Determinants of Inter-state Differences in Industrial Labour Productivity: Exploring the Role of Innovative Efforts

Savita Bhat

1 Introduction

Economic growth and development is a well-researched topic in the area of economics. Theories have been proposed that have incorporated technology or innovation as one of the factors that can stimulate economic growth. According to Verspagen (2005), during 1980s and 1990s, there emerged two dominant approaches to the analysis of the relationship between technology and growth, namely, neoclassical (e.g. Solow 1956; Grossman and Helpman 1994) and new-Schumpeterian or evolutionary theory (e.g. Nelson and Winter 1982). In a recent work Howitt (2000) proposes a multicountry Schumpeterian growth model where productivity differences due to research and development (R&D) explain cross-country income differences.

These growth models have led to several empirical studies in the context of both developed and developing countries that have tried to understand the factors that affect economic growth (Akçomak and ter Weel 2009; Banerjee and Roy 2014). Many of these studies have specially considered the issue of convergence in economic growth (see Verspagen 2005 for details). In the context of India, recent empirical studies on economic growth and development have invariably adopted variants of the standard growth model over time series data to study factors leading to convergence or divergence amongst states or districts (see Purohit 2008 for details; Agarwalla and Pangotra 2011). In a recent article, Bhat and Siddharthan (2013) observe that there is skill bias in the current technological revolution where employment and productivity grow faster in states that are better endowed in terms of human capital. However, in the presence of inter-state migration in India (Chandrasekhar and Sharma 2014), there is a possibility that high skill labour move from one state to another and contribute to income generation in latter states.

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In the light of the above facts, this paper attempts to investigate the factors that explain inter-state differences in industrial labour productivity for India based on more recent panel data. In particular, the paper tries to understand the role of innovative efforts, defined in terms of patent applications filed, in explaining the inter-state differences in the industrial output per worker in India.[1]

2 Literature Review

The well-established Cobb-Douglas production function, output can be considered as a function of labour and capital. Several researchers have tried to extend this basic production function model to explore and emphasize the role of other factors in determining economic growth. In the Solow-Swan model technological progress is the additional factor and in Mankiw-Romer-Weil model human capital is the additional factor (for details see Oosterbaan et al. 2000). The following sub-sections review the literature that explains how innovation and human capital can affect output in an economy.

2.1 Innovation and Productivity

Economic theories have given importance to the role of innovation in explaining economic growth and development (Grossman and Helpman 1994). The proponents of innovation systems approach attempt to understand how innovation affects economic development at national level (Lundvall 1992; Nelson 1993; Freeman 1995) and regional level (Cooke et al. 1997). They emphasize the role of institutions and interactions in promoting innovation led development. Regional innovation networks lead to economic development as they make firms more competitive to provide higher wages and pay more taxes (Rutten and Boekema 2007).

Empirical studies in the context of developed countries have suggested a strong influence of technology development or innovation on economic growth and development (Ogburn and Allen 1959; Akçomak and ter Weel 2009). In a recent empirical study, Lin (2015) found that firms with headquarters near a knowledge centre are likely to enjoy better stock market valuation and growth. Whether a similar relationship holds true between innovative efforts and industrial labour productivity at state level needs to be explored in the context of India.

[1]The paper follows Bhat and Siddharthan (2013, p. 14) to propose that labour productivity is a function of choice of technology, that is, capital-labour ratio and other variables.

2.2 Human Capital and Productivity

Human capital is considered to be one of the important factors for economic growth and development (Barro 1991, 2001) as it can directly increase labour efficiency (Banerjee and Roy 2014). Education and health are considered to be important aspects of human capital formation (Maitra and Mukhopadhyay 2012). While education can provide returns that could be both monetary and non-monetary (Oketch 2006), health indicators like infant mortality rate can capture the general level of health, nutrition and wellbeing of the population (Bhat and Siddharthan 2013). Higher education indicators can also be used as a proxy for quality of labour or skill formation (Maiti and Mitra 2010).

