Human Capital and Manufacturing Productivity Growth in India

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Abstract

Empirical studies on total factor productivity growth (TFPG) in developing countries highlight trade openness, research and development and market structure as being the most important determinants of TFPG. The role of human capital remains overlooked in the literature on the determinants of TFPG of Indian manufacturing sector. In this paper, we look into the role of human capital formation as proxied by literacy rate in influencing TFPG, using Indian manufacturing as a case-study. To compute TFPG, we use firm level data for both the formal and informal manufacturing sector. We correct for the simultaneity bias associated with the production function approach for TFPG estimation by employing a method recently developed by Levinsohn and Petrin. We compute period-average adult literacy rate for 15 Indian States over the period 1994-2005, and then use them in TFP growth equations to estimate the effect of literacy on TFPG. The results indicate that literacy has positively affected the TFP growth of Indian industry. The effect however is primarily for the formal sector.

Keywords: State-business Relation, Productivity growth, Formal sector, Informal sector, Levinsohn-Petrin method.

JEL Classification Codes: L60, O17, O43.

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1. Introduction

It has been shown that long-term growth and development across countries is driven to a large extent by productivity growth (Easterly and Levine, 2001). Several studies exist that have attempted to examine the effect of different factors influencing productivity growth using industries or firms as units of analysis. Most of these studies highlight the role of trade open-ness, research and development and market structure as major determinants of industry or firm productivity growth (see for example, Bartelsman and Doms 2000, Harriss 1999, Tybout 2000, Chand and Sen 2002, Goldar and Kumari 2003, Isaksson 2007, and Mitra and Ural 2007). A considerable body of research has also concentrated on the role of human capital investment in explaining the level and variation in production and earnings in the manufacturing sector (Batra and Tan, 1995; Dearden *et al*. 2000; Jones, 2001; Takii, 2003; Ilmakunnas *et al*., 2004; Nielsen and Rosholm, 2002). While there has been significant amount of literature examining the contribution of human capital to firm growth and productivity, we are not aware of any study that has attempted to analyse the contribution of human capital (proxied by education) on productivity growth of the manufacturing firms in India, especially at the sub-national (state) level. Taking cognizance of it, this paper examines the role of –human capital formation proxied by literacy in explaining productivity growth across industries.

It is argued that education plays a significant role in a rapidly changing work environment due to technological advances (Welch, 1970; Mincer, 1989; Hellerstein and Neumark, 2004). The ability of workers to process new information becomes increasingly important in an environment of technological advancement. According to this view, the better educated workers enjoy comparative advantage in adapting to new technologies than less educated ones. As a result, productivity of better educated workers is relatively greater than the less educated ones (Bartel and Lichtenberg, 1987, Tan and López-Acevedo, 2002; Hellerstein and Neumark, 2004). In this paper, we use the human capital framework to examine the relationship between education and total factor productivity growth (TFPG) in the manufacturing sector in India by using industries as units of analysis. Our empirical context is Indian manufacturing, and we examine whether the variation in TFPG for the same set of industries across Indian states and over time can be related to variations in literacy levels across these states.

We first measure TFPG using Levinsohn and Petrin (LP) method for the 15 major Indian states for the period 1994-2005. We then exploit the differences in human capital formation across Indian states (as measured by literacy level) to examine the effects of education on total factor productivity growth across industries and states and over time. India provides a rich empirical context to study the impact of human capital formation on manufacturing productivity for two reasons. Firstly, differences in regional industrial performance persist, in spite of the dismantling of the License Raj regime in 1991 and significant trade liberalization since the 1990s. These policy reforms should have led to a convergence of industrial productivity growth across Indian States, but this has not happened. Secondly, the availability of firm level data for the Indian manufacturing (encompassing both the formal and informal segments of the manufacturing sector) allows us to estimate TFPG at a very disaggregated level of analysis – and thus, circumvent the problem of aggregation bias in productivity estimates that is a common feature of most empirical studies on productivity for developing countries. As has been increasingly realized in the modern literature on productivity, there is significant degree of heterogeneity in productivity across firms and industries, and the more disaggregated the estimates of productivity, the more accurate these estimates are likely to be (Melitz 2003).

Our paper has two important methodological strengths. Firstly, we are able to test for the impact of human capital on TFPG for the combined manufacturing sector, which includes both the formal and informal segments of the manufacturing sector. Previous studies on TFPG in Indian manufacturing have estimated TFPG only for the formal manufacturing sector. This is a serious omission as nearly 35 per cent of output and 85 per cent of employment in Indian manufacturing are in the informal sector (Mukherjee, 2004). A second strength of the empirical analysis is that we use the Levinsohn-Petrin method of calculating total factor productivity growth, which addresses the simultaneity bias in standard productivity estimates.

The remaining paper is organized in five sections. Section 2 summarises the theoretical and empirical literature on determinants of productivity growth, and discusses the importance of examining the role of human capital in enhancing productivity. Section 3 describes the methodologies, both in estimating TFPG, and in testing for the effect of human capital on TFPG. This is followed by a description of the data and variables used in the empirical analysis in Section 4. The section then provides the estimates of TFPG calculations. Section 5 provides the results of the TFP growth estimations, where we test for the effects of human capital formation on TFPG. Section 6 concludes.

2. What determines productivity growth in industry?

The literature has proposed various potential determinants of firm productivity. These include trade and openness, ownership, role of institutions such as labour market, fairness in dealings etc., public investment in health, human capital, physical infrastructure leading to better quality of work force, research and development (R&D), business environment etc. As can be seen, the factors can be categorized into policy variables or institutions.[1]

There are reasons to expect a favorable effect from trade or openness on industrial productivity. Trade leads to efficient production through gains from specialization and exchange (Mitra and Ural, 2007). Availability of larger variety of inputs can augment firms' productivity through greater division of labour and/or through better matching between output and inputs (Krugman and Obstfeld, 2005). The

[1] While institutions consist of rules – formal and informal - and norms within which individuals and firms function, policies refer to various measures a government adopts to achieve its goals and objectives within the country's institutional framework (Mitra and Ural, 2007). In many cases, the dividing line between policies and institutions is very blurred.

increased competitive pressure on industrial units in a liberalized trade regime force them to be more efficient in the use of resources (through better organization of production, or effective utilization of labour, or capacity, etc.), ultimately leading to higher productivity.

