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The Impact of Information Technology Outsourcing on Productivity and Output: New Evidence from India

by

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The Impact of Information Technology Outsourcing on Productivity and Output: New Evidence from India

Grace Kite [1]

Abstract

Neither the literature on outsourcing nor the literature on the impact of information technology (IT) have previously quantified the effects of IT outsourcing. This is a particularly important omission in India, which has an IT outsourcing industry that is well placed to bring world-class applications of the technology to domestic customers. This paper provides econometric evidence which shows that there is a strong positive impact of IT outsourcing on output and productivity in India. It also demonstrates that in aggregate, IT outsourcing makes a substantial contribution to Indian economic growth.

JEL classification: O140, O330, O190

Keywords: Information Technology, Outsourcing, India

Introduction

There is now a strong consensus that information technology (IT) use has led to increases in productivity and output in the developed world. If use of IT has similar results in developing countries, any process by which successful applications of the technology can be brought to these countries is of considerable interest. A priori it seems possible that outsourcing deals between developing country firms and IT firms with experience in developed countries might provide such a process. So far though, there are only a few empirical publications that quantify the effects of IT use in developing countries and none of these evaluate outsourced IT. This paper is the first to occupy this gap in that it investigates the impact of IT outsourcing on output and productivity in India.

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India is an interesting and pertinent case study because the country is host to a large, successful, and high profile IT outsourcing industry which has a great deal of experience working with Fortune 500 and Global 2000 client firms in the United States (U.S.) and Europe. This means that if IT outsourcing does indeed offer a means to improve output and productivity, Indian firms, perhaps more than firms in any other developing country, are well placed to take advantage of it. Importantly, a very large amount of data appropriate for investigating the impact of IT outsourcing is also available for India. The analysis described in this paper uses a panel dataset which comprises over 33,500 observations on Indian firms, from both manufacturing and services sectors.

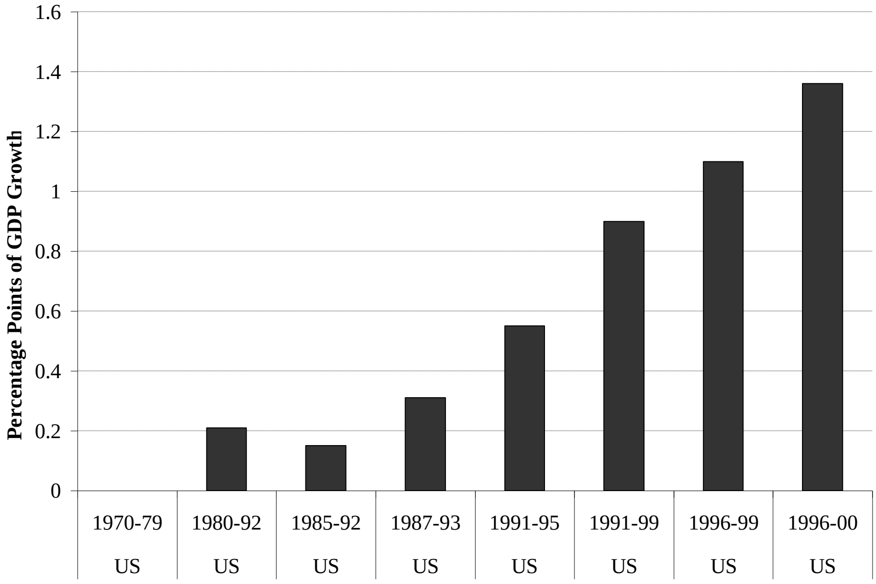
The analysis begins with a newly designed production function which has been constructed to take account of IT outsourcing alongside other inputs. Estimates of the parameters of this function reveal that there is a large and significant elasticity of output to IT outsourcing, and that it is robust to the use of techniques that correct for endogeneity. Following on from this conclusion, a second stage analysis sets out to investigate the impact of IT outsourcing on productivity. This uses a stochastic frontier model to create a measure of technical efficiency, and then analyses what impact IT outsourcing has on this measure. Again the work finds a positive and significant elasticity. Finally, a third stage analysis applies the estimated output elasticity to total domestic purchases of outsourced IT from the Indian IT sector. This results in an estimate of the impact that these purchases have on economic growth in India. At 1.3 percentage points of economic growth per year, this estimate is large enough to be comparable to the total output impact of IT in the U.S. in the 1990s.

