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Productivity Differentials in Industries across Indian States

Dr. Kaushal Kumar[1]
Trishla Singh[2]

[1](Associate Professor, Department of Commerce, D.A.V. (P.G.) College, Dehradun)
[2](Masters in Economics, Delhi School of Economics, University of Delhi)

Abstract

The trajectory of productivity differential across states in India has been a subject of scrutiny and intense debates among industrial experts and advisors. Equally important has been the attempts to locate the proximate and ultimate sources of industrial productivity. The existing literature has paid significant attention to the role of physical infrastructure, social development and trade liberalization in productivity analysis. This paper in addition tries to examine the possible role of corruption and availability of credit to industry as key determinants of Total factor productivity. A panel data regression has been conducted across 15 Indian sates over 2006-2011 to capture the deviation in productivity due to differences in state environment. For productivity estimation the paper employs Data Envelopment analysis which has been used as a dependent variable in panel regression. The paper establishes corruption, credit to industry, length of state highways and public health expenditure as significant determinants of TFP for the underlying data.

Keywords: Total Factor Productivity, Diminishing Returns, Determinants of TFP, Indian states, Corruption.

Introduction

The paper estimates Total factor Productivity across 15 Indian States for period of 2006-2011 with the aim to identify key determinants that influence growth, hence identifying the direction in which institutional policy should be enacted. This period of study is considered because over the trend of I ndustrial growth significantly negative rates were observed in 2006 whereas peaks observed in 2011.
The 15 states considered in the study are: Andhra Pradesh, Assam, Bihar, Goa, Gujarat, Haryana Karnataka , Kerala, Madhya Pradesh , Maharashtra, Punjab, Rajasthan , Tamil Nadu, Uttar Pradesh and West Bengal. The choice of states creates a representative sample in terms of state size and industrial development.

Panel data regression is done as it allows to study productivity trend over states representing different environments overtime as the state evolves. This gives a holistic view in comparison to
cross-sectional or time series analysis. Evaluating the effectiveness of variables using cross-sectional samples typically suffers the disadvantage of not being able to capture overtime impact. In other words one does not simultaneously observe what happens to an individual unit when there are changes in its external environment overtime. Panel data contains information on both the inter temporal dynamics and the individuality of entities may allow one to control the effects of missing or unobserved variables.

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Plots of the data do not represent any known functional form and since Data Envelopment analysis is non-parametric i.e. it does not assume an underlying functional form the paper focuses on this analysis. DEA compares decision making units (DMUs) considering all resources used and services provided and identifies the most efficient units or best practice units and the inefficient units in which real efficiency improvements are possible. DEA results are most useful when there are multiple inputs and outputs. The paper arrives at the TFP estimates by using value of gross output of industries as the output and physical working capital and number of persons engaged in industry as inputs.

Corruption which is a major obstruction in smooth conduct of services , has also been found to impact productivity substantially. This variable has been captured by the number of economic offences reported across states in our data. Ease of credit availability leads to best possible allocation of funds by employing them into their most productive use. The paper captures credit to industry data to take account of funds availability for use in industrial purposes and proceeds to establish significant impact of this variable on Total factor Productivity. State Highway length , Telephone per 100 users and Power generated (in KW per hour) are representative of physical infrastructure .The analysis proceeds to confirm that differences across states with respect to physical infrastructure does significantly contribute to productivity differentials across states. Education and Health which act as proxy for social development are indicators of human capital efficiency which affect Total Factor productivity.

The paper is segregated into 6 sections: Section 2 covers data, section 3 covers methodology, section 4 covers preliminary analysis and section 5 covers results. Section 6 concludes the paper with main insights.

Literature Review

Majority of literature in this direction focuses on specific determinants of Production Efficiency other than inputs like social infrastructure, educational attainment, etc. Given that India's growth is efficiency driven, productivity analysis which helps to understand level of economic prosperity, standard of living and degree of competitiveness of a country or a region lies at the core of existing empirical studies.