In addition, trade can affect R&D and hence productivity in two contrasting ways as argued by Rodrik (1992) and Devarajan and Rodrik (1991). A reduction in tariff reduces the market size of a domestic (import-competing) producer and therefore reduces the gain from a cost-reducing innovation (called as market size effect), whereas it enhances competition from foreign substitutes, thereby reducing the mark up (hence monopoly power) leading to increased output (the pro-competitive effect). The former has a negative impact on R&D and therefore on productivity, the latter represents a positive effect. Trade liberalization also induces firms to invest in R&D to increase efficiency, thereby enabling them to face the increased competition arising from international trade (Kathuria, 2008). Trade, as found by Melitz (2003), can also force least productive firms to go out of the market thereby reallocating resources to the surviving firms so as to increase overall productivity of the industry. Several studies show a beneficial effect of exports on firm TFP (see for instance, Kraay, 1999; Blalock and Gertler, 2004; Fernandes and Isgut, 2006). The evidence for developing countries, including Asian countries, however is mixed (refer Das, 2002 for a review of these).

The productivity of various inputs in production clearly depends on the quality of public infrastructure. For instance, the quality of human capital unambiguously depends on the quality of education, health and social services – as provided by the government. Investment on infrastructure and social services is thus, another policy variable having positive impact on productivity (Mitra and Ural, 2007; Iskasson, 2007). Studies by Tan and Lopez-Acevedo, 2002; Aw *et al*., 2005 among others have found positive influence of human capital and training on firm's TFP.

Another policy variable that has adverse affect on the efficiency of the firms is the prevailing competitive condition in the sector. A restriction on free entry and exit of firms hinder competition faced by existing firms and thus lowers firm efficiency. This also prevents inefficient firms from exiting the market. Thus productivity of the industry as a whole gets adversely affected. Free entry and exit of firms does not work in isolation, the precise impact depends on how it interacts with labour market institutions (Mitra and Ural, 2007). For example, easy entry and exit will not have a requisite effect if labour market restrictions on firing of workers are in place, since essentially this is an exit barrier. It is also an entry barrier since it discourages entry by discouraging firms from hiring permanent workers who would benefit from on-the-job training (*ibid*.).

Empirical evidence also exist for the positive impact of R&D activities on firm productivity (Griliches, 1998, Kathuria, 2008). Recent literature has also focused on the role of the business environment for firm TFP (Hallward-Driemeier, *et al*., 2003; Dollar, *et al*., 2005; Wagner, 2007) and the effects of foreign ownership on firm TFP (Arnold and Javorcik, 2005; Kee, 2005).

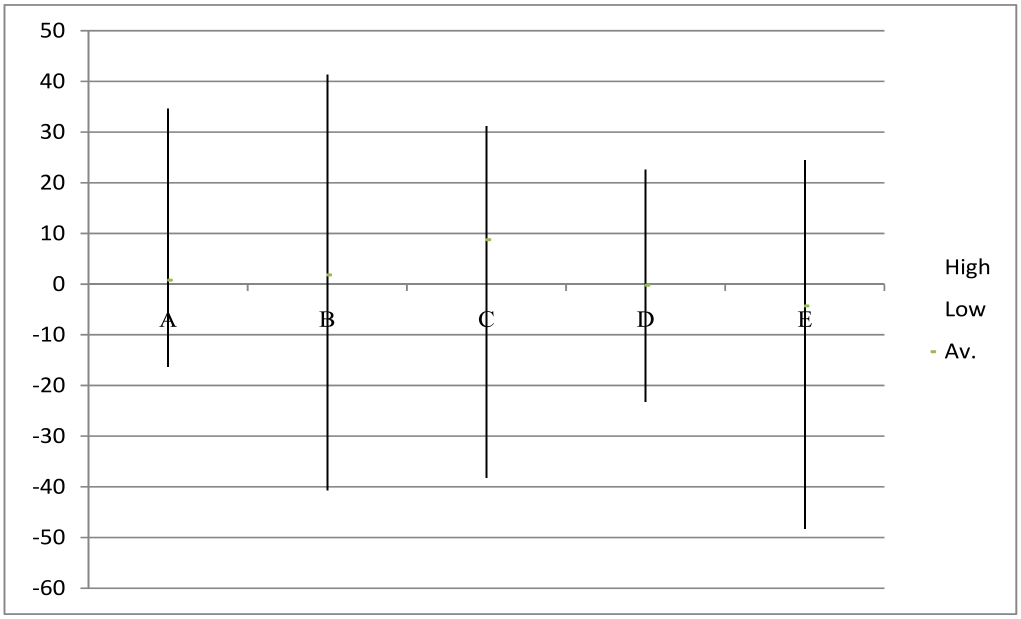
The contribution of human capital to earnings and growth is well known (Schultz 1961). Becker (1964) developed a theory of human capital formation and analyzed the rate of return to investment in education and training on growth. There is overwhelming evidence at the micro level, particularly at the firm and worker level, that education, and training proxied by experience enhance productivity and hence earnings. Batra and Tan (1995), Dearden *et al*. (2000), Jones (2001), Takii (2003) and Ilmakunnas *et al*. (2004) have demonstrated a positive association between workers' human capital and productivity at the firm level. A number of studies have also examined the impact of education on worker's earnings (Jones, 2001; Takii, 2003) and found a positive relationship between the two.