The remainder of the paper is laid out as follows. Section 1 provides a brief overview of relevant literature; Section 2 describes the data; Section 3 covers the methods and findings on output; Section 4 the methods and findings on productivity; Section 5 reports the estimated impact on economic growth; and Section 6 concludes.

1. Related literature

Literature which evaluates the impact of IT has now converged on the conclusion that there were strong impacts on output and productivity in the developed countries in the 1990s and 2000s. Figures 1 and 2 provide a selected summary of these studies. Figure 1 shows the number of percentage points of GDP growth attributable to IT in the U.S[2]. It shows that IT adoption was responsible for an impressive acceleration in economic growth in the 1990s, and that by the end of that decade, IT use was contributing almost 1.4 percentage points of GDP growth per annum. Figure 2 illustrates the share of GDP growth attributable to IT in the U.S. and other developed countries[3]. It indicates a norm of between 10% and 30% throughout the 1990s.

Figure 1: GDP growth per annum attributed to IT in US

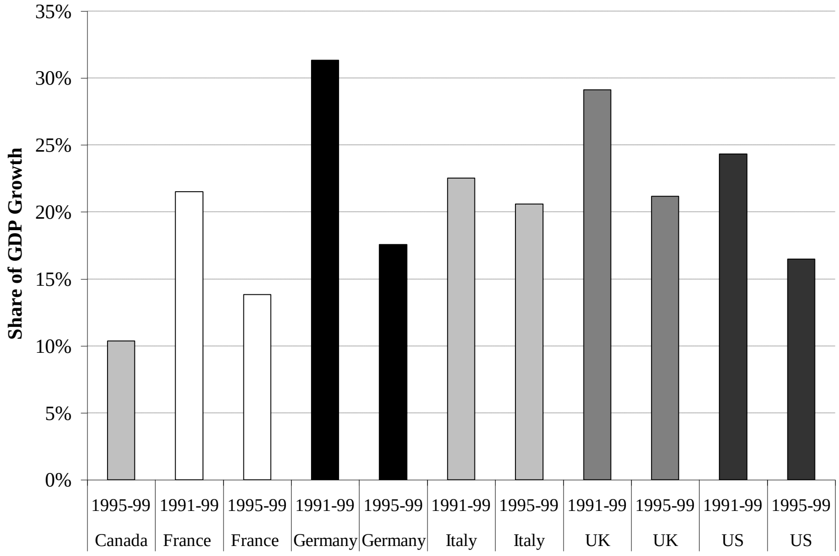


Sources: Jorgenson, Ho, and Stiroh (2007:9), International Monetary Fund (2001:106,116), Oliner & Sichel (1994), Jorgensen & Stiroh (1995), Sichel (1997), Jeong, Jeong, and Shin (2002), Crafts (2001), Daveri (2001), Oliner & Sichel (2000)

[2] Figure 1 summarizes the results of 8 separate analyses which all use the same methodology but examine different periods. The findings are arranged from left to right by the start date of the period under consideration.

[3] Figure 2 draws on the results of studies which identified percentage points of GDP growth attributable to IT use in production. These results are expressed as a share of total GDP growth in each country to facilitate comparisons between countries.

Figure 2: Share of Total GDP Growth Attributed to IT Use in Developed Countries



Notes: Adapted from Colecchia (2001); Daveri (2001); World Development Indicators (2010).

Until recently, strong impacts of IT use such as these had not been identified outside the developed world. It is only within a young literature which uses econometrics on firm-level data, often with several different countries included, that any impacts have become visible at all (Commander, Harrison, and Menezes-Filho, 2011; Motohashi, 2008; World Bank, 2006). These recent papers are encouraging signs, but as yet they do not constitute a clear consensus that IT use is important in developing countries, and none of these studies investigate the impact of outsourced IT.

As well as addressing this gap in the literature on IT, the evidence on the impact of IT outsourcing in India in this paper contributes to two other strands of literature: The first of these is composed of empirical work on the impact of outsourcing (Olsen, 2006). This literature is so far mainly focused on developed country outsourcers and in particular manufacturing firms. So far it has not considered IT outsourcing separately from other services such as back office processing or call centers (Amiti & Wei, 2004). The second is the literature on India's IT outsourcing industry. Authors in this literature have not considered the output or productivity impact of Indian firms purchasing outsourced IT from the sector. Because of a perceived preoccupation on exports in Indian IT firms, they are generally pessimistic about the possibility of this effect being large either in the present or in the future (Dahlman and Utz, 2005; D'Costa, 2003; Heeks, 1996; Kumar and Joseph, 2005).

