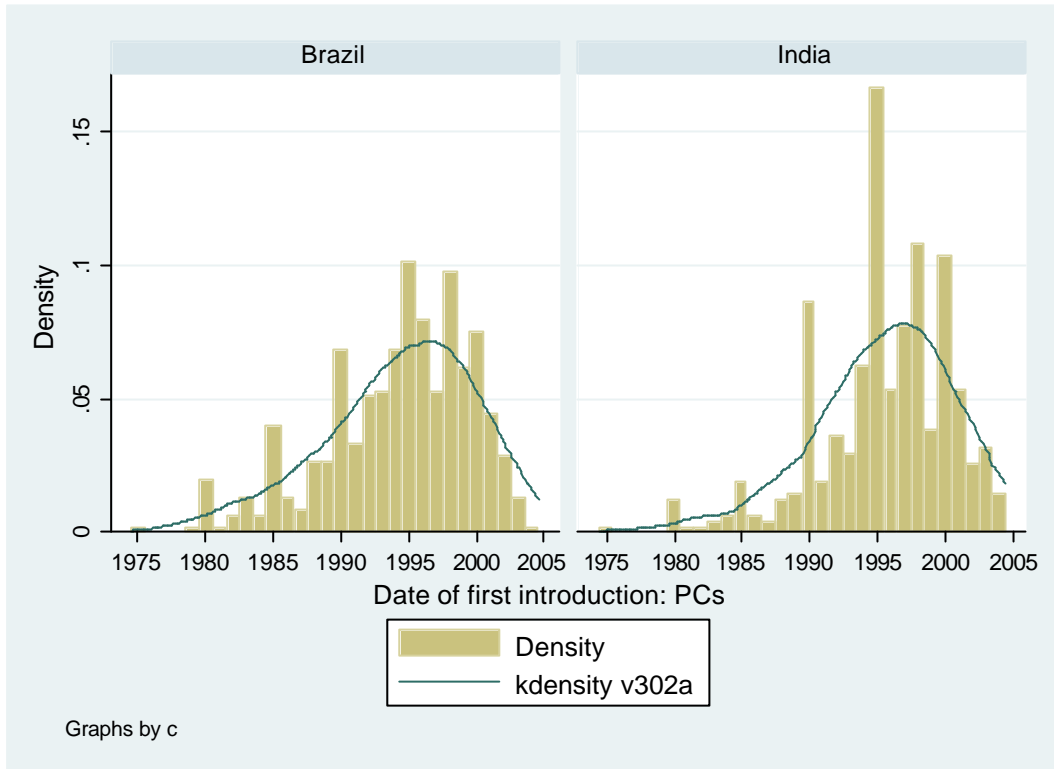
Notes: Levels are for 2003 and changes are for the 2-year period 2001-2003. A small number of outliers are excluded from the above calculations as follows: % change in sales greater than 1000% over the two-year period; materials share greater than 2; wage share greater than 2, capital intensity greater than 10.

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

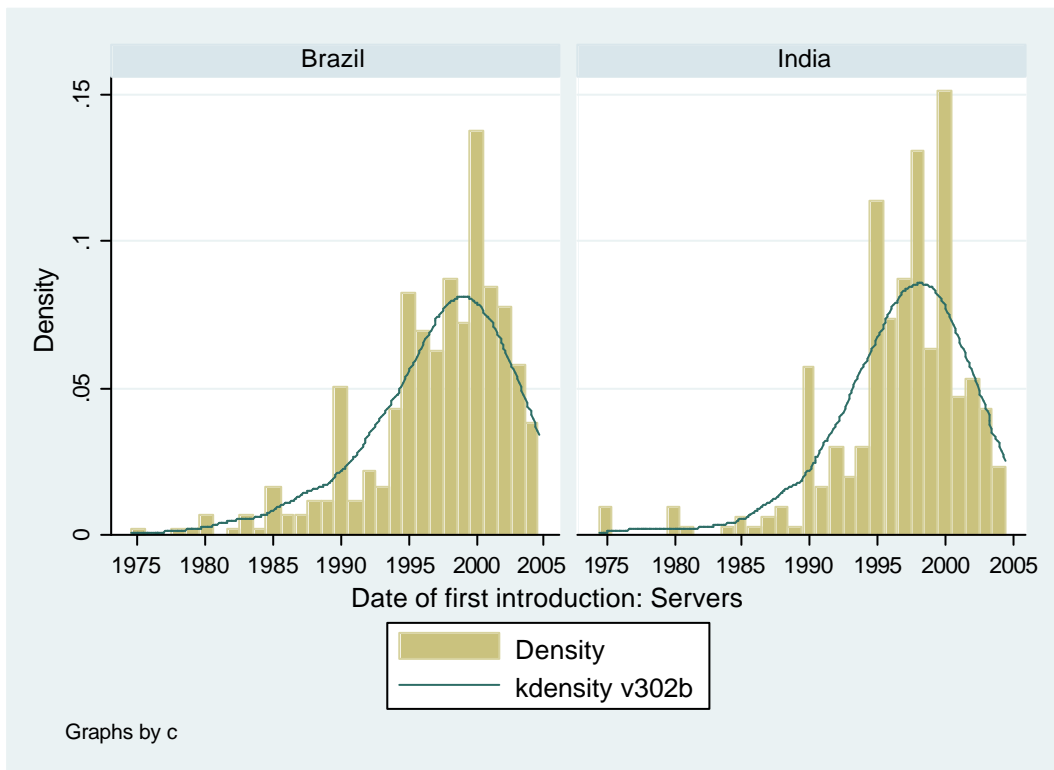


Notes: thin bars are for 2001, thick bars for 2003;

**Figure 2: Date of first introduction: PCs**



**Figure 3: Date of first introduction: Servers**



**Table 2: Measures of ICT adoption in 2003**

	Brazil				India			
	Mean	Median	s.d	Obs	Mean	Median	s.d	Obs.
<b>Summary measures</b>								
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
<b>Hardware</b>								
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
<b>Workforce usage</b>								
% 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

Notes: for ICT capital as a % of sales a small number of outliers are excluded with ICT capital as a % of sales greater than 300%.