It can be clearly seen that some of the determinants discussed are determined nationally - e.g., trade, R&D and competition policies and hence need to be controlled for, either explicitly (trade/competition) or indirectly via fixed effects (R&D). Still, nationally governed variables or industry fixed effects cannot explain why productivity and productivity growth for the same industry differs across regions. Any productivity difference or productivity growth difference for the same industry across the region / States thus would be due to the presence of varied human capital base across States. This is well illustrated in Table 1 and Figure 1, which give the range of productivity and productivity growth for some of the key industries across Indian States.

Table 1: Productivity (in Rs.) variation across the States for the same industries for three years

Industry	Year = 1994	Year = 2000	Year = 2005
Pump, Compressors and Valves	0.76 - 33,256	0.32 - 46,948	0.15 - 38,212
Agriculture and Forestry Machinery	0.61 - 170,326.1	0.39 - 433,879	0.09 - 324,703
Machine Tools	0.46 - 50,028	0.94 - 23,424	0.66 - 42,884
Food, Beverages and Tobacco Processing machinery	1.41 - 43,145	0.72 - 40,504	0.63 - 30,971
Domestic Appliances	0.50 - 31,502	1.23 - 24,931	0.31 - 38,935

Source: Own compilation



Notes: A – Pumps, compressors and valves; B – Agriculture and Forestry Machinery; C – Machine Tools; D – Food, Beverages and Tobacco Processing Machinery Industry; E – Domestic Appliances.

Figure 1: Productivity (TFP) Growth variation across States for the same industries

The table and figure indicates wide variation in productivity and productivity growth across the industries. Apparently no study exists in the Indian context that has looked into the role of human capital in affecting productivity. The present study fills this obvious gap.

3.1 Methodology

Growth equation estimation

In this paper, an attempt is made to statistically establish the relationship between human capital and TFPG. The following regression function is estimated separately for combined, formal and informal sectors.

$$TFPG_{ist}^{I,F,C} = a_0 + a_1 X_{it} + L_{st} + T + e_{ist} \qquad (1)$$

The subscript i, s and t index the industry, state and time period. TFPG is total factor productivity growth, X is a vector that includes other determinants of TFPG such as trade and competition variables, L is the period-averaged measure of literacy level for state s at time t (where t=1994-2001 and 2001-2006) and T is the time dummy, which is equal to 1 when t = 2001-2006 and 0, otherwise. e_{ist} is the state-industry-time error term. I, F, and C represent Informal, Formal and Combined sector respectively.

The trade and competition policy variables used as controls for the above growth equation estimation include the import-penetration and export orientation ratios, tariff rates and the Herfindahl-Hirschman index (HHI) at the 4 digit level. We however could not directly control for the R&D intensity, but used industry dummies in one of the specifications to see the effect of any industry-specific policies. We have included a year dummy, T, to capture macroeconomic shocks to capacity utilization, which may affect TFP over time.

We test the relationship separately for formal and informal manufacturing sector due to the existence of duality in the Indian manufacturing sector. The Indian manufacturing sector consists of two categories of firms depending on the size of the labour force in the firm – formal and informal sector. Firms which are in the formal sector are required to adhere to various regulatory norms besides providing several benefits to the workers.[2] Apart from this, the reservation of few products for small scale units and tax benefits to them has resulted in duality in Indian manufacturing (Sarkar and Majumdar, 2008). Secondly, available evidence suggest that the unorganized manufacturing sector suffers from low levels of productivity and efficiency on account of a large pool of low skilled and less educated workers using inferior technology and earning low wages. Research studies have recommended that measures like improving the technology base, strengthening the link between organized and unorganized sectors to improve the efficiency of the sector (Mukherjee, 2004; Raj and Duraisamy, 2005; Raj, 2006). However, while upgrading technology itself is a costly measure, it should be noted that steps to improve the skills of the workforce to handle the existing, if not better, technology could bring in desired changes in productivity and efficiency of the sector (Majumdar, 2004). This calls for improving the human capital base, education and on-the-job-training, of workers employed in the unorganized sector enterprises. Thus, testing the relationship for formal and informal manufacturing in a way would be test for this duality and validity of the scope of human capital formation.

TFPG estimation

For finding TFPG, we estimate the Cobb-Douglas (CD) production function in equation (2) separately for each of the 15 major Indian States.[3]

$$\ln Y_{ist} = A_{st} + \beta_L \ln L_{ist} + \beta_K \ln K_{ist} + u_i + v_{ist} \qquad (2)$$

The subscript i, s and t index the industry, state, and time period. The variables Y, L and K represent the real value added, labour and capital inputs respectively. 'A' is TFP which represents the efficiency of the firm in transforming inputs into output.

[2] The formal sector in India is defined to be the set of firms who are registered under the Factories Act (1948), and by doing so, fall under the purview of labour laws and other government regulations. Firms are required to register if they employ 10 workers if they use electricity, and 20 workers if they do not use electricity. The informal sector in India is considered to be the set of firms which employ less than 10 workers if using electricity and 20 workers if not using electricity. The formal and informal sectors in India are often referred to as the organized and the unorganized sectors.

[3] The States included are Andhra Pradesh (AP), Assam, Bihar, Gujarat, Haryana, Karnataka, Kerala, Madhya Pradesh (MP), Maharashtra, Orissa, Punjab, Rajasthan, Tamil Nadu (TN), Uttar Pradesh (UP), and West Bengal (WB).

The estimation of the coefficients of labour and capital using ordinary least squares (OLS) method implicitly assumes that the input choices are determined exogenously. Firm's input choices can be endogenous too. For instance, the number of workers hired by a firm and the quantity of materials purchased may depend on unobserved productivity shocks. These are overlooked by the researcher but they certainly represent the part of TFP known to the firm. Since input choices and productivity are correlated, OLS estimation of production functions will yield biased parameter estimates. To correct this endogeneity bias, we employ a methodology recently developed by Levinsohn and Petrin (2003).