2. Data

The main source of data is the PROWESS database published by the Centre for Monitoring the Indian Economy (CMIE, 2009). The data covers a panel of large and medium size firms registered on India's stock exchanges as well as public sector enterprises. PROWESS offers a large dataset for the purposes of evaluating the impact of IT outsourcing. In total there are over 33,500 fully populated observations covering just over 12,800 firms, with most firms reporting data in either 2, or 3, of the 4 years between 2005 and 2008. Table 1 shows the breakdown of these populated observations by year and sector. Unfortunately, the PROWESS database, and, consequently, the sample used here, suffers from attrition, particularly after 2006. This does not appear to have significantly affected the sector-wise composition of the sample, with the split for Manufacturing (50%) and Services and Finance (25% each) remaining consistent through all four of the years. Despite this, the potential for attrition bias does remain a concern and is the subject of robustness tests discussed below.

Table 1: Populated Sample by Sector and Year, Number of Firms

	2005	2006	2007	2008	Total
Manufacturing	5,594	5,054	4,122	2,510	17,280
Finance	3,061	2,623	1,847	885	8,416
Services	2,688	2,346	1,819	1,015	7,868
Total	11,343	10,023	7,788	4,410	33,564

Source: Author calculations based on CMIE (2009)

The data underwent a careful treatment designed to ensure accurate identification of the impact of IT outsourcing. Capital variables are net of cumulative depreciation, so as to better capture their productive value rather than their cost at purchase. In addition, all the variables which are measured in money terms have been corrected for inflation using individually appropriate price indexes. For non-services variables these have been sourced from Reserve Bank of India (2011). For services variables, GDP deflators have been constructed from real and nominal output in the appropriate sector, as published in the Indian National Account Statistics published by Ministry of Statistics and Programme Implementation (2011).

Software, both in-house and outsourced, is deflated using a recent index of software prices constructed by Prud'homme, Sanga, and Yu, (2005)[4].

Unfortunately PROWESS does not report expenditure on IT outsourcing separately, but includes it in the composite measure "Expenditure on Software and Other Professional Services". The definition of this latter metric shows that it includes expenditure on outsourced IT, but that it also includes all other "expenses reported by a company on external professional services engaged by the company for services other than for audit, consultancy, software development, IT-enabled services, cost audit and legal services" (CMIE 2009). Using this metric as a measure of IT outsourcing is justified because a major part of what is included in it is IT outsourcing[5]. The modelling strategy described below also mitigates for the most likely type of bias which may have arisen from use of this composite variable.

3. The Impact of IT Outsourcing on Output

3.1. Methods

The approach used to quantify the impact of outsourced IT on output combines methods from the empirical literature on the impact of IT and from the literature on more general outsourcing. This combination of approaches is necessary because, on the one hand, outsourced IT is similar to other outsourcing, in that it occurs outside the firm. On the other hand, though, outsourced IT also has the potential to either complement or substitute for IT used in-house by firms. This means that any evaluation of outsourced IT must include an evaluation of in-house IT or risk misattribution of output or productivity effects.

The literature on the impact of IT uses a production function modified to include IT assets, such as equation (1).

(1) $$Y = AF(K, IT, L, M)$$

Here Y refers to gross output; K to stocks of capital; IT to stocks of in-house hardware and software; L to the size of the labor force; M to intermediate inputs (including materials,

[4] This index is for Canada. Its use here is valid on the assumption that software is freely traded so that price movements are similar across countries. It is also consistent with comments from IT professionals in India.

[5] This is verified by the distribution of expenditure as measured by this variable across sectors in the sample. Average expenditure per firm is higher in sectors which are known to use IT intensively in other countries (Baily and Lawrence 2001: 309, Hanna 1994: 40), and which contributed a large share of the Indian IT sector's domestic revenues in 2006-07 (NASSCOM (2009: 203).

energy, and any other purchased inputs to production) and F(.) to the function which determines the amount of output produced from a given quantity of inputs. A refers to total factor productivity (TFP) and measures the efficiency with which all inputs are converted into output.

The literature on outsourcing postulates that firms who outsource experience improvements in TFP, because outsourcing is expected to facilitate the relocation of the least productive parts of a company's business, leaving better productivity in the remainder (Olsen, 2006). This leads to equation (2) in which OSS refers to outsourcing of services and OSM to outsourcing of manufactures or materials. Y, K, L, M and F(.) are defined as before.