**Table 3: Change in ICT adoption, 2001-2003**

	Brazil				India			
	Mean	Median	s.d	Obs	Mean	Median	s.d	Obs.
<b>Summary measures</b>								
Adoption index	0.68	0	0.92	482	0.59	0	0.78	475
Usage index	1.39	0	2.26	448	1.69	0	2.34	473
<b>Hardware</b>								
ICT capital as % of sales	2.06	0.27	12.74	273	2.01	0.19	13.32	430
PCs per employee	0.07	0.05	0.15	349	0.07	0.03	0.14	470
Servers per employee	0.007	0.001	0.051	346	0.004	0.000	0.033	470
<b>Workforce usage</b>								
% of non-production workers using PCs	12.5	0	20.9	462	14.2	10	19.4	476
% of production workers using ICT-controlled mach.	9.0	0	19.5	456	6.7	0	14.5	472

Notes: for ICT capital as a % of sales a small number of outliers are excluded with ICT capital as a % of sales greater than 300% in either 2001 or 2003.

**Table 4: Correlates of adoption**

<b>Panel A: Brazil</b>	(1)	(2)	(3)	(4)	(5)	(6)
	Adoption	Usage	%usingPCs	%usingMch	ln(ict/emp)	ln(ict/y)
30-250 emp	0.640 (0.181)***	0.812 (0.170)***	11.885 (5.627)**	-1.325 (4.482)	-0.442 (0.265)*	-0.485 (0.340)
250+ emp	1.551 (0.233)***	1.421 (0.215)***	24.076 (6.638)***	8.265 (6.022)	-0.324 (0.314)	-0.359 (0.399)
mne	0.657 (0.389)*	0.711 (0.341)**	13.850 (9.697)	16.646 (14.888)	-0.528 (0.365)	0.804 (1.106)
so	0.198 (0.485)	0.512 (0.473)	-18.481 (12.116)	-9.116 (8.151)	0.631 (0.706)	0.367 (0.802)
listed	0.146 (0.256)	0.514 (0.431)	-9.740 (7.042)	4.984 (7.122)	0.776 (0.542)	0.660 (0.809)
jvd	-0.435 (0.139)***	0.179 (0.126)	8.445 (4.100)**	1.591 (3.738)	-0.324 (0.232)	-0.567 (0.303)*
jvf	-0.018 (0.223)	0.030 (0.215)	-0.069 (5.867)	5.031 (6.079)	-0.200 (0.277)	-0.654 (0.465)
union	0.143 (0.132)	0.258 (0.122)**	-0.238 (4.067)	1.882 (3.643)	-0.086 (0.217)	-0.341 (0.293)
Admin	0.020 (0.005)***	0.019 (0.005)***	0.427 (0.137)***	0.320 (0.160)**	0.021 (0.008)**	0.008 (0.013)
Managers	-0.018 (0.012)	-0.012 (0.011)	-0.239 (0.471)	0.371 (0.343)	0.029 (0.016)*	0.034 (0.019)*
Other	0.022 (0.005)***	0.015 (0.005)***	0.063 (0.141)	0.197 (0.155)	-0.006 (0.010)	-0.004 (0.014)
Prod: US	0.005 (0.002)**	0.008 (0.002)***	0.047 (0.067)	0.245 (0.059)***	0.003 (0.004)	-0.001 (0.004)
Prod: Coll	0.018 (0.006)***	0.024 (0.009)***	0.113 (0.136)	0.554 (0.239)**	0.019 (0.008)**	0.012 (0.011)
Admin: US	0.005 (0.003)	0.002 (0.003)	0.247 (0.099)**	-0.067 (0.074)	-0.000 (0.005)	0.002 (0.006)
Admin: Coll	0.001 (0.003)	0.006 (0.003)**	0.281 (0.108)***	-0.073 (0.077)	0.005 (0.005)	0.005 (0.006)
Age<10	-0.108 (0.149)	0.119 (0.147)	3.311 (4.390)	2.809 (3.863)	0.494 (0.232)**	0.325 (0.297)
Age 11-20	-0.084 (0.161)	-0.198 (0.148)	4.763 (4.497)	4.486 (4.264)	0.476 (0.240)**	0.710 (0.313)**
Observations	358	358	358	358	256	226
R-squared			0.23	0.24	0.21	0.16

Note: mne= multinational firm; jvd= domestic joint venture; jvf= foreign joint venture; so= state owned firm

