TECHNOLOGICAL EFFORTS AND PRODUCTIVITY: A STUDY OF INFORMATION TECHNOLOGY SERVICE FIRMS IN INDIA

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Abstract

This paper examines the impact of technological efforts on firm level total factor productivity for a sample of the Information Technology service firms in India over the time period 2000 to 2014. The total factor productivity is estimated using the Levinsohn-Petrin method. The study finds that the total factor productivity levels of the firms decline towards the end of the study period. The output of the firms in the IT service industry is more elastic with respect to capital than labour. The total factor productivity levels differ across firm characteristics such as size and age. We do a regression analysis to examine the effect of technological efforts on the inter-firm differences in total factor productivity levels. Both embodied and disembodied technology imports have a positive effect on the productivity levels of the firms. Due to the skill intensive nature of these firms, the study finds in-house R&D efforts to contribute positively to productivity only in the presence of skilled labour force. Also, presence of foreign affiliates has a positive effect on productivity levels of the firms over a period of time.

Keywords: *Total Factor Productivity, Technology, Service, IT Industry*
JEL classification: *D24, O14, O39*

Introduction

It is widely known that a firm's performance and competitiveness is affected by its technological capabilities. These capabilities are in turn determined by the existing environment and technological regime within the industry in which the firm operates. Here, it becomes important to mention the concept of 'creative destruction' put forth by Schumpeter (1943). According to the notion innovative and technological efforts on part of the firms, to improve upon their output as well as production process, are important to be able to take cost advantages and supply quality output in order to remain competitive. In other words, it can be said that if the firms do not innovate, there is a possibility that they would lose their competitiveness in the market.

Productivity is one of the key measures of firm performance and competitiveness. Through better and efficient utilisation of available resources, increases in productivity eases constraints on the production process and spurts growth. Sustaining of growth only through increased application of inputs gets threatened either due to the limited availability of inputs or diminishing returns to factor inputs. Thus, the importance of total factor productivity arises for sustaining growth in the long run, as input growth alone is insufficient to bring about increases in output. Following the works of Abramovitz (1956) Solow (1957) and Griliches and Jorgenson (1966) the total factor productivity growth, also called the 'residual', is often said to be a result of some technical progress or technological growth.

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Acquisition of technology by firms plays a very important role in improving their productivity and driving overall economic growth. Consequently, economists have attached considerable importance in trying to understand the mechanisms through which firms acquire technology and examine their impact on productivity and firm performance. One of the prime sources of technology of firms is through in-house R&D efforts. However, the literature also highlights the importance of other routes through which technology is acquired such as import of capital and intermediate goods that embody latest technology, technology transfers in the presence of foreign affiliates and import of disembodied technology through royalty payments.

Not many studies have explored the link between productivity and technology in the case of service firms. Hence, the objective of this study is to investigate the effect of technological factors acquired though different sources, along with other firm-specific factors such size, age and presence of foreign promoters in determining the inter-firm differences in productivity. For the purpose of our analysis we use data on Information Technology service firms belonging to NIC-62 and NIC-63 from the ProwessIQ database provided by Centre for Monitoring Indian Economy. We use the Levinsohn and Petrin (2003) approach for the measurement of total factor productivity. In order to examine the effect of technological factors on productivity we then carry out a panel data analysis.

The choice of industry, Information Technology services, is particularly due to the tremendous growth witnessed in the industry in the last two decades, especially dominated by the growth of software services. During the year 2016-17, the IT service industry witnessed a growth of 8.6 per cent [3]. Nearly 70% of the revenue of the industry accrued to the export market. Over the period 2010-2016 the industry recorded a compounded annual growth rate of 11.14%[4]. With the availability of cheap labour, India stands as the largest sourcing destination in the world and accounted for nearly 55% of the global sourcing market.

With the leap from traditional servers that included hardware, operating software, storage and applications to virtual servers and cloud computing, the progress in technology has been very swift. Given, such rapid and fast changing nature of the technology, coupled with the high growth in the IT service industry, it would be interesting to note the effect of technology on firm productivity. We find that the firms in this industry source technology through import of capital goods, import of disembodied technology and in-house R&D efforts. While import of embodied and disembodied technology has a positive effect on productivity, in-house R&D has a positive impact with an increase in the skill level in these firms. In addition, we note differences in productivity levels across firm size and age.

The remainder of the paper is organised as follows. Section 2 provides an overview of the Information Technology industry in India. Section 3 discusses the literature related to technological efforts and firm performance, especially productivity. Section 4 gives a description of the data set, variables and the method used in estimation. Section 5 presents the empirical findings. Finally, section 6 concludes.

[3] < http://www.nasscom.in/sites/default/files/NASSCOM_Annual_Guidance_Final_22062017.pdf>

[4] < https://www.ibef.org/uploads/industry/Infrographics/large/IT-and-ITeS-December-2017.pdf>

The Information Technology Industry in India

During the early 1950s, the Indian government spent tremendous sums of money to improve the infrastructural facilities and the skill level of the population to attract foreign subsidiaries in the country. Consequently, the IT Industry witnessed the entry of International Business Machines (IBM) and International Computers Limited (ICL). Along with the IT hardware these firms used software developed by in-house developers. By the 1960s, as a part of the policy to achieve self-sufficiency, government insisted on the participation of Indians in ownership and control of foreign subsidiaries. They also imposed conditions whereby the manufacturers were to procure inputs from the domestic market while the foreign subsidiaries provided technical assistance and tacit technologies to produce their own products and services. This policy led to the displeasure of the foreign firms resulting in IBM exiting the Indian market and ICL splitting its operations in sales and manufacturing units. Although the 1970s witnessed the entry of Indian firms like Hindustan Computers Limited, Tata Consultancy Services, Wipro the Indian IT industry on the whole remained technologically backward compared to the world standards (Narayanan and Bhat, 2009).