Empirical studies in the context of developing countries have found a positive relationship between education and income inequality (Gregorio and Lee 2002; Paweenawat and McNown 2014). Studies have also found health expenditure (Maitra and Mukhopadhyay 2012) and health capital (Knowles and Owen 1995) to have positive effect on income.

Some recent studies have also explored the role of introduction of information and communication technology (ICT) in schools on residential adoption (Mo et al. 2013) and its spill-over effects outside schools (Tengtrakul and Peha 2013). The studies did find favourable effects of ICT in schools on skills of the students and on spill-over effects outside the school in terms of adults in the household using ICT.

3 Data, Sample and Descriptive Statistics

For the purpose of analysis secondary data has been collected from various publicly available government documents. Data for three consecutive financial years ending in 2011, 2012 and 2013 has been collected for 18 bigger states of India (excluding Delhi).[2] The details on the sources of data are in Appendix I. Suitable measures have been constructed to capture industrial labour productivity, industrial fixed capital to labour ratio, innovative efforts and human development. Table 1 gives the definitions of the variables. Innovative efforts are measured as number of ordinary patents filed at state level. Human capital is considered in terms of indicators of health and education. The health indicator considered is infant mortality rate (IMR).

Quality of education is captured using three different variables. One is the gross enrolment ratio in upper primary school (GER_UPP). This measure gives a general idea about the importance given to education beyond basic primary level by the people in the state. The second measure tries to measure the quality of elementary

[2]The Bigger States are identified as per the classification given in Sample Registration System (SRS) Bulletin September 2013. The Bigger States considered are Andhra Pradesh, Assam, Bihar, Chhattisgarh, Gujarat, Haryana, Jammu and Kashmir, Jharkhand, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Odisha, Punjab, Rajasthan, Tamil Nadu, Uttar Pradesh and West Bengal. In this study, Delhi is not considered although it is classified under Bigger States in SRS Bulletin 2013.

Table 1 Definitions of the variables

Sl.	Variables	Symbol	Definition
1.	Industrial labour productivity	ILP	Ratio of inflation adjusted value of industrial output in Rs. Lakhs to number of industrial workers in a given year in the state
2.	Industrial fixed capital labour ratio	IFCL	Ratio of inflation adjusted fixed capital in Rs. Lakhs to number of industrial workers in a given year in the state
3.	Innovative efforts	OPAT	Number of ordinary patent applications filed in a given year in the state
4.	Infant mortality rate	IMR	Number of deaths of infants below one year old per 1000 live births in a given year for the state
5.	Gross enrolment ratio at upper primary level	GER_UPP	Ratio of total enrolment in grades VI–VIII to the population in the age group 11–13 years in the state (in percentage terms)
6.	Elementary education infrastructure	EEI	Percentage of schools with electricity connection in a given year in the state
7.	Schools with computers	SCH_CMP	Percentage of schools with computers in the state

Table 2 Descriptive statistics (number of observations = 54)

Sl.	Variables	Mean	Standard deviation	Sl.	Variables	Mean	Standard deviation
1	ILP	33.80	11.09	5	GER_UPP	85.60	11.11
2	IFCL	13.58	10.83	6	EEI	53.40	35.77
3	OPAT	426.29	617.73	7	SCH_CMP	26.66	23.67
4	IMR	39.24	12.30				

education infrastructure in terms of the proxy variable percentage of schools with electricity connection (EEI). This indicator may also capture the general availability of electricity in the state. Electricity is used for various economic activities in both rural and urban areas. Availability of electricity can increase production activity late in the evening and sometimes beyond mid night. Third variable is percentage of schools with computer (SCH_CMP). This measures the amount of importance given by the state to computer based education in schools, which may be quite important in today's skill biased development (Bhat and Siddharthan 2013).