<b>Panel B: India</b>	(1)	(2)	(3)	(4)	(5)	(6)
	Adoption	Usage	%usingPCs	%usingMch	ln(ict/emp)	ln(ict/y)
30-250 emp	0.457 (0.150)***	0.396 (0.137)***	3.797 (4.002)	10.511 (1.940)***	-0.310 (0.180)*	-0.565 (0.234)**
250+ emp	1.126 (0.198)***	0.723 (0.175)***	11.532 (5.156)**	19.855 (3.626)***	-0.590 (0.276)**	-0.671 (0.349)*
mne	0.137 (0.254)	0.390 (0.271)	11.733 (7.002)*	0.029 (6.637)	-0.290 (0.383)	0.190 (0.714)
so	-0.168 (0.246)	0.185 (0.264)	-12.091 (6.399)*	2.321 (5.891)	0.410 (0.338)	1.325 (0.641)**
listed	0.010 (0.133)	0.253 (0.127)**	1.343 (3.685)	-1.811 (2.692)	-0.124 (0.195)	-0.187 (0.229)
jvd	0.106 (0.150)	0.068 (0.137)	-13.505 (3.799)***	1.562 (2.857)	-0.216 (0.192)	-0.357 (0.243)
jvf	0.295 (0.200)	0.352 (0.172)**	1.532 (5.228)	1.591 (4.224)	0.714 (0.307)**	0.184 (0.470)
union	0.135 (0.122)	0.217 (0.118)*	-0.620 (3.701)	1.438 (2.751)	0.018 (0.184)	0.057 (0.254)
Admin	0.002 (0.006)	-0.004 (0.005)	0.060 (0.139)	0.036 (0.080)	0.024 (0.007)***	0.013 (0.010)
Managers	0.019 (0.007)***	0.005 (0.007)	0.146 (0.170)	0.069 (0.108)	0.009 (0.011)	0.003 (0.014)
Other	0.011 (0.005)**	0.009 (0.005)	0.199 (0.160)	0.165 (0.103)	0.012 (0.007)*	-0.008 (0.009)
Prod - US	0.002 (0.002)	0.004 (0.002)*	0.134 (0.057)**	0.060 (0.035)*	-0.000 (0.003)	0.001 (0.004)
Prod - Coll	0.002 (0.003)	0.006 (0.002)**	0.062 (0.068)	0.261 (0.058)***	0.005 (0.004)	0.003 (0.005)
Adm - US	-0.002 (0.005)	0.003 (0.004)	0.021 (0.114)	0.000 (0.077)	0.012 (0.006)*	0.005 (0.007)
Adm - Coll	-0.003 (0.004)	0.001 (0.003)	0.110 (0.070)	-0.036 (0.055)	0.001 (0.004)	-0.000 (0.006)
Age<10	-0.315 (0.157)**	0.152 (0.141)	-5.353 (4.122)	0.272 (2.647)	-0.265 (0.212)	-0.211 (0.255)
Age 11-20	-0.117 (0.124)	-0.038 (0.112)	-2.680 (3.539)	-3.248 (2.225)	-0.123 (0.165)	0.095 (0.216)
Observations	454	454	454	454	422	418
R-squared			0.28	0.29	0.22	0.15

Note: mne= multinational firm; jvd= domestic joint venture; jvf= foreign joint venture; so= state owned firm

**Table 5: Basic production functions in levels**

Panel A: Brazil			
	(1)	(2)	(3)
Log employment	0.470 (0.114)***	0.516 (0.111)***	0.443 (0.112)***
Log materials	0.332 (0.061)***	0.353 (0.061)***	0.330 (0.062)***
Log Gross Fixed Assets	0.227 (0.082)***	0.205 (0.080)**	0.203 (0.079)**
Log ICT capital	0.157 (0.047)***		0.140 (0.049)***
Adoption=3		0.117 (0.184)	0.044 (0.185)
Adoption=4		0.689 (0.227)***	0.604 (0.224)***
Adoption=5		0.405 (0.200)**	0.267 (0.210)
Observations	198	198	198
R-squared	0.83	0.83	0.84
Panel B: India			
	(1)	(2)	(3)
Log employment	0.339 (0.063)***	0.355 (0.063)***	0.304 (0.062)***
Log materials	0.428 (0.048)***	0.436 (0.046)***	0.423 (0.047)***
Log Gross Fixed Assets	0.198 (0.037)***	0.216 (0.036)***	0.202 (0.036)***
Log ICT capital	0.115 (0.032)***		0.101 (0.032)***
Adoption=3		0.365 (0.107)***	0.326 (0.108)***
Adoption=4		0.568 (0.136)***	0.534 (0.134)***
Adoption=5		0.253 (0.149)*	0.227 (0.149)
Observations	335	335	335
R-squared	0.87	0.87	0.88



**Table 6: Levels results controlling for omitted variables**

Panel A:	(1)	(2)	(3)	(4)
Brazil	baseline	occupation	occ & skills	+ other controls
Log employment	0.392 (0.109)***			
Log materials	0.359 (0.062)***	0.357 (0.064)***	0.369 (0.064)***	0.364 (0.068)***
Log Gross Fixed Assets	0.214 (0.083)**	0.211 (0.086)**	0.201 (0.085)**	0.209 (0.087)**
Log ICT capital	0.173 (0.042)***	0.158 (0.051)***	0.131 (0.057)**	0.120 (0.066)*
Production emp		0.256 (0.100)**		
Admin emp		0.157 (0.140)		
Managerial emp		0.039 (0.126)	0.048 (0.124)	0.045 (0.125)
Other emp		0.041 (0.072)	0.024 (0.067)	0.019 (0.063)
Skilled prod			0.102 (0.074)	0.113 (0.082)
Unskilled prod			0.127 (0.047)***	0.122 (0.051)**
Skilled admin			0.175 (0.085)**	0.213 (0.089)**
Unskilled admin			0.111 (0.078)	0.076 (0.095)
Observations	172	172	172	172
R-squared	0.84	0.84	0.84	0.85