(2) $$Y = A(OSS, OSM)F(K, L, M)$$

Combining these two approaches with a focus on IT outsourcing, denoted OSIT, gives equation (3). Assuming a Cobb-Douglas functional form for F(.) and taking logs of the resulting expression leads to equation (4). In equation (4), ln(.) is the natural logarithm, γ is the elasticity of output to IT outsourcing, and the α's are the elasticities of output to the other inputs. All other elements of the equations are defined as before.

(3) $$Y = A(OSIT)F(K, IT, L, M)$$

(4) $$\ln(Y) = \gamma \ln(OSIT) + \alpha_K \ln(K) + \alpha_{IT} \ln(IT) + \alpha_L \ln(L) + \alpha_M \ln(M)$$

3.2 Findings

Table 2 shows the results of estimating equation (4) using the populated sample from the PROWESS data. All variables in all models are significant at the 0.1% level. Column 1 shows a benchmark estimate of the production function without outsourcing included and with in-house IT combined with ordinary capital. Column 2 splits out in-house IT from ordinary capital and then column 3 splits IT capital into hardware and software. Columns 4 and 5 introduce IT outsourcing to the models in columns 2 and 3. These provide the first estimates of equation (4). In both column 4 and column 5, real IT outsourcing is highly significant and its coefficient indicates that doubling expenditure on IT outsourcing leads to a 9% increase in real gross output.

Table 2: Econometric Estimates of Equation (4)

	(1)	(2)	(3)	(4)	(5)
Dependent variable is log of real output					
Log real capital	0.1776*** (0.011)	0.1520*** (0.011)	0.1529*** (0.011)	0.1382*** (0.011)	0.1392*** (0.011)
Log labor	0.2123*** (0.008)	0.2162*** (0.009)	0.2214*** (0.009)	0.2137*** (0.010)	0.2145*** (0.010)
Log real intermediate inputs	0.3593*** (0.008)	0.3532*** (0.008)	0.3542*** (0.008)	0.3226*** (0.007)	0.3236*** (0.007)
Log real IT capital	--	0.0498*** (0.003)	--	0.0357*** (0.003)	--
Log real in-house hardware	--	--	0.0441*** (0.003)	--	0.0290*** (0.003)
Log real in-house software	--	--	0.0254*** (0.003)	--	0.0207*** (0.003)
Log real outsourced IT	--	--	--	0.0896*** (0.004)	0.0897*** (0.004)
Constant and year dummies	Yes	Yes	Yes	Yes	Yes
N	*33,558*	*33,558*	*33,558*	*33,558*	33,558
R-squared	*43.7%*	*43.7%*	*43.6%*	*44.7%*	44.7%

Source: Author calculations based on CMIE (2009).
Notes: Estimated using OLS with cluster robust standard errors to account for panel data. Robust standard errors in parentheses. All variables are in 2005 rupees crore (Rs. 1 crore was equivalent to US$221,900 in 2005).
*** Significant at the 1 percent level.

The coefficients on labor and capital from columns 2 and 3 are reasonably robust to the inclusion of IT outsourcing. Their output elasticities in columns 4 and 5 are within 90% confidence intervals for the same elasticity in the models without outsourcing. This suggests that the majority of the impact of IT outsourcing comes through increases in TFP, not through changes to firms' use of, or return from, labor or capital. The coefficients on in-house IT capital, on the other hand, do not remain stable between columns 2 and 4 or between columns 3 and 5. The inclusion of IT outsourcing reduces the size of their estimated output elasticity by between 20% and 35%. This shows that estimating the impact of in-house IT without controlling for IT outsourcing, as is common in the existing literature on IT, leads to misleading results as some of the impact of IT outsourcing is misallocated to in-house IT capital.

Table 3 takes the results in column 4 of Table 2 and subjects them to a first set of robustness tests. Column 2 performs the first of these, which was necessary because of panel attrition in the PROWESS data. To test for any bias arising from loss of firms over time from the database, the model is re-estimated using only observations in earlier years of the sample, before any significant attrition took place. The estimated coefficients on all variables are similar to the baseline estimates in column 1. This suggests that attrition bias is not driving any of the results. Column 3 adds other control variables expected to influence productivity into the baseline regression. The main effect of this on the estimated production function is an approximate 50% decrease in the elasticity of output to labor. This suggests that the productivity variables included mainly work to augment labor productivity.