Researchers in the past have used techniques like fixed effect estimation or the semi-parametric methodology developed by Olley and Pakes (1996) (henceforth OP) to correct this bias. The fixed effects estimation however eliminates only unobservable *fixed* firm characteristics that may affect simultaneously input choices and TFP; there may still be unobserved *time varying* firm characteristics affecting input choices and TFP. The main idea behind LP methodology is that an observable firm characteristic – intermediate inputs – can be used to proxy the unobserved firm productivity and estimate unbiased production function coefficients.

Levinsohn and Petrin (LP) Methodology

Simultaneity arises because productivity is observed by the profit maximizing firms (but not by the econometrician) early enough to influence their input levels (Marschak and Andrews, 1944). This means that the firms will increase (decrease) their use of inputs in case of positive (negative) productivity shocks. OLS estimation of production functions thus yield biased parameter estimates because it does not account for the unobserved productivity shocks.

OP method overcomes the simultaneity problem by using the firm's investment decision to proxy unobserved productivity shocks. The estimation rests on two assumptions. First, productivity – a state variable in the firm's dynamic problem – is assumed to follow a Markov process and is unaffected by the firm's control variables. Second, investment – one of the control variables of the firm – becomes part of the capital stock with a one period lag. In the OP method, labour is treated as a non-dynamic input and capital is assumed to be a dynamic input. A firm's choice of labour has no impact on the future profits of the firm. The OP estimation involved two steps. The coefficients of the variable inputs and the joint effect of all state variables on output are estimated in the first step. In a two input framework, the former is just labour and the latter are capital and productivity. Investment is assumed to be a monotonically increasing function of productivity and inverting the investment equation non-parametrically provides an observable expression for productivity. This expression is used to substitute the unobserved productivity term of the production function, hence allowing identification of the variable input elasticities.

The coefficients of the observable state variables (capital if there are only two inputs) are identified in the second step by exploiting the orthogonality of the quasi-fixed capital stock and the current change in productivity. A nonparametric term is included in the production function to absorb the impact of productivity, to the extent it was known to the firm when it chose investment in the last period. The second term included in equation (4) below captures the unobserved productivity shock and uses the results of the first stage (i.e., equation 3).

The estimating equations for the two steps are

$$y_{ist} = \beta . l_{ist} + \gamma . k_{ist} + h_{is}(i_{ist}, k_{ist}) + e_{ist} \tag{3}$$

$$V_{ist} = \gamma . k_{ist} + g(\emptyset_{t-1} - \gamma . k_{t-1}) + \mu_{ist} + e_{ist} \tag{4}$$

The functions h and g are approximated non-parametrically by a fourth order polynomial or a kernel density. Once both the equations are estimated, we have estimates for all the parameters of interest. The labour coefficient is obtained in the first stage and capital coefficient in the second stage. These estimates are termed as OP estimates. A major advantage of this approach is the flexible characterization of productivity, only assuming that it evolves according to a Markov process. However, the method also has few drawbacks. OP method demands a strictly monotonous relationship between the proxy, which is investment, and output. This means that observations with zero investment have to be dropped from the dataset in order for the correction to be valid. Given that not every firm will have strictly positive investment every year, this may lead to a considerable drop in the number of observations in the dataset, an obvious efficiency loss. This is all the more important for firms in the informal sector, where for years together firms hardly invest in capital. Levinsohn and Petrin (2003) developed an estimation technique that is very much similar to the one developed by OP but use intermediate inputs (m) as a proxy rather than investment.[4] Typically, many datasets will contain significantly less zero-observations in materials than in investment. This is what has been used in the present study. In LP, the first stage involves estimating the following equation:

$$y_{ist} - \beta_0 + \beta_l l_{ist} + \emptyset_t(m_{ist}, k_{ist}) + \varepsilon_{ist} \tag{5}$$

where $\emptyset_t(m_{ist}, k_{ist}) = \beta_k k_{ist} + f_t^{-1}(m_{ist}, k_{ist})$ is a non-parametric function. The estimates of β_l and $\emptyset_t$ are obtained in the first stage.

The second stage of the LP estimation obtains the estimate of β_k. Here, like OP, LP assumes that productivity (ω) follows a first-order Markov process, and is given by

$$\omega_{ist} = E[\omega_{ist} | \omega_{ist-1}] + \epsilon_{ist} \tag{6}$$

This assumption states that capital does not respond immediately to ϵ_{it}, which is the innovation in productivity over last period's expectation (i.e., the shock in productivity). It leads directly to the following moment condition:

[4] LP use electricity as a proxy in their study. We could not use electricity as majority of firms in the informal sector are working without power which would lead to dropping considerable number of firms from our sample.

$$E[\epsilon_{ist}|k_{ist}] = 0 \qquad (7)$$

The equation (7) states that the unexpected part of the innovation in productivity in the current period is independent of this period's capital stock, which was determined by the previous period's investment. Using this moment condition, β_k can be estimated from the following expression:

$$\epsilon_{ist}(\beta_k) = \omega_{ist} - E[\omega_{ist}|\omega_{ist-1}] = (\hat{\emptyset}_{ist} - \beta_k k_{ist}) - \hat{\varphi}(\beta_k) \qquad (8)$$

This moment condition identifies the capital coefficient, β_k. The saliency of this technique lies in the assumption that the current period's capital stock is determined before the shock in the current period's productivity.