In the 1980s however, with the aim of modernising the IT industry the government introduced policies to promote exports of software and peripherals. In the year 1986, Department of Electronics announced the Software Export Development and Training Policy with incentives in the form of 100% income tax exemption on profit earned from software exports. Also, in 1988 National Association of Software and Service Companies (NASSCOM) was set up to facilitate business and trade in software and services as well advancement in software technology. Around the 1990s software parks were set up to provide duty free imports of capital goods, high-speed data communication links and tax holidays for 10 years (Parthasarathy, 2005; Narayanan and Bhat, 2009). Thus, as Arora and Athreye (2002) put it, the initial growth of the software service industry in India was facilitated by the 'hands off" policies of the government.

With little barriers to entry, a software firm could be set up without having to incur significant sunk costs; just a little more than one software development team and a handful of computers, a steady supply of electrical power and ready access to modes of communication. More recently, the Information Technology Act of 2000 was enacted. This act provided the legal infrastructure for e-businesses (Basu and Jones, 2005). Coupled with the growing size of the skilled labour force the resource endowment of the country suited the needs of the software industry. Thus, the Indian software industry consists of a large and growing number of firms. The number of NASSCOM members increased from 430 in 1996-97 to around 2500 in 2017[5].

[5] Source: Nasscom, <http://www.nasscom.in/sites/default/files/media_pdf/rp-chairman-appointed.pdf>

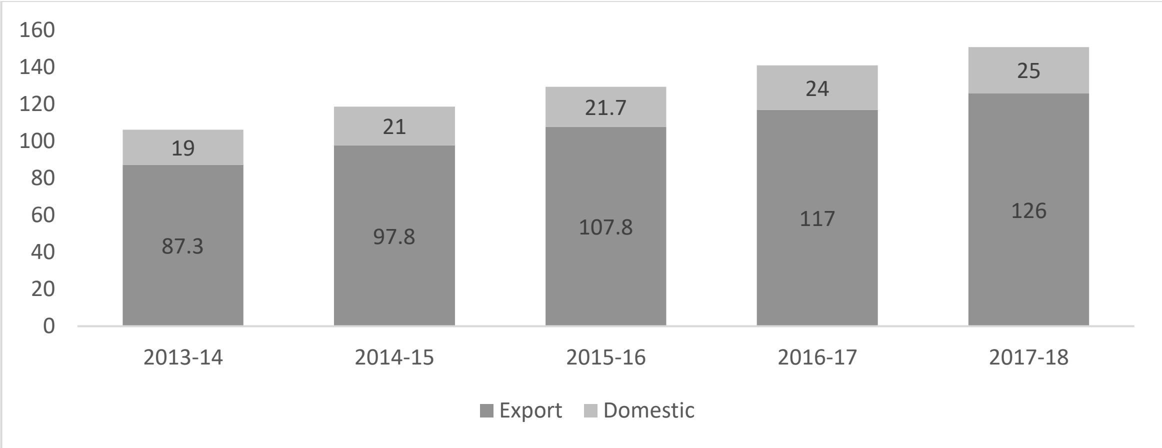

Figure 1. Size of Export and Domestic markets in USD Billion. Source: Ministry of Electronics and Information Technology.

One of the unique features of the Indian IT-software and service industry is the sector's export orientation which generates the lion's share of revenues. Even in the recent years more than 50% of the revenue is earned through exports as can be seen in figure 1. The revenue earned from exports is largely generated from sale of software services that include custom software development, consultancy and professional services (Figure 2). These activities performed by Indian firms involve simple routine tasks with low level of design and technology compared to software product designing and development which was derisively termed as "body shopping" by Heeks (1998). However, it has been noted that the Indian firms are gradually moving up the value chain, with the exports comprising software products (Kumar 2001; Arora et al 2001, Arora and Athreye, 2002).

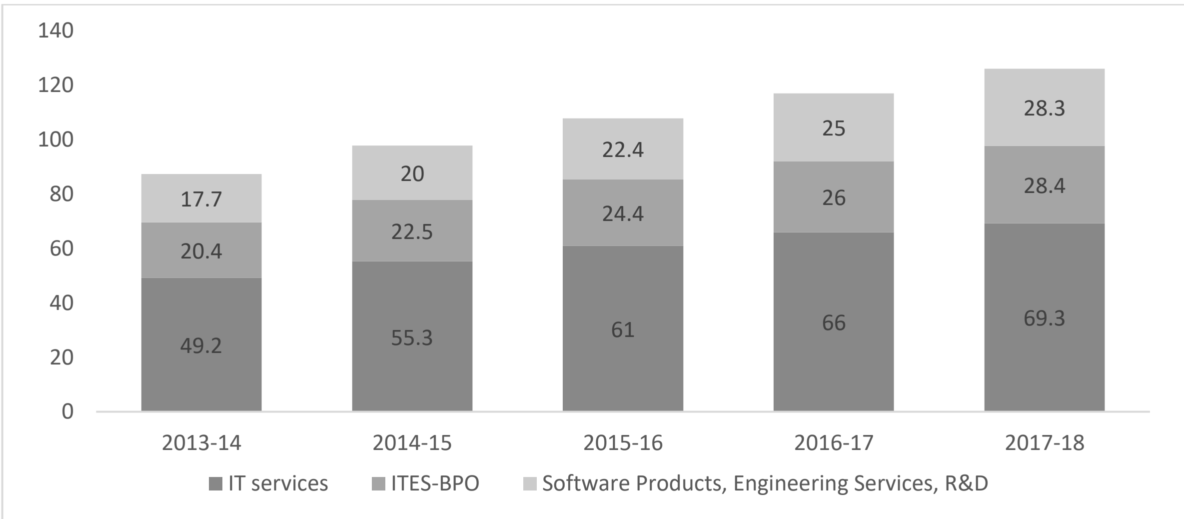

Figure 2: Composition of IT exports in USD Billion. Source: Ministry of Electronics and Information Technology.

On the other hand, the share of the domestic market remains comparatively low and it is in this segment that the Indian firms have met with a little success in developing software packages. Arora and Athreye (2002) in their case studies of these firms find that the reason behind the limited success of the firms is due to the lack of experience in design and marketing necessary for producing a successful product. While the contribution of the software industry to India's growth cannot be doubted, the need for the industry to maintain its competitiveness cannot be overlooked. The firms that have experience in the domestic market do not appear to have any advantage from it in the export market. This is because the relatively simpler tasks involved in current software exports renders less value to the sophisticated capabilities of these firms(Arora et al, 2001). It appears that underlying growth of the industry is a somewhat pessimistic outlook for the future given the nature of its growth. Once the surplus of skilled labour is exhausted and the cost advantage erodes, India would become a less attractive destination for lower value sevices. The question then arises is how the firms would then continue to maintain their competitiveness. Thus, there is a need for these firms to innovate and improve productivity to sustain growth in the long run.