While Webber, Boddy and Plumridge(2010) has tried to explain productivity gaps across 2 regions (Wales and UK). In papers such as this, in order to explain productivity concentration is focused on Infrastructural parameters like roads, power, health, education etc. However in the current realm productivity is influenced by social evil of corruption which has been completely missed out. Moreover availability of credit which is fundamental for growth of any industry. Moreover, Hall and Jones (1999) has discussed the effects of social infrastructure on productivity. Our paper extends the analysis of productivity determinants to factors beyond physical and social infrastructure which have been focal points thus far. Also work done in the direction is a cross country analysis –While one expects productivity differentials to differ across countries (Due to endowments as well as policy infrastructure).Our paper is a modification and improvement in the sense that it gives a cross- state analysis where intra-country disparities will be the focus. Moreover it is interesting to observe how within

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the bounds of one country productivity varies to a large extent when they share even the central government and a general constitutional environment.

Our paper has taken motivation from paper such as Tangdira et al which have used productivity using DEA to measure performance of firms in competitive markets. Our paper is an extension in the sense that it uses Malmquist index as a measure of Total Factor Productivity not only as a measure of performance but an an indicator of industry productivity which further is used to help identify imperative determinants of TFP which will be used to develop policy initiatives. Most of the work in the direction has identified the problems but our paper considers each problem supported at econometric and theoretical fronts as an opportunity to provide suggestive policy resolutions. These policy resolutions become the reason why such analysis is imperative.

Also Acemoglu et al(2006) find that at the early stages of development anti-competition policies targetedtowards increasing investment and adoption of existing technologies may be beneficial .But as the economies approach towards the technological frontiers, the economies are required to abandon anti-competition policies and embrace appropriate 'Institutions'. Our paper has taken the ideology forward and suggests necessary policy implications and institutional restructuring that needs to co-exist along with the enhancement of technology and input capacity expansion to foster productivity growth.

In order to focus on factors that have emerged as important factors for determining growth in the current economy and thus are not considered in theory so far articles from The Economics Journal, The Economic Times and The American Economic Review were shuffled.

Our paper is different from any analysis that has been explored so far in the sense that with cross-state analysis one considers the gaps within a nation with a common central authority and suggestive corrections that can be done fill this gap .Also the focus has been shifted not only away from inputs which have been considered since the development of traditional production theories but also from much of the work in the field which has concentrated on physical and social infrastructure that has been considered as necessary determinants of industrial productivity towards factors such as crimes reported under industrial firms and ease of credit which have become rolling parameters given the current economic situation of the country.

Data

The present study investigates productivity efficiency differences of states in India. Total Factor Productivity is constructed using working capital and number of persons engaged and Industry Output, the data for which has been extracted from Reserve Bank of India. The explanatory variables considered are: Physical Infrastructure (Road length, Telephone Availability, Power Generated), Social Infrastructure (Education, Health), ease of credit availability and corruption. The data for physical as well as social infrastructure has been taken from Niti Aayog .Credit to Industry which serves as a proxy for ease to credit is taken from Ministry of Finance. The data for corruption is taken from National Crime Records Bureau.

Social Infrastucture measured by health and education impact Human Capital formation.Human Capital formation is a parameter for measuring quality of labor as it tries to capture the efficient labor unit as it

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adds value to the labor by encompassing educational value. Higher skill level contributes to higher productivity and hence enhances the ability to produce a given level of output with lesser labor units or produce a higher level of output with given labor units.

Ease of credit availability relaxes financial constraints and hence helps easy procurement of loans through formal lending institutions which charge nominal interest on loans which reduces the cost of borrowing and promotes investment sentiments. This increases the inclusion rates of entrepreneurs who were earlier not able to produce due to credit constraints.

Crimes reported under economic offences have been used as a proxy for corruption. Corruption sands the wheels of economy and hinders the productivity potential of the economy by misallocation of resources by diverting them to less efficient purposes. This culminates in wastage of resources which could have been employed in more productive alternatives. It also has an overall negative impact on various Human Development Indices.