Table 2 gives the descriptive statistics for the sample. The mean value of industrial labour productivity for the large states during the period of study (2011–2013) was around Rs. 34 Lakhs per worker. During all three years, Gujarat had the highest industrial labour productivity at more than 56 Lakhs per worker. For the large states, the average investment on fixed capital per worker in the industries was around Rs. 14 Lakhs. Of all the states in the study, Orissa had the highest fixed capital investment per worker during all the three years (2011–2013). Kerala and Bihar were among the states with lowest fixed capital investment per worker during the study period.

With regards to the health indicator, the average infant mortality rate for the large states was around 39. During all the three years, Madhya Pradesh had the highest value and Kerala had the lowest value on IMR. In the bigger states of India, the average gross enrolment ratio at upper primary level (GER_UPP) is around 86 %. During all three years, Tamil Nadu has the highest and Bihar has the lowest GER_UPP measure among the sample states. Only around 53 % of the schools on an average have electricity connection. Punjab and Gujarat have been the leading states in term of EEI indicator with more than 97 % of the schools having electricity connection. Bihar and Jharkhand are at the other extreme with less than 12 % of schools having electricity connection. The mean of percentage of schools with computers (SCH_CMP) is low at only 27 % with less than 2 % schools in Bihar and more than 85 % of the schools in Kerala having computers.

In the case of variable representing innovative efforts, OPAT, that average number of patents filed by the large states during the last three years is around 426. However, the standard deviation is also high. More detailed information on number of patents filed in each state is presented in Fig. 1. As is clear, Maharashtra is the

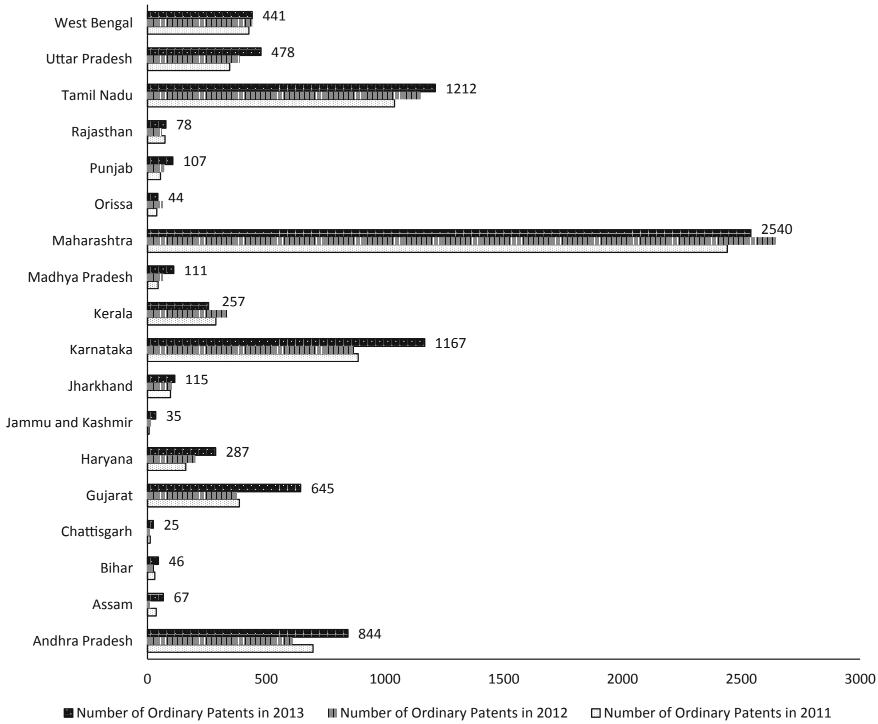

Fig. 1 Number of ordinary patents filed by the states during 2011–2013

leading state in terms of number of ordinary patents filed with around 2540 ordinary patents during 2013. During the same year, Tamil Nadu and Karnataka each account for 1212 and 1167 ordinary patents, respectively. Karnataka has many of the leading information technology companies like Samsung, Infosys and Wipro that are active in terms of filing patents. The states of Chattisgarh and Jammu and Kashmir have least number of patents filed in the state.