Literature Review

In this section we review studies of technological and other firm specific characteristics that affect productivity. Firm's efforts to acquire technology can be either through in-house efforts or through external sources. The firm specific characteristics such as size of the firm, age of the firm, skill level of workers and presence of foreign promoters are considered as controls in the present study.

Technological Factors

Firms differ in terms of their efforts at enhancing their technological capabilities and it is one of the important factors that affect productivity. Nelson (1981) noted that firms with similar capital input would show different levels of productivity at a given point in time due to variations in the generation and distribution of technology.

Investment in R&D is one of the ways through which firms innovate and develop their technological capabilities. The R&D efforts is noted to be one of the important factors that influence productivity growth (Griliches, 1979, 1998). Firms engage in R&D to produce products that are different, unique and of high quality. Griliches (1979), Griliches and Mairesse (1984), Lichtenberg and Seigel (1991) on US, Hall and Mairesse (1995) and Mairesse and Mohnen (2005) on France, Harhoff (1998) on Germany and Parisi et al (2006) and Hall et al (2009) that document how the firm level R&D efforts result in a productivity increase.

Studies at the firm level between R&D and productivity in India also have found mixed evidence. While there are studies that find R&D to be favourable for firm performance (Ferrantino, 1992; Raut, 1995) there are still others which find weak support for effect of R&D on firm productivity (Basant and Fikkert, 1996; Hasan, 2002). Even in the context of export performance the evidence on R&D remains mixed. Some studies found R&D to be unimportant in determining the export performance of firms (Kumar and Siddharthan, 1994; Narayanan, 2006) whereas others found that R&D to have a positive effect on the exports (Aggarwal, 2001; Bhat and Narayanan, 2009). Specifically, in the case of Indian IT sector it has been noted that the in-house R&D investments are low compared to the developed countries (Radhakrishan, 2006). On the other hand, Narayanan and Bhat (2011) note that the large firms and multi-national corporations in the IT sector in India have relatively larger investments in R&D so that they are able to participate in the international markets.

Besides R&D, there are other channels through which firms try to acquire technology. It is widely believed that while the developed countries are creators of technology, the developing countries are mere followers. It has been observed that firms from developing countries like India depend on import of technologies to have a competitive advantage over their rivals (Lall, 2001). These imported technologies can either be in embodied or disembodied form. Firms acquire embodied technology generally in the form of capital goods import. These capital goods are usually based on modern designs and technologies. The use of these imported capital goods in the production process are likely contribute better quality of output. On the other hand, disembodied technology is acquired through import of designs, drawings, blueprints, and formulae against a payment of royalty and technical fee. These technologies are assimilated in the existing production process to have a better quality of output. Sahoo (2013) in studying the Indian software industry finds that firms that spend on royalty improve more on their productivity than those that spend less. However, Narayanan and Bhat (2011) note that although the large corporations in Indian IT industry frequently import capital goods it does not seem to have a significant impact on their decision to invest abroad.

For the information technology industry where the technology changes are rapid, it is important for the firms to be continuously updated with the latest technologies by investing in at least one of the ways of technology sourcing. In addition to these technology sources there are firm specific characteristics that can also affect the productivity of firms.

Firm Specific Characteristics

Size of the firm: Firm size is one of the most commonly used non-technological variables in firm performance studies. Larger firms are endowed with better resources than the smaller ones and hence are more likely to innovate. Large size also gives firms the capacity to bear risks and undertake innovative activities. In the case of Information Technology industry, we find mixed evidences of firm size. Siddharthan and Nollen (2004) note that firm size contributes to more exports by the IT firms that do not have foreign ownership compared to the multinational corporations. Narayanan and Bhat (2011) find that size is one of the determinants of the firm's decision to invest abroad. Sahoo (2013) finds size to be a positively influencing productivity growth in the software industry.

Age of the firm: Age is a firm specific non-technological factor that can affect productivity. The age of a firm is reflective of its learning curve. It is believed that technology development is path dependent and cumulative in nature (Teece, 1996; Basant, 1997). Hence, it is expected that the firms with longer span in the industry would have acquired more knowledge in the form of tacit transfers and thereby perform better than their counterparts. Narayanan and Bhat (2011) in analysing the information technology firms do not find age to be important in determining the performance of the firms in international participation. They argue that in an industry where the product life cycle is short, the experience gained over time is not likely to give extra advantage to the older firms unless they keep updating their knowledge base.

Presence of Foreign Promoters: With the advent of globalisation India has also witnessed the presence of MNCs in different industries. The extent of foreign equity participation becomes important in determining the nature of technological investments in a firm. According to Siddharthan (1992), high transaction costs are involved in transfer of non-standardised technology since they cannot be easily codified. High transaction costs are also present when technology transfer involves a large amount of tacit and firm-specific components, information asymmetry and use of brand names. In all such cases foreign direct investment is preferred to purchases through market.

Siddharthan and Safarian (1997) argue that in order to avoid the spill-over and diffusion of their expensive and newly evolved technologies and to avoid taxes and restrictions related to profit repatriation transnational corporations support internalised transfer of technology. They further find intra firm transfers of technology when it is relatively new and still evolving, but when the technology is codified and standardised technology is usually acquired through purchases. In several industries they find that taking advantage of deregulation foreign affiliates acquired technology through import of capital goods and undertook modernisation expenditures. Narayanan (2006) in the case of Indian automobile sector found that the firms with foreign equity participation grew faster in both pre and post liberalisation phases. However, during the deregulation period import of capital goods turned out to be more important. For firms in the Indian IT sector studies find that find that foreign equity participation favourably affects the performance of firms in the international market (Siddharthan and Nollen, 2004; Narayanan and Bhat, 2011).