4. Data and Variables

Data for the productivity estimation

A key feature of the present paper is the use of firm level data for both formal and informal manufacturing sector. The data for the informal manufacturing sector for the selected States are obtained from the National Sample Survey Organisation (NSSO) surveys on the informal manufacturing sector for 1994-95, 2000-01 and 2005-06.[5] In order to compute TFPG for a sector, data for the same three years for the formal sector are obtained from the Annual Survey of Industries (ASI).[6] We have aggregated the unit level data to arrive at the four-digit industry level data for each State. To use the Levinsohn-Petrin technique, we considered only those industries for which three year data was available. While aggregating the data up to four digit level, we have omitted units reporting zero or negative capital stock, zero output and zero employment.[7]

Variables

The variables used in TFP estimates are output, labour, capital, and intermediate inputs. To make the values of output, capital and intermediate inputs comparable over time and across industries and States, suitable deflators have been used as discussed below.

Output: As in common in the literature, Gross value added (GVA) is used as the measure of output in this study (Goldar, 1986; Ahluwalia, 1991; Balakrishnan and Pushpangadan, 1994, 1998). The advantage of GVA over gross output as a measure of output is that it allows comparison between the firms that are using heterogeneous raw materials (Griliches and Ringsted, 1971) and takes into account differences and changes in the quality of inputs (Salim and Kalirajan, 1999). We also use the

[5] The NSSO conducts surveys on the informal manufacturing sector quinquennially. Though the NSSO initiated this survey in 1978-79, a complete firm level dataset was available only from 1994-95. This fits well with our objective too.

[6] It is important to note here that at the time of the analysis the ASI data for 2005-06 was yet to be released. On account of it, we have considered the ASI dataset for the year 2004-05.

[7] In 2000, Bihar, MP and UP were bifurcated and three new States - Uttrakhand, Chattisgarh and Jharkhand were formed, for the present analysis, these three States were merged with their parent States so as to have consistent data for all the three time periods.

single deflation method (where nominal value added is deflated by the output price index) in estimating real GVA rather than the double deflation method (where the output and material inputs are deflated separately) due to the non-availability of industry specific input deflators. For the output price deflator, we use the industry specific wholesale price index.

Capital: We have used the total fixed assets as given in the ASI and NSSO reports to represent capital[8] input in the formal and informal sectors respectively. The total fixed assets are deflated by WPI for machinery and machine tools in both the sectors. The WPI for machinery and machine tools are not available at the industry level forcing us to use the values at the all India level. The values are expressed in 1993-94 prices.

Labour: Total number of persons engaged is used as the measure of labour input. Since working proprietors / owners and supervisory/managerial staff have a significant influence on the productivity of a firm, the number of persons engaged was preferred to the total number of workers.

Data for the growth equation estimation

In this empirical exercise, we intend to statistically establish the relationship between human capital and TFPG. To represent human capital, we included levels and changes in adult literacy as a variable to capture the role of education in improving productivity in the manufacturing sector. We argue that improvement in literacy overtime in a state would enhance the overall human capital base in the sector thereby creating a positive impact on productivity growth. Data on adult literacy rate expressed as a percentage of age group were drawn from various issues of Educational Statistics published by Human Resources Department, Ministry of Education, New Delhi.

The control variables for the TFP growth equation estimation are import-penetration and export orientation ratios, tariff rates and the Herfindahl-Hirschman index (HHI). Data on exports orientation, imports penetration and tariff rates are obtained from Nicita and Olarreaga (2006). These data are at the 3-digit ISIC level and are matched to the NIC 2-digit industry level. As exports and imports data are reported in US dollars, we converted them to Indian Rupees using the dollar-rupee exchange rates prevailed during the selected sample years. These figures are then deflated using WPI for manufactured products at the two-digit industry level. All values are expressed in 1993-94 prices. Data on HHI are drawn from the PROWESS database of the Centre for Monitoring Indian Economy (CMIE).

The specific variables used in the regressions are:

Import penetration ratio (IMPEN): for a particular industry is defined as the ratio of its imports to domestic demand and is calculated as: IMPEN = Real imports / Domestic demand, where Domestic demand = Real output + Real imports – Real exports

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[8] The capital input includes land, buildings and other construction, plant and machinery, transport equipment, tools and other fixed assets that have a normal economic life of more than one year from the date of acquisition.

Export orientation ratio (EXPOR): for a particular industry is the ratio of its exports to its output. It is given as: EXPOR = Real exports / Real Output

Simple average applied tariff rate (SIMTF): represents the simple average tariff rate on goods entering the country (for details refer Nicita and Olarreaga, 2006)[9] in percentage points.

Weighted average applied tariff rate (WHTTF): is the import weighted average applied tariff rate on goods entering the country (for details refer Nicita and Olarreaga, 2006) in percentage points.

Herfindahl-Hirschman Index (HHI): HHI is an indicator of the extent of competition among firms in an industry. It is defined as the sum of the squares of the market shares of the 50 largest firms (or summed over all the firms if there are fewer than 50) within the industry. The index can vary from zero to one with increases in the HHI reflecting a decline in competition and an increase of market power and *vice versa*.

Table 2 gives the summary statistics for the literacy, trade and competition variables for the two time periods – 1994-2000 and 2001-2005. We can easily infer the following: a) there is a considerable improvement in literacy rate over time (row 1); b) trade restrictions on the manufacturing sector has lessened over time, as evident by the decrease in tariffs, though this has not led to increased import penetration or export orientation (rows 2, 3, 5 and 6); and c) competition has increased in the Indian manufacturing sector, as evident from the decline in HHI (row 4).

Table 2: Average Values for Human Capital, Trade and Competition Variables

	Variable	1994-2000	2001-2005
1	Literacy	60.89	67.85
		(10.88)	(9.19)
2	Change in	7.60	6.34
	Literacy	(2.91)	(2.43)
3	SIMTF	41.82	39.12
		(21.805)	(18.537)
4	WHTTF	46.13	43.20
		(36.094)	(31.907)
5	HHI	0.17	0.164
		(0.108)	(0.103)
6	IMPEN	0.096	0.096
		(0.138)	(0.138)
7	EXPOR	0.132	0.0398
		(0.189)	(0.064)

Note: Figures in parentheses are standard deviation.