Panel B: India	(1) baseline	(2) occupation	(3) occ & skills	(4) + other controls	(5) + software
Log employment	0.337 (0.066)***				
Log materials	0.434 (0.051)***	0.452 (0.049)***	0.444 (0.049)***	0.446 (0.048)***	0.448 (0.049)***
Log Gross Fixed Assets	0.188 (0.038)***	0.205 (0.040)***	0.213 (0.039)***	0.209 (0.041)***	0.205 (0.041)***
Log ICT capital	0.115 (0.034)***	0.082 (0.034)**	0.088 (0.036)**	0.095 (0.037)**	0.051 (0.049)
Log software stock					0.073 (0.047)
Production emp		-0.019 (0.070)			
Admin emp		0.160 (0.084)*			
Managerial emp		0.251 (0.075)***	0.267 (0.073)***	0.240 (0.074)***	0.231 (0.073)***
Other emp		-0.032 (0.044)	-0.028 (0.041)	-0.039 (0.043)	-0.054 (0.044)
Skilled prod			-0.026 (0.051)	-0.044 (0.055)	-0.043 (0.056)
Unskilled prod			0.014 (0.036)	-0.000 (0.040)	0.003 (0.040)
Skilled admin			0.113 (0.080)	0.137 (0.085)	0.127 (0.086)
Unskilled admin			0.067 (0.059)	0.064 (0.062)	0.062 (0.061)
Observations	312	312	312	312	312
R-squared	0.87	0.87	0.87	0.87	0.88

**Table 7: Two-year differences (2001-2003)**

Panel A: Brazil	(1) Levels	(2) Baseline	(3) Occupation	(4) Occ&skills	(5) Other controls
Log employment	0.262 (0.139)*	0.190 (0.096)**			
Log materials	0.534 (0.111)***	0.369 (0.124)***	0.364 (0.132)***	0.349 (0.122)***	0.296 (0.127)**
Log Gross Fixed Assets	0.190 (0.115)	0.159 (0.132)	0.167 (0.130)	0.199 (0.135)	0.132 (0.145)
Log ICT capital	0.123 (0.081)	0.193 (0.070)***	0.217 (0.069)***	0.195 (0.060)***	0.223 (0.063)***
Production emp			-0.062 (0.137)		
Admin emp			0.306 (0.137)**		
Managerial emp			-0.076 (0.088)	-0.061 (0.087)	-0.084 (0.096)
Other emp			0.023 (0.051)	0.016 (0.058)	0.020 (0.061)
Skilled prod				0.160 (0.186)	0.162 (0.191)
Unskilled prod				0.042 (0.094)	0.003 (0.094)
Skilled admin				0.001 (0.146)	0.039 (0.148)
Unskilled admin				0.059 (0.077)	0.055 (0.111)
Observations	130	130	130	130	130
R-squared	0.78	0.59	0.60	0.60	0.66

Panel B: India	(1) Levels	(2) Baseline	(3) Occupation	(4) Occ&skills	(5) Other controls	(6) Software
Log employment	0.081 (0.139)	0.180 (0.078)**				
Log materials	0.563 (0.074)***	0.343 (0.104)***	0.364 (0.108)***	0.358 (0.107)***	0.335 (0.109)***	0.346 (0.105)***
Log Gross Fixed Assets	0.099 (0.061)	0.154 (0.099)	0.154 (0.101)	0.149 (0.098)	0.128 (0.094)	0.175 (0.095)*
Log ICT capital	0.175 (0.063)***	0.101 (0.039)**	0.095 (0.039)**	0.084 (0.040)**	0.101 (0.044)**	0.091 (0.037)**
Log software						0.036 (0.038)
Production emp			-0.013 (0.039)			
Admin emp			0.059 (0.051)			
Managerial emp			0.005 (0.049)	0.021 (0.048)	0.025 (0.054)	0.025 (0.054)
Other emp			0.099 (0.055)*	0.121 (0.052)**	0.120 (0.053)**	0.101 (0.059)*
Skilled prod				0.012 (0.040)	0.013 (0.040)	0.009 (0.039)
Unskilled prod				-0.037 (0.037)	-0.042 (0.036)	-0.049 (0.039)
Skilled admin				0.055 (0.046)	0.053 (0.048)	0.063 (0.046)
Unskilled admin				-0.053 (0.038)	-0.047 (0.043)	-0.061 (0.041)
Observations	248	248	248	248	248	248
R-squared	0.68	0.38	0.39	0.40	0.43	0.46