Skill Level of Workers: Higher skill content of the workers in a firm also affects its performance. Lall (2000) argues that reaching best practice levels of technology, management and marketing requires new skills, more advanced and varied than those needed to serve domestic markets. If the production structure has to shift from simple to complex, technology-intensive activities, skill needs to grow broader and more demanding.

In the case of IT firms, to deal with international clients especially from the technology forerunners the Indian firms require a high level of skills. Kapur (2002) notes that the abundance of skilled professionals in India is capable of catering to the demands of the IT sector. Due to high levels of attrition the firms are required to pay higher salary packages to retain their workers and thereby maintain the skill level of the workforce in the firm (Arora et al 2001, Kumar 2001). Studies have found that higher investments on skilled employees favourably affect those firms that participate in the international markets through exports as well as overseas investments (Narayanan and Bhat, 2009, 2011).

To summarize, we note that firms source the latest technologies in varied ways. These could either be in the form of in-house efforts at R&D, through import of capital goods and even by acquiring disembodied technology through royalty payments. While these efforts are expected to give the firms cost and quality advantages to result in better performance and productivity there are firm specific characteristics that come to play in the process of assimilation of these technologies in the production process.

Data and Variables

Annual company level data for the period 2000-2014 are compiled from Centre for Monitoring Indian Economy Prowess IQ database for computer programming, consultancy and related activities and information service activities classified as NIC-62 and NIC-63 in the national industry classification, 2008. Since we confine our analysis to the aforementioned sectors, the Prowess database gives us information on a total of 1454 firms. However, due to non-availability of data related to the empirical variables we choose 1016 firms with an unbalanced panel of 5457 observations. The firms within these sectors are divided into four categories based on their products, namely, computer software, ITES, Business services & consultancy and media-broadcasting. The table below gives a brief description of the firms used in the sample.

Table 1: Brief Sample Description

Data period	2000-2014
No. of firms	1016
Computer programming, consultancy and related activities (NIC-62) Information service activities (NIC-63)	74% 25%
Size distribution over time* Large Small	 51% 49%
Age distribution over time* Old Young	 48% 52%

Note: *Own calculations based on CMIE Prowess data. Size is defined in terms of logarithm of sales. The median values of age and size are taken to divide firms into the above categories.

Variables

All the variables used in the estimation of productivity have been converted to real terms. The details of the construction of the variables are given in the appendix. Following are the variables used in the estimation of total factor productivity.

Output- We use the deflated annual sales turnover of the firms as a measure of output[6].
Labour- We use an estimated number of workers in the firm as a measure of labour.

Capital- Estimated capital stock adjusted for depreciation of different kinds of fixed assets of the firm is used as capital.

Energy- Electricity expenses incurred by the firm are taken as a proxy for energy input variable.

Intermediate Inputs- We use deflated communications expenditure of the firm as an intermediate input[7].

For the second part of our study, where we look into the technological efforts of the firms and how that affects the firm level productivity we use the following variables.

Dependent Variable

Productivity: The total factor productivity levels calculated from the use of Levinsohn-Petrin (2003) method is considered.

[6] The service sector comprises a highly heterogenous group of activities and hence the nature of output of this sector has often been debated upon. Services are said to be characterised by simultaneity in production and consumption. This makes the output difficult to measure in specific units and also largely intangible and perishable in nature. However, with advancements in information technology, tangibility must be interpreted carefully. Many of the software programmes and digital electronic content might have only limited tangibility but are also storable and transferable. The creation of these digital products may often be classified as services, as also their delivery (for debate on output of services see Hill, 1977; Griliches, 1992; Nayyar, 2012).

[7] There are hardly any material expenses for firms in the service sectors. But given the nature of output and the way it is stored and transferred or delivered to the clients, the communication expenditure of these firms becomes an important intermediate input.

Independent Variables

Technology variables: Based on the discussion done in section 3, we use the expenditures incurred on import of capital goods, royalty and technical know-how fees payment and R&D normalised by sales as the technology variables that can affect productivity.

Controls

Control variable are used to account for other factors that could influence firm level productivity. We use firm size, age, skill level of workers and presence of foreign promoters as controls in our study.

Table2: Variables, symbols and definitions used in the study

Variables	Symbol	Definition
Output	Output	Logarithm of deflated sales
Capital	Capital	Logarithm of capital stock values
Energy	Energy	Logarithm of expenditures on electricity
Intermediate Inputs	Int.Input	Logarithm of communication expenses
Total factor productivity	TFP	TFP estimated from L-P method
Import of capital goods intensity	MK	[Expenses on import of capital goods/Sales] * 100
Import of designs, drawings and blueprints intensity	RT	[Royalty expenses and technical know-how fees/Sales] * 100
R&D intensity	RD	[R&D expenses/Sales] * 100
Foreign equity participation	FOR	[Equity of foreign promoters/Total Equity] * 100
Firm size	SIZE	Logarithm of sales turnover
Firm Age	AGE	Firm incorporation year-relevant year

Methodology

As mentioned earlier we conduct our estimations in two phases. In the first phase we estimate the productivity of firms in the IT sector. In the second part of our estimation we examine the effect of technological efforts on the productivity of IT service firms.

Method of Productivity Estimation

One of the major hurdles in estimating firm level productivity using the regression technique is the potential correlation between input levels and unobserved productivity shock. These unobservable factors affect the use of production inputs and consequently the use of these inputs are determined endogenously. This problem is referred to as simultaneity or endogeneity bias. Since Ordinary Least Square (OLS) regression technique assumes the production inputs to be uncorrelated with unobserved productivity shocks, it fails to address the issue of endogeneity of inputs and thereby produce inconsistent and biased estimates of the production function (Olley and Pakes, 1996; Levinsohn and Petrin, 2003). To take account of these problems the semi parametric approach proposed by Olley and Pakes (1996) and Levinsohn and Petrin (2003) have been used by many studies. In Olley and Pakes (1996) investment is used as a proxy to control for such bias resulting from unobserved productivity shock. However, the problem with using investment is that there are a large number of zero observations. This leads to a large truncation in the dataset. Hence, we use the Levinsohn and Petrin (2003) methodology to estimate the firm level production function. The LP method uses the intermediate inputs as proxy for controlling the unobserved productivity shocks.