4 Econometric Models and Analysis

The data is a balanced panel data consisting of 18 states and 3 years. Hence, panel data regression model has been used for the analysis. Following Baltagi (2005), the econometric model is specified as follows:

$$y_{it} = \alpha + X'_{it}\beta + u_{it}$$

where y is the explained variable, namely, industrial labour productivity (ILP) and X is the vector of relevant explanatory variables from Table 1. The value of i ranges from 1, …, 18 (representing the states) and t takes the value 1–3 (for the years, 2011, 2012 and 2013 respectively). α is a scalar, β is coefficient on the explanatory variables and u is the stochastic error. Hausman specification test (Baltagi 2005) is used to choose between fixed and random effects model. Statistical analysis has been carried out in STATA version 10 statistical package. The coefficients of the explanatory variables representing innovative efforts (OPAT), capital (IFCL) and education related indicators (GER_UPP, EEI, SCH_CMP) are expected to have positive signs. The coefficient on the health indicator (IMR) is expected to have a negative sign.

Table 3 presents the correlation matrix for the variables used in this study. Industrial capital to labour ratio is correlated to industrial labour productivity. Variable representing innovative efforts (OPAT) is correlated to the human capital indicators. However, the correlation coefficient is less than 0.5. The health variable

Table 3 Correlation matrix

	ILP	IFCL	OPAT	IMR	GER_UPP	EEI	SCH_CMP
ILP	1.00						
IFCL	0.51*	1.00					
OPAT	0.19	−0.09	1.00				
IMR	0.15	0.35*	−0.49*	1.00			
GER_UPP	0.05	−0.04	0.32	−0.53*	1.00		
EEI	−0.02	−0.28	0.47*	−0.63*	0.51*	1.00	
SCH_CMP	−0.05	−0.30	0.35*	−0.77*	0.55*	0.83*	1.00

*Indicates statistical significance at 1 % level

Table 4 Determinants of inter-state differences in industrial labour productivity (ILP)

Regressors	Model 1	Model 2[a]	Model 3[a]	Model 4	Model 5	Model 6	Model 7
Constant	26.77 (9.33)*	31.79 (5.20)*	26.94 (7.12)*	24.90 (7.67)*	25.64 (7.91)*	31.56 (4.08)*	38.99 (6.18)*
IFCL	0.32 (3.64) *	0.32 (3.64)*	0.32 (3.59)*	0.31 (3.65)*	0.32 (3.65)*	0.30 (3.38)*	0.29 (3.21)*
OPAT	0.01 (2.16) **	0.01 (2.23)**	0.01 (2.01)**	0.005 (1.41)	–	0.005 (1.55)	–
IMR	–	–	–	–	–	−0.11 (−0.67)	−0.23 (−1.68) ***
GER_UPP	–	−0.06 (−0.93)	–	–	–	–	–
EEI	–	–	−0.004 (−0.07)	–	–	–	–
SCH_CMP	–	–	–	0.1 (1.35)	0.14 (2.15)**	–	–
No. of Obs.	54	54	54	54	54	54	54
Wald-Chi^2	18.30*	19.14*	17.97*	20.48*	18.14*	18.61*	15.88*

All the econometric models are random effects based on Hausman test. z-statistics is in parenthesis
[a]Even in the absence of OPAT, coefficients of GER_UPP and EEI are statistically insignificant in determining ILP
*, **, ***Represent statistical significance at 1, 5 and 10 % respectively

IMR is correlated to industrial fixed capital-labour ratio and has a high correlation coefficient of above 0.5 with all the three education related variables.

Table 4 presents the results for the econometric models with various combinations of the explanatory variables. As expected, fixed capital to labour ratio is statistically significant in determining industrial output in all the seven econometric models. Thus, higher amounts of investments on fixed capital like modern plants and machinery can improve industrial worker's output.