**Table 8: Organisational change: flattening**

Panel A: Brazil				
	(1)	(2)	(3)	(4)
	Full	Full	3-5	3-5
Log employment	0.180 (0.087)**	0.167 (0.086)*	0.295 (0.125)**	0.271 (0.102)**
Log materials	0.367 (0.121)***	0.351 (0.115)***	0.407 (0.158)**	0.394 (0.160)**
Log Gross Fixed Assets	0.111 (0.122)	0.099 (0.116)	0.029 (0.173)	0.010 (0.162)
Log ICT capital	0.160 (0.065)**	0.100 (0.058)*	0.087 (0.079)	0.025 (0.074)
Org change	-0.005 (0.046)	-0.169 (0.095)*	-0.003 (0.061)	-0.373 (0.172)**
OC * ICT capital		0.150 (0.091)		0.296 (0.125)**
Observations	156	156	105	105
R-squared	0.55	0.56	0.62	0.65
Panel B: India				
	(1)	(2)	(3)	(4)
	Full	Full	3-5	3-5
Log employment	0.159 (0.069)**	0.160 (0.070)**	0.136 (0.086)	0.137 (0.086)
Log materials	0.355 (0.103)***	0.357 (0.103)***	0.273 (0.115)**	0.276 (0.114)**
Log Gross Fixed Assets	0.155 (0.095)	0.154 (0.095)	0.170 (0.118)	0.170 (0.118)
Log ICT capital	0.088 (0.038)**	0.093 (0.039)**	0.069 (0.037)*	0.084 (0.038)**
Org change	0.020 (0.020)	0.032 (0.055)	0.045 (0.020)**	0.080 (0.066)
OC * ICT capital		-0.011 (0.042)		-0.030 (0.049)
Observations	266	266	158	158
R-squared	0.38	0.38	0.51	0.51

**Table 9: Organisational change: improved monitoring**

Panel A: Brazil				
	(1)	(2)	(3)	(4)
	Full	Full	3-5	3-5
Log employment	0.180 (0.087)**	0.181 (0.088)**	0.295 (0.124)**	0.287 (0.118)**
Log materials	0.367 (0.120)***	0.364 (0.120)***	0.407 (0.162)**	0.418 (0.162)**
Log Gross Fixed Assets	0.111 (0.122)	0.092 (0.119)	0.030 (0.164)	-0.004 (0.151)
Log ICT capital	0.160 (0.066)**	0.127 (0.071)*	0.087 (0.086)	-0.017 (0.108)
Org change	0.002 (0.024)	-0.022 (0.035)	0.000 (0.035)	-0.078 (0.064)
OC * ICT capital		0.023 (0.034)		0.068 (0.055)
Observations	156	156	105	105
R-squared	0.55	0.55	0.62	0.63
Panel B: India				
	(1)	(2)	(3)	(4)
	Full	Full	3-5	3-5
Log employment	0.156 (0.069)**	0.155 (0.070)**	0.130 (0.088)	0.130 (0.089)
Log materials	0.352 (0.105)***	0.350 (0.105)***	0.271 (0.118)**	0.272 (0.117)**
Log Gross Fixed Assets	0.157 (0.095)*	0.157 (0.095)*	0.184 (0.121)	0.184 (0.121)
Log ICT capital	0.093 (0.039)**	0.088 (0.040)**	0.076 (0.038)**	0.083 (0.042)**
Org change	0.018 (0.015)	0.010 (0.026)	0.025 (0.018)	0.034 (0.043)
OC * ICT capital		0.008 (0.020)		-0.009 (0.035)
Observations	266	266	158	158
R-squared	0.38	0.38	0.50	0.50

**Table 10: Organisational change: improved management decision making**

Panel A: Brazil				
	(1)	(2)	(3)	(4)
	Full	Full	3-5	3-5
Log employment	0.179 (0.088)**	0.182 (0.088)**	0.297 (0.125)**	0.292 (0.127)**
Log materials	0.361 (0.121)***	0.357 (0.118)***	0.408 (0.157)**	0.418 (0.162)**
Log Gross Fixed Assets	0.113 (0.121)	0.124 (0.118)	0.028 (0.164)	0.020 (0.154)
Log ICT capital	0.157 (0.067)**	0.223 (0.123)*	0.085 (0.082)	0.056 (0.149)
Org change	-0.050 (0.056)	0.051 (0.116)	-0.024 (0.087)	-0.073 (0.202)
OC * ICT capital		-0.097 (0.113)		0.043 (0.155)
Observations	156	156	105	105
R-squared	0.55	0.55	0.62	0.62
Panel B: India				
	(1)	(2)	(3)	(4)
	Full	Full	3-5	3-5
Log employment	0.171 (0.070)**	0.170 (0.070)**	0.150 (0.090)*	0.149 (0.091)
Log materials	0.353 (0.103)***	0.352 (0.103)***	0.271 (0.116)**	0.270 (0.116)**
Log Gross Fixed Assets	0.149 (0.095)	0.149 (0.095)	0.167 (0.119)	0.167 (0.120)
Log ICT capital	0.089 (0.038)**	0.085 (0.045)*	0.071 (0.040)*	0.065 (0.046)
Org change	0.063 (0.030)**	0.051 (0.067)	0.090 (0.035)**	0.072 (0.088)
OC * ICT capital		0.011 (0.057)		0.017 (0.071)
Observations	266	266	158	158
R-squared	0.38	0.38	0.51	0.51

**Table 11: Descriptive statistics on regional averages of constraints**

	Brazil			India		
	Mean	Median	s.d	Mean	Median	s.d
<b>Power disruptions</b>						
Mean days disrupted	-	-	-	21.76	16.71	7.86
Median days disrupted	-	-	-	9.09	2.00	11.35
<b>Reported constraints</b>						
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

Notes: 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; availability of skills is an average across four types of workers; standard deviations are for the variation in the mean values across 7 Brazilian regions and 9 Indian States.