[9] Applied rates take into consideration the available data for preferential schemes (i.e. the variable takes the tariff rates for each partner that export to the market country in constructing the average) (for details, refer Nicita and Olarreaga, 2006).

Productivity Growth Estimates

The section now gives the productivity growth estimates. The estimates are obtained using production function approach, where the function is estimated for 15 major Indian States using LP method separately for formal, informal and combined sectors using four-digit industry level data for the three time periods.[10]

Tables 3-5 give the TFPG[11] estimates for formal, informal and combined manufacturing sectors respectively. The TFP grew steadily in the formal manufacturing sector over the period 1994-2005 (Table 3). A comparison of TFPG during 1994-2001 and 2001-2005 reveals that TFP growth accelerated in the latter period as compared to the former. The average annual TFPG for the 15 States was 0.04 per cent in the first period, which increased to 3.14 per cent during the second period. We also find that the aggregate growth masks the inter-regional differences in productivity growth.

Table 3: Total Factor Productivity Growth in the Formal Sector

State	1994-2001		2001-2005		1994-2005	
	Mean	SD	Mean	SD	Mean	SD
Punjab	1.74	22.81	2.22	21.7	3.04	10.64
Haryana	-2.97	22.43	2.56	31.47	-1.79	15.7
Rajasthan	-0.73	22.46	1.09	36.87	-1.96	22.38
UP	-1.28	19.05	6.65	24.24	1.29	10.53
Bihar	-0.94	24.71	-3.8	27.02	-5.24	22.16
Assam	3.89	32.78	1.66	22.33	4.06	10.34
WB	-0.59	14.37	4.82	42.77	-0.94	14.16
Orissa	-0.08	16.07	1.23	27.11	-0.69	18.37
MP	6.31	28.54	0.71	22.14	4.69	11.58
Gujarat	5.52	30.34	0.74	29.15	5.2	17.9
Maharashtra	-6.17	8.86	5.14	17.08	-1.64	6.63
AP	-1.32	11.87	9.57	40.13	1.71	7.5
Karnataka	-0.16	20.34	8.2	51.56	2.83	10.95
Kerala	0.47	14.12	3.13	20.09	-0.31	12.1
TN	-3.11	11.54	3.25	24.25	-0.58	6.91
Mean	**0.04**		**3.14**		**0.64**	

Notes: * estimated from the data without outliers.[12]

We notice a completely different picture with regard to TFP growth in the informal manufacturing sector (Table 4). TFP reported a steady decline over the period 1994-2005. The decline that started during 1994-2001 continued unabated in the period 2001-2005 with a decline of 16 per cent in this period. Majority of the States registered TFP decline in both the periods.

[10] The estimation is carried out in STATA 11.

[11] It is to be noted that wherever growth rate has been computed in Table 3 or elsewhere, it is the compound annual growth rate (CAGR) for the period. The CAGR is calculated as $[(Y_t/Y_o)^{(1/t)}-1]*100$, where Y_t and Y_o are the terminal and initial values of the variable and 't' is the time over which CAGR has to be calculated.

[12] On checking standard deviation of TFPG, it was found that for some States, few industries were influencing TFPG. The present table gives TFPG estimates after omitting these industries. For the TFPG estimates from the data with outliers refer Kathuria *et al*. (2010).

Table 4: Total Factor Productivity Growth in the Informal Sector

State	1994-2001		2001-2005		1994-2005	
	Mean	SD	Mean	SD	Mean	SD
Punjab	-7.69	10.39	-3.72	24.57	-6.25	12.02
Haryana	-8.91	10.55	-11.04	21.26	-10.63	10.69
Rajasthan	-7.6	10.23	-11.48	20.51	-9.96	10.1
UP	-2.8	21.58	4.44	20.83	0.6	9.51
Bihar	0.74	24.26	-13.75	31.26	-8.48	22.2
Assam	-3.89	10.92	-32.52	12.27	-18.33	7.73
WB	-4.54	8.49	-10.75	21.38	-8.48	10.55
Orissa	-6.67	10.4	-34.18	9.74	-20.29	4.59
MP	7.99	32.95	-4.06	23.38	4.92	14.92
Gujarat	-2.51	12.06	-19.38	16.9	-10.7	8.83
Maharashtra	-2.45	10.22	-4.74	22.7	-4.03	12.06
AP	-3.08	9.88	-26.98	16.26	-14.73	9.08
Karnataka	-3.64	10.79	-26.52	15.2	-15.26	9.52
Kerala	-13.7	12.39	-22.21	14.3	-17.94	8.89
TN	-1.42	6.96	-23.14	19.21	-12.59	9.63
Mean	**-4.01**		**-16.0**		**-10.14**	

Notes: Same as Table 3.

Table 5: Total Factor Productivity Growth in the Combined Sector (formal + informal)

States	1994-2001		2001-2005		1994-2005	
	Mean	SD	Mean	SD	Mean	SD
Punjab	-0.46	21.06	-1.46	23.45	0.73	10.46
Haryana	-5.69	22.1	0.61	26.55	-3.34	14.82
Rajasthan	-0.8	22.95	-0.69	28.06	-1.29	17.82
Uttar Pradesh	-1.27	19.06	4.74	19.11	1.08	9.57
Bihar	-0.68	24.38	-6.04	22.21	-5.98	20.57
Assam	3.02	32.01	-8.31	24.58	-1.39	13.63
West Bengal	-1.96	13.13	1.4	27.84	-1.94	13.19
Orissa	0.9	26.45	-6.35	25.85	-4.54	18.83
Madhya Pradesh	2.8	26.49	2.27	18.62	3.52	9.86
Gujarat	-0.79	26.27	24.8	219.8	2.36	15.66
Maharashtra	-6.37	9.58	3.38	14.79	-1.39	6.73
Andhra Pradesh	-2.42	12.19	4.94	31.77	-0.12	8.39
Karnataka	-0.7	14.81	2.42	25.89	1.16	8.99
Kerala	-4.32	11.83	1.35	18.78	-3.31	12.03
Tamil Nadu	-3.63	11.34	0.74	21.73	-1.1	6.49
Mean	**-1.49**		**1.59**		**-1.04**	

Notes: Same as Table 3

As regards the combined manufacturing sector, TFP registered a turnaround in the second period, 2001-2006. TFP switched over from a negative growth of 1.5 per cent per annum in 1995-2001 to a positive growth rate of 1.6 per cent per annum during 2001-2006.