Columns 4 and 5 show the results of estimating the model separately for manufacturers and services firms. Many of the coefficients in these specifications are different from one another in ways that are expected. For example, services firms' output is more elastic to labor inputs and less elastic to increases in materials than that of manufacturers. This is expected because manufacturing is more materials intensive and less labor intensive than many services industries. In both column 4 and column 5, the impact of IT outsourcing is positive and significant at the 0.1% level. In services firms, the coefficient suggests that a 100% increase in SWIS outsourcing leads to 13.6% more output, whilst in manufacturers the same proportional increase in spending leads to only 4.8% more output. These estimates suggest that the services industries in the sample get significantly greater benefit from IT outsourcing than the manufacturing industries. This is a finding that is reflected in the wider literature on in-house IT and could have arisen because services production is simply more amenable to automation using IT (Stiroh, 2002: 6).

Table 3: Robustness Tests

	(1) Base	(2) 2005 and 2006 only	(3) Productivity controls	(4) Manufacturing	(5) Services
Dependent variable is log of real output					
Log real capital	0.1382*** (0.011)	0.1345*** (0.011)	0.1295*** (0.012)	0.1718*** (0.022)	0.1569*** (0.012)
Log labor	0.2137*** (0.010)	0.2161*** (0.010)	0.1165*** (0.012)	0.0890*** (0.009)	0.2582*** (0.018)
Log real intermediate inputs	0.3226*** (0.007)	0.3106*** (0.008)	0.3088*** (0.007)	0.5802*** (0.016)	0.1978*** (0.008)
Log real IT capital	0.0357*** (0.003)	0.0380*** (0.003)	0.0481*** (0.003)	0.0068*** (0.003)	0.0489*** (0.005)
Log real outsourced IT	0.0896*** (0.004)	0.0872*** (0.004)	0.0886*** (0.004)	0.0478*** (0.004)	0.1359*** (0.007)
Constant and year dummies	Yes	Yes	Yes	Yes	Yes
Productivity controls	--	--	Yes	--	--
N	*33,558*	*21,400*	*33,558*	*17,300*	*16,300*
R-squared	*44.7%*	*43.7%*	*43.6%*	*44.7%*	*44.7%*

Source: Author calculations based on CMIE (2009).
Notes: Estimated using OLS with cluster robust standard errors to account for panel data. Robust standard errors in parentheses. All variables are in 2005 rupees crore (Rs. 1 crore was equivalent to US$221,900 in 2005). Column 2 includes only data from 2005 and 2006. Productivity controls are age, age squared, and the firm's expenditure on royalties.
*** Significant at the 1 percent level.

Table 4 reports a set of re-estimations of equation (4) that control for endogeneity. As with any econometric model, endogeneity problems here can either arise from reverse causality, or from the existence of one or more variables which are not included in the model but which cause both dependent and explanatory variables to change. The literature identifies possibilities for both of these. Reverse causality concerns arise because high-productivity firms may be better able to afford purchases of IT, whether in-house or outsourced (Olley and Paikes, 1996: 1264). Similarly, high-productivity firms may also be more likely to outsource non-core competencies such as IT, as part of their strategy to maintain their productivity lead (Nolan, 2001). Concerns around possible excluded variables which drive both choice of inputs and the level of output are even more widespread. Two of the most often cited issues in the literature on IT are organizational set-up and highly skilled, well managed workforces; these are both complementary to IT investments and productivity-enhancing in their own right (Bresnahan, Brynjolfsson, and Hitt, 2002). In the literature on outsourcing, cross-border activities present a similar issue; firms that export or import products are exposed to more foreign companies. This means they are more likely to set up outsourcing agreements and it also means they are exposed to international best practices and so more productive (Amiti and Wei, 2006: 4).

Methods for dealing with these issues depend on whether the source of endogeneity predominantly varies between firms or within each firm over time. If the source is a third variable that changes rarely or very slowly over time but is very different across firms, controlling for unobserved firm level heterogeneity using either fixed effects or first differences will correct most of the bias in elasticity estimates. On the other hand, if the source of endogeneity is reverse causality or a third variable that changes within firms over time as well as between firms, an instrumental variables version of fixed effects is also necessary. Because all of these sources of endogeneity are possible in equation (4), the approach taken here is to undertake all 3 of the possible cures and compare the results.