**Table 12: Power disruptions and ICT adoption across Indian states**

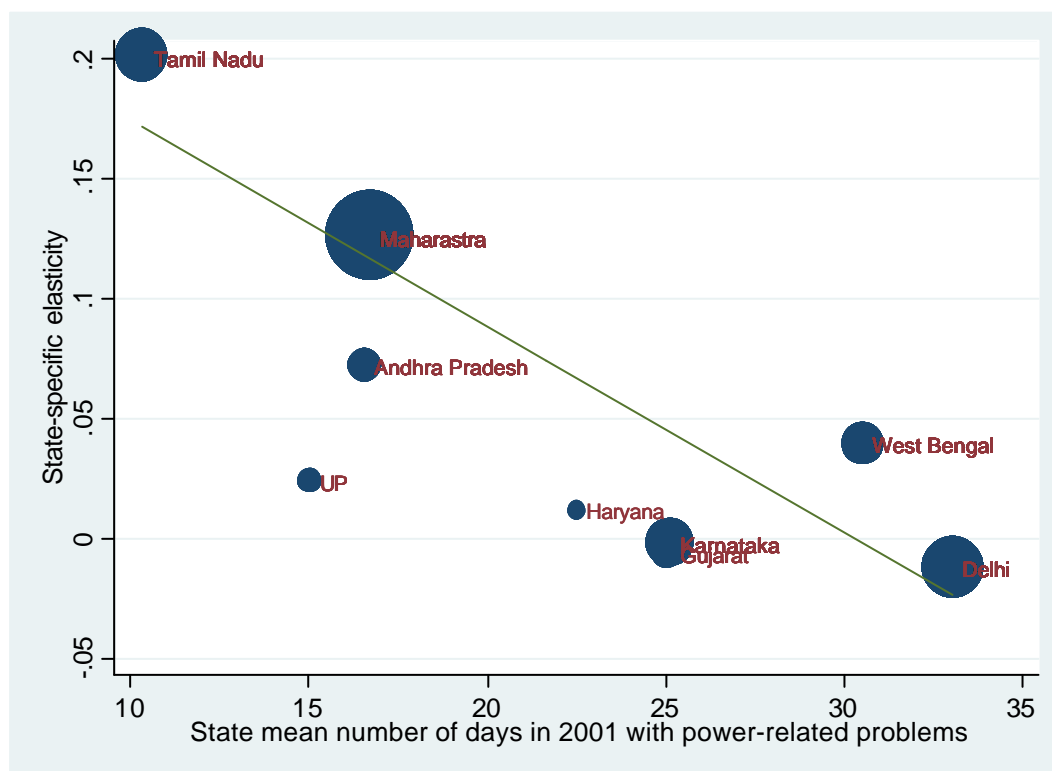
Panel A: Levels	(1) Adoption	(2) Usage	(3) %usingPCs	(4) %usingMch	(5) ln(ict/y)
Mean days disrupted	-0.025 (0.010)***	-0.001 (0.009)	-0.415 (0.368)	-0.073 (0.257)	-0.051 (0.019)**
Observations	454	454	454	454	418
R-squared			0.20	0.25	0.09
Panel B: Changes	(1) dAdoption	(2) dUsage	(3) d%usingPCs	(4) d%usingMch	(5) dln(ict/y)
Mean days disrupted	-0.022 (0.010)**	0.002 (0.005)	-0.164 (0.061)**	-0.213 (0.129)	0.011 (0.007)
Observations	452	452	452	452	417
R-squared			0.15	0.15	0.21



**Table 13: Power disruptions and returns to ICT across Indian states**

	(1)	(2)
Log employment	0.148 (0.038)***	0.158 (0.040)***
Log materials	0.359 (0.117)**	0.358 (0.114)**
Log GFA	0.153 (0.098)	0.155 (0.094)
Log ICT capital	0.246 (0.049)***	0.122 (0.046)**
Mean days * ICT	-0.008 (0.002)***	
Median days * ICT		-0.005 (0.002)**
Observations	266	266
R-squared	0.39	0.38

**Figure 4: Power disruptions and elasticity of ICT capital across Indian states**



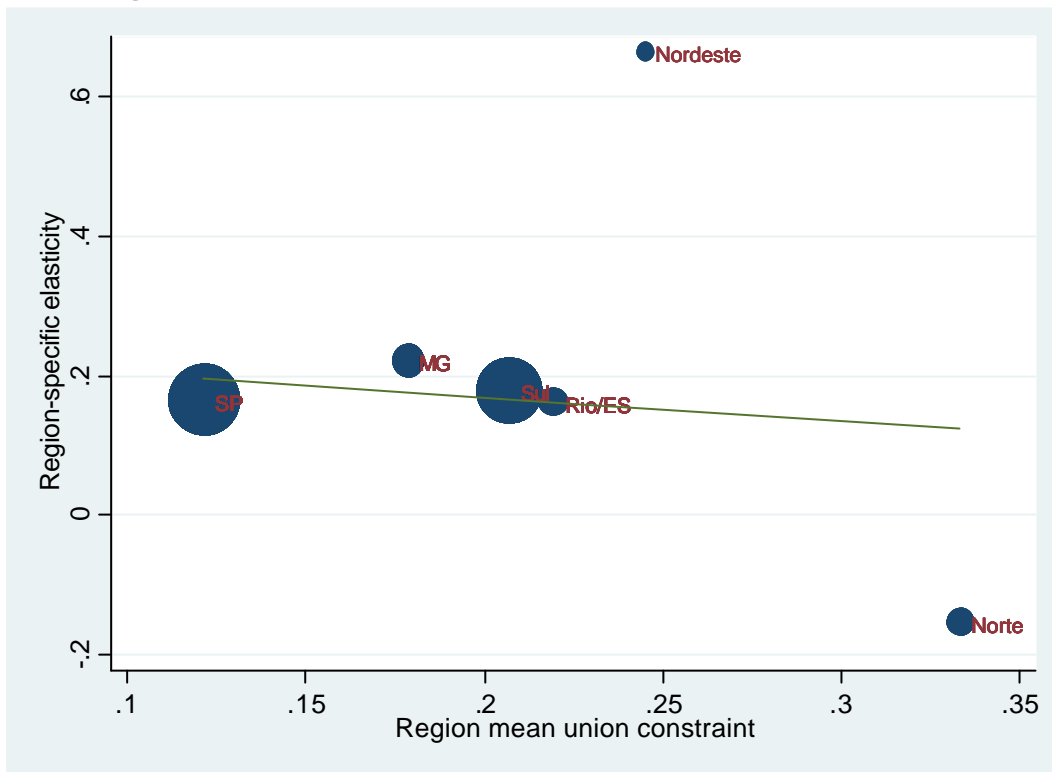
**Table 14: Constraints and returns to ICT capital across Indian states**