The variable representing innovative efforts (OPAT) is statistically significant with a positive sign in Model 1. Thus, higher innovative efforts by the firms and researchers in the state do imply better labour productivity of industrial workers in the states. In this study, the large states with higher values on patents happen to be Maharashtra, Tamil Nadu and Karnataka. In the light of the innovation systems approach, there is evidence that states like Maharashtra do have institutions that support small and medium enterprises (SMEs) in terms of funding, helping in filing patents and even building intellectual property (FICCI 2012). Often there can be spill-over effects of innovative activities in the region.

Even in the presence of education based variables like GER_UPP (Model 2) and EEI (Model 3), the variable representing innovative efforts is statistically significant in determining labour productivity of the industries. However, in the presence of

SCH_CMP (Model 4) and IMR (Model 6), the variable loses its statistical significance. This may be due to the presence of correlation between OPAT and the other two variables.

In the absence of OPAT, of the three indicators related to education, only SCH_CMP is important in determining inter-state differences in industrial output (Model 5). When the school children are exposed to latest technologies like computer, their skills improve. The households of these children also get exposed to computer and other latest technologies including information and communication technologies. This in turn may help them bring in efficiencies in their work and also make more informed decisions with regards to economic activities. Furthermore, familiarity with internet makes children motivated for higher education and better employment.

Again, in the absence of OPAT, the health indicator IMR is statistically significant with expected sign (Model 7). A healthy population in general implies more productive labour and hence higher industrial output in the state.

5 Conclusion and Implications

This study tried to understand the factors responsible for inter-state differences in industrial labour productivity in India. The study specifically explored the role of innovative efforts, in terms of patent applications filed, in determining the differences in industrial output per worker for the bigger states in India. In line with the theory on production function, this study empirically confirmed that choice of technology in terms of capital-labour ratio is important in determining industrial labour productivity. After accounting for capital, innovative efforts are also important in determining inter-state differences in industrial labour productivity. Thus, one can further explore the role of strong institutions and networks in promoting innovative efforts by organizations in the state, which ultimately can lead to higher industrial output per worker in the state.

Human capital variables like IMR and percentage of schools with computers also determine industrial output per worker. Healthy and skilled workforce can contribute towards improved labour productivity (Bhat and Siddharthan 2013. In line with other studies carried out in context of other countries (Tengtrakul and Peha 2013), in India too, one can further explore the spill-over effects of introduction of computers in schools on the economic activities and decisions of the households, which ultimately will affect the economic development of the state.

Appendix I

Sources of data

Sl.	Measure	Source
1.	State-wise value of industrial output in Rs. Crore	Annual Survey of Industries
2.	State-wise fixed capital in Rs. Crore	Annual Survey of Industries
3.	State-wise number of workers	Annual Survey of Industries
4.	State-wise ordinary patent applications filed	Annual reports of The Office of the Controller General of Patents, Designs, Trademarks and Geographical Indications, Department of Industrial Policy and Promotion, Ministry of Commerce and Industry, Government of India
5.	State-wise infant mortality rate	Sample Registration System (SRS) Bulletins, Office of the Registrar General and Census Commissioner, Ministry of Home Affairs, Government of India
6.	State-wise gross enrolment ratio at upper primary level	District Information System for Education (DISE), National University of Educational Planning and Administration (NUEPA), New Delhi, India
7.	State-wise percentage of schools with electricity connection	District Information System for Education (DISE), National University of Educational Planning and Administration (NUEPA), New Delhi, India
8.	State-wise percentage of schools with computers	District Information System for Education (DISE), National University of Educational Planning and Administration (NUEPA), New Delhi, India
9.	Whole sale price index with 2004–05 = 100 as base	Office of Economic Adviser, Department of Industrial Policy and Promotion (DIPP), Ministry of Commerce and Industry, Government of India

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