Table 4: Controlling for Endogeneity

	(1)	(2)	(3)	(4)
	Base	Fixed Effects	First Differences	IV-FE
Dependent variable is log of real output				
Log real capital	0.1382*** (0.011)	0.0660*** (0.018)	0.0519*** (0.019)	0.0971*** (0.024)
Log labor	0.2137*** (0.010)	0.0558*** (0.016)	0.0640*** (0.023)	0.0216 (0.019)
Log real intermediate inputs	0.3226*** (0.007)	0.1781*** (0.014)	0.1600*** (0.014)	0.1535*** (0.019)
Log real IT capital	0.0357*** (0.003)	0.0239*** (0.005)	0.0250*** (0.005)	0.0285*** (0.006)
Log real outsourced IT	0.0896*** (0.004)	0.0576*** (0.007)	0.0534*** (0.007)	0.0468*** (0.010)
Log of real output (t-1)	--	--	--	0.4457*** (0.004)
Constant and year dummies	Yes	Yes	No constant	No Year Dummies
N	33,558	33,558	20,622	20,622
R-squared	44.7%	44.5%	4.5%	--

Source: Author calculations based on CMIE (2009).

Notes: Column 1 is estimated using OLS and cluster robust standard errors; column 2 is estimated using fixed effects; column 3 is estimated using OLS on first differenced data; column 4 is estimated using general method of moments and uses both lags of the variables and lags of first differences of the variables as instruments (as suggested by Blundell and Bond, 1998). Year dummy variables were tested and found insignificant in the model reported in column 4.

*** Significant at the 1 percent level.

Table 4 includes in column 1 the baseline OLS estimates as before. In column 2 fixed effects estimates are given and in column 3 first differences. Column 4 shows an instrumental variables fixed effects estimator suggested by Blundell and Bond (1998). Columns 2 and 3 in the figure eliminate unobserved firm level heterogeneity. In both of these two models the variable for IT outsourcing remains positive and highly significant. However, the magnitude of the effect falls from 9% per 100% increase in expenditure to 5.8% for the fixed effects model and 5.3% for the model in first differences. This shows that there are unobserved firm level characteristics which are related to the use of outsourced IT and which also have a positive effect on output. Column 4 develops the fixed effects model of column 2 further by using instrumental variables to eliminate other sources of endogeneity. Importantly, IT outsourcing remains positive and significant with a coefficient that implies 4.7% more output from 100% more expenditure.

The models which correct for endogeneity also correct for the most likely type of bias arising from the use of a composite variable to measure IT outsourcing. This bias arises if some sub-groups of firms - perhaps multinationals or larger firms - have both higher productivity and a higher proportion of the expenditures measured by the composite variable being IT outsourcing. Assuming IT outsourcing is more important for output and productivity than the other miscellaneous expenditures included in the measure, this situation would tend to bias the estimated elasticity for IT outsourcing upwards. However, as long as the mix of IT outsourcing versus other types of expenditures included in the composite variable depends predominantly on the nature of each firm's business it will mostly vary across firms and will change rarely, or slowly, over time. In this scenario any bias arising from the mix of what is in the composite variable will be largely corrected in the fixed effects, first difference, and instrumental variables fixed effects estimates presented above.

Table 5: In Sample Effects of IT Outsourcing

	IT Outsourcing	In-House IT
Gross marginal product (Rs.)	11	8
Growth in output per firm from IT investment (%)	20%	11%
Growth in output per firm from IT investment (Rs. Crore)	35	20
Share of total growth in output per firm from IT investment	10%	5%

Source: Author calculations based on CMIE (2009).
Notes: Gross marginal products are calculated at the mean amongst those firms which have some spending on the IT type in question. All growth figures refer to growth between 2005 and 2008 in real terms. Rs.1 crore was equivalent to US$221,900 in 2005.

Table 5 uses the instrumental variables fixed effects elasticity estimate to illustrate the effect of IT outsourcing on output in the firms in the PROWESS sample. It also includes the same analysis for the impact of in-house IT capital as a comparison. The first row in the table gives the gross marginal products arising from the elasticity estimates. These are substantially larger than 1 indicating that both types of investment into IT offer supernormal returns.

However, when the gross marginal product of IT outsourcing is compared to that of in house IT capital it is clear that on average an additional Rs. 1 would be better spent on outsourcing. The other rows in the table are concerned with how much output growth in the sample firms can be attributed to investment into IT. Between 2005 and 2008 real IT outsourcing per firm in the sample increased from an average of Rs. 0.45 crore (US$100,000) to an average of Rs. 2.3 crore (US$520,000) per firm, giving a percentage growth rate of 420%. Applying the IV-FE elasticity to this growth rate gives an increase in output per firm attributable to IT outsourcing of 20%. This amounts to an output increase per firm from Rs. 180 crore to Rs. 215 crore, or 10% of a total 203% growth in output per firm over the period 2005-2008.