The production technology is assumed to be Cobb-Douglas. The functional form is represented as

$$y_t = \beta_0 + \beta_l l_t + \beta_e e_t + \beta_k k_t + \beta_m m_t + \omega_t + n_t \quad (1)$$

Where y_t , l_t , e_t, k_t and m_t are the logarithmic form of the firm's output, labour, energy, capital stock and intermediate inputs respectively. l_t, e_t, m_t are the freely variable inputs and $k_t$is a state variable. The error has two components: ω_t denotes productivity shock of the firm (the transmitted component of the error term) and n_t is an error term that is uncorrelated with input choices (independent and identically distributed). The major difference between ω_t and n_t is that the former affects the firm's decision and the latter has no impact on the firm's decision. ω_t is also treated as a state variable.

The intermediate inputs account for the endogeneity bias and control for unobserved productivity shock. The firm's expenditure on these inputs is assumed to depend on the two state variables ω_t and k_t, such that, $m_t = m_t(\omega_t, k_t)$. Following the LP method, we assume that the demand for intermediate inputs of the firms is monotonically increasing given its capital stock. This allows the inversion of the demand function of intermediates, so ω_t can be written as a function of m_t and k_t: $\omega_t = \omega_t(m_t, k_t)$.

Equation (1) can be written as,

$$y_t = \beta_l l_t + \beta_e e_t + \phi_t(m_t, k_t) + n_t \quad (2)$$

Where now

$$\phi_t(m_t, k_t) = \beta_0 + \beta_k k_t + \beta_m m_t + \omega_t(m_t, k_t) \quad (3)$$

In LP method the parameters of the production function are estimated in two stages. The first stage involves the estimation of equation (2). It can be estimated by using OLS and a third order polynomial expansion in m_t and k_t to approximate $\phi(.)$.

At the second stage LP obtains the capital coefficient and a firm level measure of productivity. It is assumed that capital does not respond immediately to an innovation in productivity over the last period's expectation. Similar is the assumption about the intermediate inputs of the firm. The last period's level of intermediates m_{t-1} is assumed to be uncorrelated with current period's error. The moment conditions following from the two assumptions are

$$E[\xi_t + n_t | k_t] = E[\xi_t, k_t] = 0 \quad (4)$$

Where $\xi_t = \omega_t - E[\omega_t | \omega_{t-1}]$ indicates the innovation in productivity over the last period's expectation. And,

$$E[\xi_t + n_t | m_{t-1}] = 0 \quad (5)$$

Now, we have

$$E[y_{t+1} - \beta_l l_{t+1} - \beta_e e_{t+1} | k_{t+1}] = \beta_0 + \beta_k k_{t+1} + \beta_m m_{t+1} + E[\omega_{t+1}|\omega_t] \quad (6)$$

Denoting $\omega_t = \beta_0 + E[\omega_{t+1}|\omega_t]$ the above equation can be re-written as

$$y_{t+1} - \beta_l l_{t+1} - \beta_e e_{t+1} = \beta_k k_{t+1} + \beta_m m_{t+1} + g(\phi_t - \beta_k k_t - \beta_m m_t) + \xi_t + \eta_t \quad (7)$$

Equation (7) can be estimated using previously obtained values of β_l, β_e and ϕ while the unknown functional form g is approximated using a third order polynomial expansion of $(\phi_t - \beta_k k_t - \beta_m m_t)$. This estimation will yield consistent coefficients for intermediate and capital inputs. Once all the coefficients are obtained total factor productivity of each firm is calculated as the difference between actual and predicted values of output for each firm.

$$TFP_t = y_t - \widehat{\beta_l} l_t - \widehat{\beta_e} e_t - \widehat{\beta_k} k_t - \widehat{\beta_m} m_t \quad (8)$$

It is to be noted that the TFP level values thus obtained are in their logarithmic form.

For the second phase of our estimation process the study uses a panel data to examine the effect of technological efforts of firms on their productivity levels. Fixed effects estimation method is used which addresses the concern of omitted variable that is caused by unobserved firm specific characteristics. In our study the standard errors are clustered at the level of the firms to control for heteroscedasticity. The following regression model has been estimated:

$$TFP_{it} = \beta_0 + \beta_1 MK_{it} + \beta_2 RD_{it} + \beta_3 RT_{it} + \beta_4 FOR_{it} + \beta_5 SKILL_{it} + \beta_6 SKILL_{it}^2 + \beta_7 SKILL_{it}\ X\ RD_{it} + \beta_8 AGE_{it}\ X\ FOR_{it} + \alpha_i + \varepsilon_{it}$$

Empirical results

The estimated production function using Levinsohn and Petrin (2003) approach shows the coefficient values for labour, capital, energy and intermediate inputs are all significant at one percent level as seen table 3. It also shows that the elasticity of output of the IT sector with respect to capital is higher than the elasticity of output with respect to labour. In the table we also report the chi^2 values for Wald's test for returns to scale which implies increasing returns to scale for the estimated production function at one percent level of significance. Also, the comparison of the coefficients of inputs estimated from the OLS method shows that OLS underestimates the coefficient of capital as compared to that estimated by the LP method.

Table 3: Comparison of estimates from LP and OLS

Variables	LP	OLS
Labour	.4225*** (.0253)	.4221*** (.0124)
Capital	.5295*** (.1174)	.2809*** (.0097)
Energy	.0717*** (.0285)	.0730*** (.0146)
Int. Input	.3333*** (.1092)	.2182*** (.0135)
Chi^2	7.61	-
No. of observations	5457	5457

Note: The variables have been used in their log forms in both OLS and LP estimations. The figures in the parentheses are the standard errors.