	(1)	(2)	(3)	(4)	(5)	(6)
Log employment	0.158 (0.040)***	0.160 (0.040)***	0.159 (0.040)***	0.162 (0.040)***	0.161 (0.040)***	0.159 (0.040)***
Log materials	0.360 (0.116)**	0.358 (0.115)**	0.358 (0.115)**	0.358 (0.115)**	0.359 (0.115)**	0.357 (0.114)**
Log GFA	0.154 (0.095)	0.154 (0.094)	0.153 (0.094)	0.153 (0.094)	0.153 (0.094)	0.153 (0.094)
Log ICT capital	0.169 (0.059)**	0.108 (0.044)**	0.131 (0.051)**	0.145 (0.067)*	0.237 (0.095)**	0.158 (0.062)**
Skills * ICT	-0.210 (0.070)**					
Unions * ICT		-0.172 (0.121)				
Lab laws * ICT			-0.174 (0.085)*			
i-access * ICT				-0.136 (0.089)		
i-users * ICT					-0.319 (0.137)**	
Gov * ICT						-0.197 (0.097)*
Observations	266	266	266	266	266	266
R-squared	0.38	0.38	0.38	0.38	0.38	0.38

**Table 15: Constraints and returns to ICT capital across Brazilian regions**

	(1)	(2)	(3)	(4)	(5)	(6)
Log employment	0.186 (0.142)	0.202 (0.126)	0.198 (0.129)	0.179 (0.138)	0.192 (0.128)	0.180 (0.141)
Log materials	0.365 (0.107)**	0.368 (0.105)**	0.372 (0.099)***	0.376 (0.104)**	0.380 (0.106)**	0.367 (0.105)**
Log GFA	0.113 (0.107)	0.115 (0.114)	0.119 (0.115)	0.110 (0.108)	0.116 (0.115)	0.112 (0.107)
Log ICT capital	0.306 (0.224)	0.372 (0.092)***	0.707 (0.287)**	0.433 (0.368)	0.672 (0.313)*	0.194 (0.200)
Skills * ICT	-0.286 (0.480)					
Unions * ICT		-1.176 (0.580)*				
Lab laws * ICT			-1.454 (0.838)			
i-access * ICT				-0.634 (0.911)		
i-users * ICT					-1.164 (0.753)	
Gov * ICT						-0.069 (0.407)
Observations	156	156	156	156	156	156
R-squared	0.55	0.55	0.56	0.55	0.55	0.55

**Figure 5: Union constraint and elasticity of ICT capital across Brazilian regions (excluding Centro)**



## Appendix A

**Table A1: Sample distribution by region/state and sector**

	Electronic Components	Plastic Products	Soap & Detergents	Auto Parts	Machine Tools	Wearing Apparel	Total
<b>Panel A: Brazil</b>							
Norte	2	4	2	1	0	3	12
Nordeste	1	12	9	1	7	19	49
Sul	18	26	9	24	33	25	135
Centro	2	6	8	3	3	4	26
Rio / Espirito Santo	4	8	6	6	7	10	41
Sao Paulo	29	20	31	37	23	33	173
Minas Gerais	20	5	12	6	8	5	56
<b>Total</b>	<b>76</b>	<b>81</b>	<b>77</b>	<b>78</b>	<b>81</b>	<b>99</b>	<b>492</b>
<b>Panel B: India</b>							
Andhra Pradesh	8	10	1	4	4	0	27
Delhi	14	22	10	27	5	23	101
Gujarat	2	15	2	1	1	4	25
Haryana	0	0	0	6	0	0	6
Karnataka	12	4	1	8	10	3	38
Maharashtra	25	56	22	32	17	22	174
Tamil Nadu	10	8	2	18	9	7	54
Uttar Pradesh	3	1	1	5	0	0	10
West Bengal	4	10	8	9	6	4	41
<b>Total</b>	<b>78</b>	<b>126</b>	<b>47</b>	<b>110</b>	<b>52</b>	<b>63</b>	<b>476</b>