4. The Impact of IT Outsourcing on Productivity

4.1 Methods

This section investigates how IT outsourcing impacts the technology component of firms' TFP, that is, their technical efficiency[6]. It uses stochastic frontier modelling, a type of econometric analysis which was specifically designed to measure and then analyze this aspect of TFP (Battese & Coelli 1992, 1995). The technique involves estimating the parameters of a production function which applies to the most technically efficient firms, and for each firm, a "distance" away from this ideal. The distance, or inefficiency, metric measures the difference in output between what each firm would produce if it was as efficient as the high performers and what it actually produces. This gives equation (5) below, where the starred α's denote elasticities for the most efficient firms and -ln(E) is the measure of inefficiency.

(5) $$\ln(Y) = \alpha^*_K \ln(K) + \alpha^*_{IT} \ln(IT) + \alpha^*_L \ln(L) + \alpha^*_M \ln(M) - \ln(\mathrm{E})$$

To test the hypothesis that IT outsourcing is a significant driver of technical efficiency, the firm level inefficiencies, -ln(E), are used to create the dependent variable in a second regression[7]. This is shown as equation (6) below:

[6] A technically efficient firm uses the most efficient technology for converting inputs into output. This means it cannot raise output without increasing one or more inputs. It also cannot produce the same output with less of one or more inputs, unless it increases the amount of other inputs used.

[7] Kumbhakar and Lovell (2000:262-265) provide a clear technical explanation of the two step process which has been followed to reach the results here.

(6) $$\ln(\hat{E}) = \beta_{SWIS}\ln(\mathrm{OSIT}) + \sum \beta_{\mathrm{j}}\ln(\mathrm{z}_{\mathrm{j}})$$

In it, the dependent variable is a positive measure of efficiency estimated using equation 5 and the β's measure the elasticity of technical efficiency to outsourced IT and to other controls denoted by z.

4.2. Findings

Table 6 shows the results of estimating equation (5) using the PROWESS data. Table 7 then goes on to report the findings from using the resulting inefficiency estimates to investigate how IT outsourcing impacts technical efficiency. Column 1 in Table 7 shows a regression of technical efficiency on IT outsourcing and column 2 modifies this regression by including a range of other relevant control variables. Both sets of estimates show that technical efficiency is significantly higher for firms which purchase outsourced IT. This adds another important result to the findings above. It demonstrates that IT outsourcing genuinely does improve the production technology that firms use. It moves firms closer to a situation where they cannot improve their output without increasing one or more of their inputs.

Table 6: Stochastic Frontier Model

	Coefficient	Standard Error	z-value
Dependent variable is log of real output			
Log real capital	0.053***	0.002	23.80
Log labour	0.235***	0.005	46.76
Log real intermediate inputs	0.120***	0.002	78.90
Log real IT capital	0.018***	0.001	19.22
Constant	Yes		
N	*33,558*		
R-squared	*44.7%*		

Source: Author calculations based on CMIE (2009).
Notes: Gross marginal products are calculated at the mean amongst those firms which have some spending on the IT type in question. All growth figures refer to growth between 2005 and 2008 in real terms. Rs.1 crore was equivalent to US$221,900 in 2005.
*** Significant at the 1 percent level.

Table 7: The Impact of Outsourced IT on Technical Efficiency

	(1)	(2)
Dependent variable is technical efficiency		
Log real outsourced IT	0.0021*** (0.0001)	0.0016*** (0.0001)
Age		0.0012*** (0.0001)
Log research and development expenditure		0.0035*** (0.0002)
Log expenditure on royalties and licences		0.0022*** (0.0002)
Banks		0.2002*** (0.0185)
Financial Institutions		0.2476*** (0.0279
Finance - Securities		0.0522*** (0.0058)
Wholesalers		0.0684*** (0.0065)
Dummy for 2006	0.0053*** (0.013)	0.0046*** (0.013)
Dummy for 2007	0.0141*** (0.0017)	0.0110*** (0.0017)
Dummy for 2008	0.0368*** (0.0026)	0.0279*** (0.0025)
Constant	*Yes*	*Yes*
N	*33,558*	*33,558*

Source: Author calculations based on CMIE (2009).
Notes: Tobit models. Robust standard errors are in parentheses. The dependent variable is ln(E) as detailed in the methods section above, and estimated using the model in Table 6.
*** Significant at the 1 percent level.