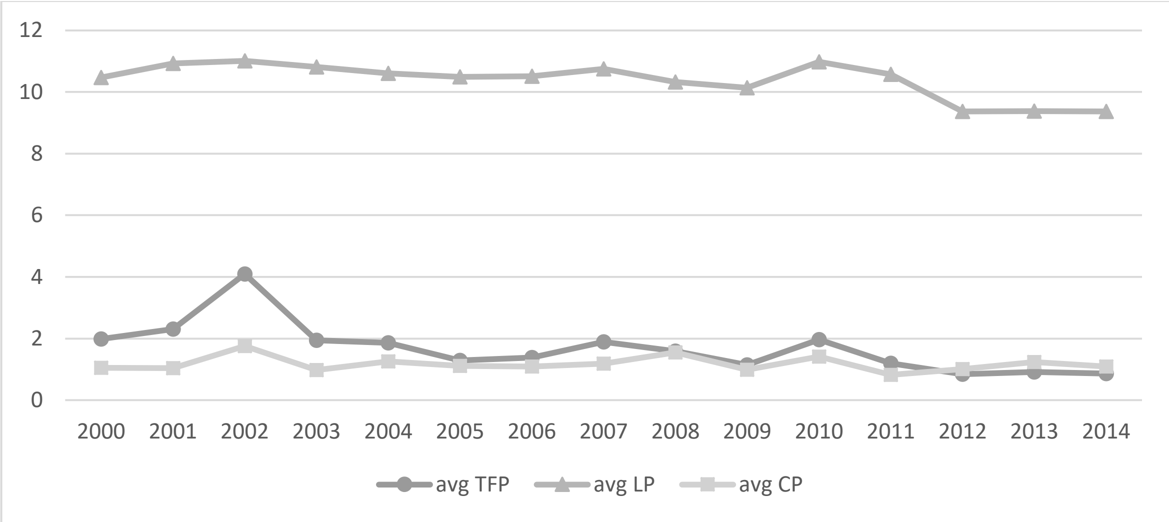

Figure 3: Trends in average labour productivity (LP), capital productivity (CP) and total factor productivity (TFP).

The trend in total factor productivity shows a decline in the productivity levels of the firms in IT industry towards the end of the sample period compared to the levels at the beginning of the study period (Figure 3). We also compare the trends in total factor productivity levels with that of the labour and capital productivity. It is to be noted that while the labour productivity levels remained mostly stable through the study period, there have been changes in the capital productivity and total factor productivity levels. Also, the changes in the total factor productivity levels have mostly followed the changes in the capital productivity levels.

Studies related to micro datasets explain that there are differences in productivity across firm size and age groups (Syverson, 2011). This is an indication of the underlying heterogeneity in productivity across firms. We divide our sample of firms into large and small on the basis of their median size. We measure size in terms of logarithm of sales. We also divide the firms on the basis of their median age in young and old. Table 4 reports the mean productivity of small and large firms and also young and old.

Table 4: Mean TFP across firm Size and Age

Year	Large	Small	Young	Old
2000	2.01 (3.24)	1.97 (2.28)	1.22 (1.52)	2.15 (2.86)
2001	2.14 (3.26)	2.43 (4.49)	1.25 (1.54)	2.56 (4.38)
2002	6.84 (55.09)	1.98 (3.07)	1.59 (2.69)	6.41 (50.44)
2003	1.49 (3.57)	2.27 (4.29)	1.56 (2.44)	2.28 (4.99)
2004	1.35 (2.45)	2.17 (4.50)	1.67(3.43)	2.00 (4.16)
2005	0.91 (1.54)	1.56 (2.72)	1.19 (1.92)	1.37 (2.59)
2006	1.55 (5.53)	1.26 (1.38)	1.38 (4.83)	1.39 (2.94)
2007	2.03 (10.62)	1.77 (4.67)	1.95 (10.98)	1.85 (4.74)
2008	1.67 (7.69)	1.52 (2.65)	1.72 (8.11)	1.50 (2.78)
2009	1.34 (5.29)	0.97 (1.33)	1.21 (5.29)	1.10 (1.97)
2010	1.41 (3.90)	2.54 (11.40)	1.49 (4.20)	2.39 (10.97)
2011	1.06 (2.79)	1.37 (1.38)	1.06 (1.42)	1.32 (2.82)
2012	0.81 (2.74)	0.89 (0.90)	0.77 (2.21)	1.01 (1.83)
2013	0.81 (2.74)	1.10 (1.31)	0.84 (2.61)	1.03 (1.84)
2014	0.72 (2.46)	1.17 (1.21)	0.77 (2.46)	1.05 (1.33)
Total	**1.47 (1.20)**	**1.62 (0.51)**	**1.84 (1.13)**	**1.21 (0.38)**

Note: Figures in the parentheses are the standard deviation in TFP each year.

In the case of small versus large firms the mean productivity of smaller firms is higher compared to that of large firms along with lower dispersion. On the other hand, in the case of young versus old firms the mean of younger firms is higher compared to that of older firms albeit with a higher dispersion level. However, it is important to note that across the size and age classifications the productivity levels of the firms at the end of the sample period has fallen as compared to the beginning of the sample period.

Table 5 shows the combination of the three technology sources that we consider in our study, namely, import of capital goods, import of disembodied technology and in-house R&D. Based on this table we note in which of the ways firms acquire technology. We find that only around 40 per cent of the firms in the sample are technologically active. It is largely through the import of capital goods that the firms acquire technology. Besides, a few firms also make royalty payments to gain access to proprietary technology. The in-house R&D efforts of the firms in our sample remain relatively low.

The last column in table 5 shows the presence of foreign equity holders amongst the firms that acquire technology amongst those combinations. We observe that the firms which do not acquire technology through any of the sources have a lower presence of foreign equity holders. Amongst the firms that import capital goods we observe that around 14 per cent have foreign equity holders. There does not emerge a clear pattern for foreign equity holders with respect to the mode of technology sourcing.

Table 5: Mode of technology sourcing and presence of foreign equity holders

Combinations	No. of observations	No. of firms with Foreign presence
none	3327 (60.96%)	225 (6.76%)
MK	1592 (29.17%)	233 (14.63%)
RD	361 (6.61%)	65 (18.00%)
RT	622 (11.39%)	52 (8.36%)
MK & RD	176 (3.22%)	41 (2.32%)
MK & RT	238 (4.36%)	30 (12.60%)
RT & RD	62 (1.13%)	12 (26.05%)
MK &RD & RT	31 (0.01%)	11 (35.48%)

Table 6 shows the correlation between total factor productivity and some of the variables used in the study. As can be seen from the table *age* negatively correlated with TFP. This means that as the firm gets older the productivity of the firm declines. The positive correlation age and size indicates that as the age of the firm increases its size also increases. The technology variables, import of capital goods and R&D, and skill is negatively correlated with size of the firm. However, the size of the firm is positively correlated with foreign presence. This means that the larger firms have more foreign presence than the smaller firms. The positive correlation between skill and R&D means that with an increase in skill the R&D in the firms also increase.