**Table A2: Branch information for Brazil and India**

	Electronic Components	Plastic Products	Soaps & Detergents	Auto Parts	Machine Tools	Wearing Apparel
<b>India</b>						
Share of manufacturing employment	0.5	1.9	5.8	2.2	1.9	4.6
Growth rates of employment (1998-2003)	-1.6	2.5	0.8	2.3	-3.3	3.7
Mean manufacturing wages (Rupees millions)	0.07	0.04	0.05	0.07	0.07	0.03
Growth rates of manufacturing wages (1998-2003)	10.6	5.7	4.4	14.2	1.8	7.6
Share of value added	0.9	1.7	11.0	2.5	2.2	2.0
Growth rates of value added (1998-2003)	9.2	6.5	5.0	6.5	4.6	8.6
Growth rates of value added per worker (1998-2003)	10.6	12.3	5.2	8.0	3.6	-0.5
<b>Brazil</b>						
Share of manufacturing employment	1.0	6.1	4.7	5.8	6.8	5.4
Growth rates of employment (1998-2003)	9.4	33.3	18.2	23.3	31.8	13.5
Mean manufacturing wages (Reais 000)	9.1	6.8	10.9	12.3	8.3	4.9
Growth rates of manufacturing wages (1998-2003)	33.8	76.0	70.0	61.9	42.4	25.9
Share of value added	1.7	3.8	10.8	7.4	5.7	2.2
Growth rates of value added (1998-2003)	-19.1	-11.4	-9.9	-12.2	-18.0	-12.7
Growth rates of value added per worker (1998-2003)	-12.6	-12.2	16.4	16.6	10.6	2.6

**Table A3: Country indicators for ICT, 2000 and 2004**

	<b>Brazil</b>		<b>India</b>	
	<b>2000</b>	<b>2004</b>	<b>2000</b>	<b>2004</b>
GNI per capita (current US\$)	3590	3090	450	620
Adult literacy rate (%)	n.a	89	n.a	61
Tertiary enrolment rate	16	22	10	11
ICT expenditure/GDP	5.6	6.7	3.6	3.7
Secure Internet servers (per 1m)	6.0	11.2	0.1	0.4
Telephone main lines (per1000)	182	237	32	43
Internet users (per 1000)	29	109	5	23
PCs (per 1000)	50	86	5	11
Broadband subscribers (per 1000)	0.6	12.8	0	0.6
International Internet bandwidth (bits per person)	5	154	1	4

Source: World Bank, 2006

**Table A4: Descriptive statistics for production functions in levels**

	<b>Brazil</b>				<b>India</b>			
	<b>Mean</b>	<b>Median</b>	<b>s.d</b>	<b>Obs</b>	<b>Mean</b>	<b>Median</b>	<b>s.d</b>	<b>Obs.</b>
<b>Log sales</b>	15.27	15.16	2.12	198	18.21	18.06	2.03	335
<b>Log employment</b>	4.21	4.08	1.43	198	4.45	4.24	1.53	335
<b>Log materials</b>	13.97	13.71	2.14	159	16.97	16.81	2.16	335
<b>Log GFA</b>	14.32	14.15	2.17	136	16.82	16.52	2.10	335
<b>Log ICT capital</b>	10.43	10.41	1.94	198	12.57	12.62	2.09	335

**Table A5: Descriptive statistics for production functions in differences**

	<b>Brazil</b>				<b>India</b>			
	<b>Mean</b>	<b>Median</b>	<b>s.d</b>	<b>Obs</b>	<b>Mean</b>	<b>Median</b>	<b>s.d</b>	<b>Obs.</b>
<b>DLog sales</b>	0.252	0.201	0.372	156	0.250	0.223	0.277	266
<b>DLog Deployment</b>	0.092	0.042	0.361	156	0.145	0.134	0.253	266
<b>DLog materials</b>	0.310	0.288	0.403	129	0.269	0.223	0.312	266
<b>DLog GFA</b>	0.209	0.182	0.291	104	0.157	0.091	0.224	266
<b>DLog ICT capital</b>	1.071	0.998	0.562	156	1.016	1.025	0.500	266

**Table A6: Correlations between power disruptions and constraints across states**

	Days disrupted	Skills	Unions	Labour laws	Internet avail. or price	No. using the net
Days of disruptions	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 or 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 govt support	0.6226	0.9101	0.9332	0.9839	0.9569	0.9188

**Table A7: Two-year differences complemented with IBGE data (2001-2003)**

Panel A: Brazil	(1) Levels	(2) Baseline	(3) Occupation	(4) Occ&skills	(5) Other controls
Log employment	0.182 (0.112)*	0.172 (0.083)**			
Log materials	0.506 (0.096)***	0.398 (0.106)***	0.403 (0.110)***	0.415 (0.113)***	0.396 (0.106)**
Log Gross Fixed Assets	0.170 (0.094)*	0.168 (0.103)	0.174 (0.105)	0.195 (0.104)*	0.150 (0.079)*
Log ICT capital	0.175 (0.069)***	0.125 (0.058)***	0.131 (0.059)***	0.128 (0.058)***	0.130 (0.053)***
Production emp			0.073 (0.125)		
Admin emp			0.097 (0.094)		
Managerial emp			-0.045 (0.079)	-0.051 (0.078)	-0.001 (0.066)
Other emp			0.050 (0.044)	0.042 (0.051)	0.041 (0.051)
Skilled prod				0.092 (0.113)	0.094 (0.115)
Unskilled prod				0.139 (0.083)	0.123 (0.081)
Skilled admin				-0.117 (0.123)	-0.064 (0.116)
Unskilled admin				0.048 (0.066)	0.075 (0.063)
Observations	148	148	148	148	148
R-squared	0.82	0.453	0.457	0.467	0.570