5. The Impact of IT Outsourcing on Economic Growth

This section reports the results of applying the output elasticity estimates from Section III to macro data on domestic purchases of IT outsourcing from Indian IT firms. This approach to identifying a macro level impact of IT outsourcing is justified because the profile of firms in the PROWESS database is similar to the profile of firms which purchase outsourced IT from the Indian IT sector[8]. The PROWESS dataset covers Indian firms which are listed on stock markets or government owned. These are predominantly large and middle sized firms and

[8] The "Indian IT sector" referred to here includes both Indian and foreign owned firms, but to be included an IT firm must be registered in India. This definition is adopted to be consistent with the data source used in this section and described below.

together they comprise a large proportion of the Indian formal sector (CMIE 2009). According to the trade association whose members generate 95% of the Indian IT sector's revenues, these are exactly the kinds of Indian firms that purchase outsourced IT from the domestic IT industry. The National Association of Software and Services Companies (NASSCOM) describes its members' domestic clients as either "large Indian enterprises", "multinationals" or "mid-sized" (2008:4).

Table 8: The Impact of Outsourced IT on Economic Growth

	Real aggregate spend on IT outsourcing (2005 Rs. crore)	Growth in aggregate spend on IT outsourcing (%)	Contribution to macro output growth (%)	Share of total GDP growth (%)
2005	Rs. 25,600	35%	1.6%	17%
2006	Rs. 34,390	34%	1.6%	17%
2007	Rs. 44,438	29%	1.4%	15%
2008	Rs. 48,885	10%	0.5%	8%
2005-2008 (Average)		*27%*	*1.3%*	*14%*

Source: Author calculations based on CMIE (2009), MOSPI (2011), NASSCOM (2009: 6, 203).*Notes:* Spending on IT outsourcing is measured using revenues for NASSCOM members in the domestic market which are published in US dollars. These have been converted to Rs. Crore using exchange rates published by RBI (2011) and deflated as described using an index by Prud'homme, Sanga, and Yu, (2005).

The exercise is carried out in Table 8. The first column in the table contains domestic expenditure on outsourced IT from NASSCOM's members in the Indian IT industry and the second column shows percentage growth rates in these figures. The third column applies the instrumental variables fixed effects elasticity from Section III to these growth rates to obtain estimates of the contribution to real output growth at the macro level. Finally, the fourth column shows this as a share of total GDP growth. On average IT outsourcing purchased from the domestic IT sector contributed 1.3 percentage points of real output growth per year between 2005 and 2008. This amounts to 14% of all GDP growth in the period. These figures are of a comparable magnitude to the impact of IT experienced in the US and the developed world in the 1990s (Figures 1 and 2).

Conclusions

This paper has, for the first time, investigated the impact of IT outsourcing. It made three important findings. The first is that the use of outsourced IT makes an important contribution to firms' productivity and output. The second is that in at least one developing country, the effect on output is sufficiently large to make a significant contribution to economic growth. The third and final role is suggested by the comparison of outsourced IT to in-house IT included above. Both the output elasticity and marginal product of outsourced IT was found to be larger than the same estimate for in-house IT, and in both cases the difference was substantial. A likely explanation for this difference is that IT firms offer advice which allows better returns from IT spending. If this advice is built on knowledge accumulated during previous work in more advanced firms there is a third and very important role for IT outsourcing. That is that it can act as a conduit into developing countries, of knowledge about how to successfully use IT.

The work included here contributes in several ways to the literature on the impact of IT. Perhaps the most important of these is that it adds evidence to the small but burgeoning literature which finds that IT is relevant in developing countries and can have a strong positive impact. In particular, this paper adds new evidence which supports the recent finding by Commander, Harrison, and Menezes-Filho (2011) that the impact of IT in Indian firms is substantial. This paper also suggests a methodological improvement to authors interested in the impact of IT. It shows that estimating the impact of in-house IT through the use of firm level econometrics may give misleading results if IT outsourcing is important, but not included separately. In future, and particularly in countries with large IT outsourcing markets, it will be important to control for outsourcing whenever the role of IT is investigated.

In highlighting the importance of IT outsourcing in developing countries this paper opens a rich vein for new research. An investigation into the role of IT outsourcing in Brazil and China, which both have significant IT outsourcing industries, is an important next step. Another possible route for extending the line of enquiry here is to assess the impact of developing country firms purchasing other types of outsourced goods and services. It may be that know-how on IT is not the only type of expertise that is being spread via the conduit of outsourcing.

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