Table 6: Correlation matrix

Variables	TFP	Size	Age	Skill	MK	RD	RT	FOR
TFP	1.00							
Size	-0.0078	1.00						
Age	-0.0424*	0.2177*	1.00					
Skill	-0.0100	-0.0866*	-0.0251	1.00				
MK	-0.0030	-0.0613*	-0.0100	0.0145	1.00			
RD	-0.0069	-0.0520*	-0.0166	0.0578*	-0.0020	1.00		
RT	-0.0027	-0.0171	-0.0355*	0.0244	-0.0007	-0.0014	1.00	
FOR	-0.0214	0.0929*	0.1546	-0.0054	-0.0080	-0.0054	-0.0134	1.00

Note: *shows significance at 1% level.

Table 7: Model specification test

Computed Test Statistic	p-value
Breusch-Pagan LM Test: $\chi2(1)$ =134.79	0.000
Hausman Test: $\chi2(8)$ =34.98	0.000
F-test: F(1015, 4431) =67.11	0.000

As can be seen from table 7, the Breusch-Pagan Lagrange Multiplier test justified the use of panel data estimation. The Hausman test rejected the null hypothesis that firm specific effects are not correlated with the regressors. The estimated F statistic showed the presence of fixed effects in the database and suggests that unobservable firm specific characteristics affects total factor productivity. Hence, we use a panel fixed effects model for carrying out our regression analysis.

Table 8: Regression Results

Variables	Symbols	Unbalanced
Intensity Import of capital goods	MK	0.0004***
		(0.0001)
Intensity of R&D	RD	-0.0005
		(0.0005)
Intensity of disembodied technology	RT	0.0030**
		(0.0012)
Firm size	SIZE	0.3674***
		(0.1356)
Firm age	AGE	-0.1616***
		(0.0209)
Skill intensity of employees	SKILL	-0.0014*
		(0.0008)
Square of skill intensity	$SKILL^2$	1.24e-07**
		(6.16e-08)
Interaction of skill intensity and R&D	SKILL X RD	1.83e-06**
		(7.55e-07)
Interaction of age and foreign equity holders	AGE X FOR	0.0008**
		(0.0003)
Intensity of foreign equity holders	FOR	-0.0171**
		(0.0069)
F-value (10,1015)		16.75
No. of observations		5457

Note: Dependent variable: TFP. *, **, *** are significance level at 10%, 5% and 1% respectively. The figures in the parentheses are the robust standard errors. No. of firms= 1016.

Table 8 reports the estimated coefficients of the variables from our regression analysis. The respective marginal effects are reported in Table 9. The results clearly identify the role of technology variables in determining interfirm differences in total factor productivity levels. The import of capital goods representing embodied technology turns out to be statistically significant at 1 per cent level with a positive sign. It means that there is positive change in the productivity level with change in the import of capital goods. The coefficient for disembodied technology also turns out to be significant at 5 per cent level and with a positive sign. Firms in the industry access proprietary technology through payments of royalty or technical know-how fees. This means that the firms in our sample acquire technology either through imports of capital goods or in disembodied form through payment of royalty and technical know-how fees. These acquired technologies are then assimilated in the production of software products and service that are of higher quality. Our findings are similar to that of Sahoo (2013) where royalty payments are found to have a positive effect on total factor productivity growth. Narayanan and Bhat (2008) also find import of capital goods to be a significant technology variable. Our results indicate that the firms in the service sector are more of being followers of the developed countries where-in the technologies are developed. This in a way also supports the observation of Arora et al (2001) and Arora and Athreye (2002) on software and IT firms in India to be more dominant in providing software services and consultancy rather than being developers of software products.

Table 9: Estimates of marginal effects

Variables	Symbols	Marginal effects
Intensity Import of capital goods	MK	0.0036*** (0.0011)
Intensity of R&D	RD	-
Intensity of disembodied technology import	RT	0.0020** (0.0008)
Firm size	SIZE	2.0436*** (0.7543)
Firm age	AGE	-1.9806*** (0.2566)
Skill intensity of employees	SKILL	-0.0906** (0.0506)
Square of skill intensity	$SKILL^2$	0.0531** (0.0263)
Interaction of skill intensity and R&D	SKILL X RD	0.0010** (0.0004)
Interaction of age and foreign equity holders	AGE X FOR	0.0427** (0.0175)
Intensity of foreign equity holders	FOR	-0.4673** (0.0190)
No. of observations		5457

Note: *, **, *** are significance level at 10%, 5% and 1% respectively. The figures in the parentheses are the robust standard errors. No. of firms=1016.

The in-house R&D intensity did not turn out to be significant when considered alone. However, the interaction of R&D with skill turned out to be positive and significant. This suggests that R&D activities in the IT firms are highly skill intensive in nature. This is an interesting result given that the IT service firms require skilled labour to create their software products and services. It means that only the firms that have a higher skilled labour are also the firms that have been able to engage in meaningful R&D activities and thereby improve their productivity levels.

The relationship between skill and productivity takes a non-linear form; we observe a U-shaped form. Thus, there is a threshold level of skill beyond which the productivity level of the firm increases. This is another interesting finding for the IT service firms as it reflects the skill intensive nature of the firms in the industry. The development of newer software products and services demands skills that are updated with the latest available techniques and the better quality of these services provided by the firms contribute to higher total factor productivity within these firms. Due to the high rates of attrition within the IT industry the firms are required to pay higher compensation to their workers in order to maintain the quality of the service provided as well as attract more skilled workers.