5. Estimation of the TFPG Growth Equation - Results

Table 6 gives results for the combined manufacturing sector. We present the results for the relative change in these variables (i.e., log differences) rather than the absolute values. The choice of log differences is dictated by the fact that any productivity shock in a period will be governed more by the changed trade regime or competition instead of the actual regime.[13] Further, to represent education, we use period averaged measure of adult literacy rate.

From the table, it is clear that education (row 1) is key factor in influencing the TFP growth of Indian industry (Model 1). However, none of the trade variables and competition variable is significant though, they have come with the right sign (rows 2, 3 and 4). One possible reason for trade variables not attaining significance is the fact that major trade reforms were carried out in 1991, and that tariff rates had fallen quite sharply by 1994.[14] Another reason for the variable not affecting TFPG is the level of disaggregation of trade variables used,[15] which being at three digit levels whereas TFPG is computed at the four digit level. Same is the case with HHI, which too has been computed at the three digit level.

Table 6: Human Capital and Productivity Growth across Indian States, robust estimations: Combined Manufacturing Sector

	Variables	Model 1	Model 2	Model 3	Model 4 (IV)
1	Literacy	1.48*	0.27*	0.14	0.26*
		(0.39)	(0.14)	(0.12)	(0.14)
2	HHI	-9.80	7.23	--	7.15(31.19)
		(35.46)	(20.15)		
3	IMPEN	-185.75	18.16	--	18.49
		(158.43)	(86.32)		(42.41)
4	EXPOR	40.89	2.50	--	2.67
		(56.88)	(38.32)		(41.80)
5	Outlier	--	2981.83*	2852.12*	2981.92*
			(290.49)	(240.93)	(42.01)
6	Year effect	Yes	Yes	Yes	Yes
7	Industry effects	--	--	Yes	--
8	R Squared	0.02	0.75	0.74	0.75
9	N	1751	1751	2754	1751

Notes: * indicates significance at minimum 10% level; Figures in the parentheses are standard errors; the results are obtained after correcting for heteroskedasticity if any; the number of observations in Models 1, 2 and 4 are less because for some of the industries we do not have data on trade and competition variables.

A closer look at the TFPG estimates indicates that a few industries have very high TFPG during the period. It is possible that these industries might be driving the results on the impact of education on productivity growth. The inclusion of a dummy for these outliers industries (Model 2) not only improves our estimates, the explanatory power of the model also increases. Further, since all these variables are at the industry level, and literacy variable is at the State level, it does not make sense to

[13] We also used these variables in average form and the beginning of the period, the results are not reported but in all these models the SBR variable hardly changed.

[14] To give an example of the kind of steep fall in tariff we had, the maximum tariff for a large number of industries which was varying between 100 per cent to 355 per cent in 1990, fell to 65 per cent in 1992 for almost all the industries except for beverages, iron and steel and industrial chemicals (Nicita and Olarreaga, 2006).

[15] Including trade variables at higher aggregation is because it is very difficult to obtain at such a disaggregated level of industrial classification.

introduce industry dummies and State dummies, at the same time as they will be correlated with the variables above. We include only industry dummies instead of IMPEN, EXPOR and HHI as a robustness test. The inclusion of only industry dummies (instead of trade and competition variables) does not change the results (Model 3). The literacy variable is robust to these alternate specifications.

Testing for Potential Endogeneity

One potential concern with our results is that the literacy variable may be endogenous to productivity growth in a particular state. There are two possible ways that this may happen. States with a literate and more educated workforce are likely to be more efficient because of their greater ability to absorb and effectively utilize new technology. Also, the presence of more literate workforce in a particular state (or particular region in a state such as Bangalore, Mumbai, Delhi, Chennai and so on) may lead to more productive firms from other states to relocate to that state. In order to control for the potential endogeneity of the literacy variable, we used two sets of instruments: one based on land reform legislation enacted by Indian states in different points in time, and the other based on the nature of the political regime in a given state.

Land reform was implemented under the 1949 Indian legislation, according to which states are granted the powers to enact (and implement) land reforms. There are significant differences in the intensity with which states have enacted the various types of land reform legislation over time. We use the measure of intensity of land reform across different states as constructed by Besley and Burgess (2000). Since there has not been any major land reform legislation since 1992 (see World Bank 2007), we retain the same values for the land reform variable for the post-1992 period.

The second type of instrument is based on the results of the political elections at the state level. We exploit the fact that the human capital formation in a state is the result of the political formation in power in a state. We use data from records of the number of seats won by different national parties at each of the state elections under four broad groupings in line with the classification by Besley and Burgess (2000). We express these as a share of total seats in the legislature. We use average of the preceding four years to decrease the potential concern about their endogeneity.

Model 4 in Table 6 are the results of the instrument variables (IV) estimations to account for potential endogeneity. The coefficients for literacy and other variables however do not change. Thus, endogeneity is not a problem with our estimations. This is also verified by Wooldridge's (1995) robust score test, which is not significant, thereby rejecting endogeneity.