We find that size of the firm is significant at 1 per cent level and positively affects the total factor productivity levels. This implies that larger the firm size higher is the productivity level. Bigger firms are endowed with more resources and hence are able to put in more efforts to acquire technology. Since the duplication of the software products are not very difficult, it is possible that the large sized firms are able to quickly cut their cost of production and have higher productivity levels.

The coefficient for age on the other hand is statistically significant at 1 per cent level with a negative sign. This means that the younger firms have higher productivity levels compared to the older firms. Because the technology in IT industry is rapid and fast changing, it is possible that the newer firms are equipped with better knowledge of the upgrading techniques and thereby have a higher total factor productivity levels.

The estimated coefficient for intensity of foreign equity holders turn out to be significant but with a negative sign. This means that the foreign affiliated firms have lower productivity compared to their domestic counterparts. However, the interaction of age and foreign equity holders turns out to be positive and significant. Foreign firms have entered the IT industry relatively recently. The industry has had older and larger firms making their presence felt in domestic and international markets. The presence of foreign affiliates facilitates the within firm transfer of know-how and other kinds of tacit knowledge over a period of time. As a result, the firms with foreign affiliation in a new entity would take some more years to improve their total factor productivity levels.

Summary and Conclusion

The present study is an attempt to understand productivity differences in the case of Information Technology firms and how the technological efforts of the firm explain the differences in productivity. We measure productivity in terms of total factor productivity that is estimated using the Levinsohn-Petrin (2003) approach for the firms in our sample. A panel data analysis using a fixed effects model is carried out to the investigate the link between technological sources of the firms and its effect on total factor productivity. Following are the points that emerge from our study:

First, from the estimation of total factor productivity we find that the output in the Information Technology firms is more elastic with respect to capital than with respect to labour. It suggests that the output level of the firm changes more with the change in capital stock of firms. In addition, we find that overall during our study period the total factor productivity level falls for the firms in the IT sector irrespective of their size and age attributes. However, in terms of size the larger firms are comparatively more productive than the smaller firms, whereas in terms of age it is the younger firms that have relatively higher productivity levels than the older ones. These findings are again noted in our regression analysis where size and age of the firms have significant effect on total factor productivity levels. Despite the improved export performance of the IT firms (Siddharthan and Nollen, 2004; Narayanan and Bhat, 2009) the fall in the productivity levels of these firms over the years is indicative of the need for them to improve upon their performance, through efficient utilisation of resources and use of better technologies to maintain competitiveness and sustain in the long run.

Second, the technological efforts of the firms are important in determining inter-firm differences in total factor productivity levels. Of the different sources of technology, the import of capital goods, the embodied technology, is higher among the IT sector firms followed by the use of disembodied technology in the form of royalty payments and technical know-how fees. It can be said the IT firms are largely users of the developed technologies rather than innovating themselves. This finding is further strengthened by the weak effect of research and development on the firm productivity levels. For meaningful research and development in the industry there is a need for skilled workers in the industry.

Third, as mentioned earlier, the IT sector is comprised of firms that are heterogenous in nature. The larger firms, endowed with more resources have higher productivity levels compared to the smaller firms. The bigger firms, given their resource endowments, are also able to quickly replicate technologies and adapt to the demands of their clients. In terms of age on the other hand, it is the new and younger firms that have relatively higher productivity levels. These young firms are able to adapt to the technological developments within the industry and there by maintain higher productivity levels.

Fourth, firms with foreign affiliates appear to have lower total factor productivity levels. Because the industry has been dominated by the larger and older firms, the newer firms with foreign affiliates would achieve higher productivity only over a period time with the transfer of tacit knowledge.

Unlike other studies, the present study is on the Information and Technology service firms that produces computer software products and packages and provides business solutions and other IT enabled services. We use a more recent and longer dataset to draw meaningful inferences. While the previous studies look into performance of the IT firms in the international market, we take more conventional approach to study the performance of these firms in terms of their total factor productivity and technological capabilities. The study finds evidence that the firms in the IT sector are importers of technology products rather than only engaging in in-house R&D. However, technological improvements and innovations through in-house efforts would be important to sustain the competitiveness of this industry in the face of rising competition from other countries like Ireland and Israel who are the other major software exporters.

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Appendix

Here we describe in detail the construction of inputs used in productivity estimation.

Output- The annual sales turnover of the firms is deflated using an implicit price deflator for services sector. The formula used for construction of the deflator is as given below:

$$Deflator = \frac{Nominal\ GDP\ of\ services\ sector}{Real\ GDP\ of\ services\ sector} \text{ x } 100$$

Labour- The prowess database provides information on the expenditure incurred on compensation to employees for nearly all the firms in our sample but has information on the number of employees for only a few firms. Following Chawla (2012), we arrive at an estimate of employment for each of these firms using the available information. An average wage rate for the industry is computed for each year on the basis of the firms that report their employment, where the 'wage rate' for each firm is obtained by dividing its compensation to employees by its reported number of employees. The average wage is an unweighted average of these firm level 'wage rates'. This average wage is then used to estimate the number of employees for the firms by dividing the compensation to employees for each firm by the corresponding year's wage rate.

Capital- Studies have used various methods to measure capital. While there are some that consider capital as a stock measured by the book value of fixed assets, some others consider it to be a flow of services. In the latter case studies use the perpetual inventory method to construct a capital stock series. A problem that arises specific to the service sector is regarding the kind of capital that is used. Some of the capital that is used by the service firms is intangible in nature and the data on depreciation of such capital is rare.

The prowess database derives the gross fixed assets as a sum of intangible assets, machinery and computer installation, communication and transport equipment and land and buildings and other amenities. Due to unavailability of data, for estimation of the capital stock we use the first reported value of fixed assets as the initial capital stock. Then we arrive at the estimate the capital stock for the next periods as a sum of investment and depreciation adjusted capital stock of the previous year. The depreciation rates as used in the India KLEMS project for the different types capital namely building and construction, machinery and equipment (including ICT equipment and software) and transport equipment are 2.5%, 10% and 8% respectively.
Mathematically,

$$K_{it} = I_{it} + (1 - \delta)K_{it-1}$$

Where δ is the depreciation rate, I_{it} is the difference between the reported book value of the fixed assets.