Effect of human capital on Formal and Informal manufacturing

The results thus indicate that literacy has a positive impact on the TFP growth of Indian industry. However, it is posssible that the effect may vary between formal and informal sectors due to the differences in the characteristics of the workforce they employ. As argued elsewhere, the informal sector is alleged to be a reservoir of less skilled and low educated workforce while the formal sector employ mostly skilled workforce. Thus it is possible that the contribution of education will be significantly higher in the formal sector as compared to the informal sector. In other words, the effect of literacy should be mainly on the formal manufacturing; the informal sector is less likely to benefit from literacy. Moreover, given the duality in Indian manufacturing sector (Sarkar and Majumdar, 2008), the informal sector may not be affected by even trade related reforms or the prevailing competitive market structure. Thus, it is important to carry out estimates for formal and informal manufacturing sector separately. Tables 7 and 8 give results for formal and informal manufacturing sectors respectively. The scheme of analysis is same as followed in combined manufacturing.

Table 7: Human Capital and Productivity Growth across Indian States, robust estimations: Formal Manufacturing Sector

	Variables	Model 1	Model 2	Model 3	Model 4 (IV)
1	Literacy	3.45* (1.09)	1.02* (0.52)	0.69 (0.45)	0.97* (0.53)
2	HHI	-30.16 (73.10)	62.30 (83.25)	--	60.86 (119.20)
3	IMPEN	-201.92 (412.63)	110.48 (314.21)	--	116.46 (157.70)
4	EXPOR	-0.35 (121.59)	26.19 (139.93)	--	29.43 (158.81)
5	Outlier	--	6113.18* (1057.93)	5626.42* (809.54)	6114.85* (155.06)
6	Year effect	Yes	Yes	Yes	Yes
7	Industry effects	--	--	Yes	--
8	R Squared	0.02	0.49	0.49	0.49
9	N	1687	1687	2572	1687

Notes: Same as Table 6

As conjectured, presence of human capital proxied using literacy level is found to have significant effect on the TFPG of formal sector (row 1, Table 7). The coefficient of literacy variable for the formal manufacturing sector (row 1, Table 7) becomes more meaningful when we control for few industries having abnormally high TFPG (Models 2 and 3). With respect to trade and competition variables, none of them is found to have any impact on TFPG for the formal sector variable. Contrary to our expectation, for informal sector, in one of the specifications, with industry dummies instead of trade and competition variables, the results indicate that human capital formation in the state leads to decline in TFPG (Model 3). One possible reason could be the potential endogeneity. The Wooldridge (2005) endogeneity test for informal sector confirms weak endogeneity. The IV results change accordingly (Model 4). The IV estimation, however do not change the result for formal manufacturing indicating no endogeneity. It shows that increasing human capital base in a state is creating a positive impact only in the formal manufacturing sector as the presence of skilled workers is primarily crucial to the formal sector.

Table 8: Human Capital and Productivity Growth across Indian States, robust estimations: Informal Manufacturing Sector

	Variables	Model 1	Model 2	Model 3	Model 4 (IV)
1	Literacy	0.17	-0.06	-0.16*	-0.07
		(0.18)	(0.06)	(0.05)	(0.12)
2	HHI	-42.49*	9.97*	--	9.69*
		(22.16)	(5.66)		(24.18)
3	IMPEN	36.32	22.00	--	23.87
		(102.00)	(39.69)		(36.30)
4	EXPOR	96.44*	-13.27	--	-12.46
		(45.82)	(15.38)		(33.81)
5	Outlier	--	3276.33*	3273.61*	3276.53*
			(610.49)	(606.94)	(54.53)
6	Year effect	Yes	Yes	Yes	Yes
7	Industry effects	--	--	Yes	--
8	R Squared	0.01	0.74	0.74	0.74
9	N	1291	1291	2112	1291

Note: Same as Table 6

On the basis of results, we can say that literacy has a direct impact on the TFPG of the manufacturing sector. The effect however is confined to the formal sector only. This supports that there exist duality in Indian manufacturing. The presence of educated and skilled workers that matter most to the formal sector and our results indicate that they may not have much relevance for the informal sector as such.

6. Conclusions

In contrast to previous studies that have examined the effects of trade and market structure on productivity growth in industry, in this study, we examine the role of human capital as captured by literacy rate in influencing sectoral productivity. Our empirical context is Indian manufacturing, and we examine whether the variation in TFPG for the same set of industries across Indian states and over time can be related to variations in literacy levels across these states. We compute period average adult literacy rates for 15 Indian States over the period 1994-2005 and determine whether variations in literacy rates both across States and over time can explain total factor productivity growth in Indian manufacturing, independent of variables that capture trade open-ness and market structure across disaggregated Indian industries. A key feature of the present paper is the use of unit level data for both formal and informal manufacturing sector.

The study employs a Cobb-Douglas production function to estimate TFPG for nearly 90 industries for 15 major States in India for formal, informal and combined sectors using four-digit level data. To correct the endogeneity bias associated with the production function estimation, we use a method recently developed by Levinsohn and Petrin. The TFPG estimates as obtained from the production function are then used to see the effect of literacy.

TFP grew steadily in the formal manufacturing sector while reported a decline in the informal manufacturing sector. The results indicate that literacy has positively affected the TFP growth of Indian industry. To see how duality between the formal and informal sectors affects the influence of literacy variable, the estimates are carried out for formal and informal manufacturing sector separately. Literacy is found to have no effect on the TFPG of informal sectors. The coefficient of literacy variable for the formal manufacturing sector is not only significant in all the variants but significantly higher than that of the coefficient for the informal manufacturing sector. We also find that our results are robust to alternate specifications and to possible endogeneity concerns to do with the literacy measure. Our results suggest that independent of policy measures that bring out trade openness and greater competition, there is a need to attract a better educated workforce into the sector so as to bring about sustained increases in productivity and consequently in standards of living.

One possible extension of the present paper is to carry out analysis separately for the three categories of informal sector units – OAMEs, NDMEs and DMEs. This is because the human capital may be more relevant for DMEs which are in direct competition with small formal sector firms

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