Infrastructure bottlenecks serve as friction to economic growth and productivity. Poor infrastructure is not conducive to investment environment as the true returns to investments are not realized leading to lower investments and hence lower productivity. The physical infrastructure is captured through road length, telephone density (per 100 users) and power generation (in KWH). Road length is measured by roads per 100 sq km and hence promotes easy transportation. Better transportation, communication and electricity availability create an environment for better utilization of resources. Public capital expenditure measures asset creation. Complementarity of public and private investment ensures higher public investment is accompanied by higher private investments which fosters overall economic growth.

Methodology

The paper conducts a panel regression across 15 states of India over the period 2006-2011, to capture the key determinants of productivity change. The paper proceeds in 2 steps, with step 1, measuring the TFP change and step 2 , analyzing the impact of the explanatory variables on TFP change as well as each of it's components, namely, efficiency change and technical change.

Step 1 deals with estimation of Total Factor productivity, which is the dependent variable of the regression analysis. The estimation is conducted by invoking the non parametric approach of DEA methodology to arrive at the estimate of Malmquist index. The measure of productivity growth is taken from Fare et al, which defines TFP as the geometric mean of two Malmquist productivity indices. The technique allows decomposition of TFP growth into two mutually exclusive and exhaustive components, namely, efficiency change(changes in technical efficiency) and technical change (shifts in technology over time). Improvements in EC component is considered up to the frontier, while improvement in TC is considered as evidence of innovation. DEA is advantageous over SFA as it does not impose any arbitrary functional form and it allows to use multiple input and output technologies.

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There are two methods to estimate efficiency, namely, parametric methods (Stochastic Frontier Approach of Aigner and Deterministic Approach of Aigner and Chu) and non-parametric methods (Data Envelopment Analysis described in Cooper and Rhodes). The relative merits of the alternative approaches are that the parametric approach can account for noise and allow conventional hypothesis tests to be conducted, while the non-parametric approach has the advantage of not requiring the arbitrary selection of a functional form of the production structure and distributional forms for the error terms and that it can easily account for multiple outputs. Under parametric estimation production possibility frontier is assumed to be known and hence the required distances maybe calculated. In reality, the production surface is unknown and must be estimated in some way.

The DEA model adopted in the paper, has an output orientation and supposed that there are constant returns to scale. The constant returns to scale have been assumed as, under non constant returns to scale as suggested by Grifell- Datje and Lowell , the Malmquist index does not accurately measure productivity change. The output orientation has been used as input and output orientations are equivalent under CRS. This methodology seeks to establish which state of a sample determines the envelopment surface or efficient production frontier. The radial distance of a state from the frontier provides the measurement of its efficiency. DEA Methodology is applied to the unitary evaluation of homogeneous units or states. The evaluation unit which is normally known as Data Management Unit is what transforms the inputs into outputs. This is why its identification in any study is a difficult and crucial aspect. According to the DEA the productive efficiency of a state is evaluated on an efficient frontier which is built by the linear combination of the existing states with respect to utilization of their inputs to produce given level of output

Step 2 studies the impact of the various explanatory variables discussed in the data, both overall and component wise. The regression of Malmquist Index, Technical change and Efficiency change on key explanatory variables is performed and results have been analyzed subsequently.

The paper identifies the problem of multicollinearity by conducting auxiliary regressions, which is a possible shortcoming of the paper which might be the reason why some of the variables are turning out to be insignificant. But since multi collinearity is a data specific problem, it could not act as a sufficient enough reason to drop the variables.

In this paper, DEA technique has been used to arrive at the productivity estimates by using the CCR input oriented model with constant returns to scale using Industry output as the output and Total persons engaged and Total working capital as inputs. This is then used as basis for studying the differences across state owing to differences in policy environments. Hence Panel Regression has been conducted under the following formulation:

$$TFP\_Change_{it} = \beta_0 + \beta_1(ROADS_{it}) + \beta_2(POWER_{it}) + \beta_3(TELE100_{it}) + \beta_4(CORRUPTION_{it}) + \beta_5(CREDIT_{it}) + \beta_6(HEALTH_{it}) + \beta_7(\ln EDUC_{it}) + u_{it}$$

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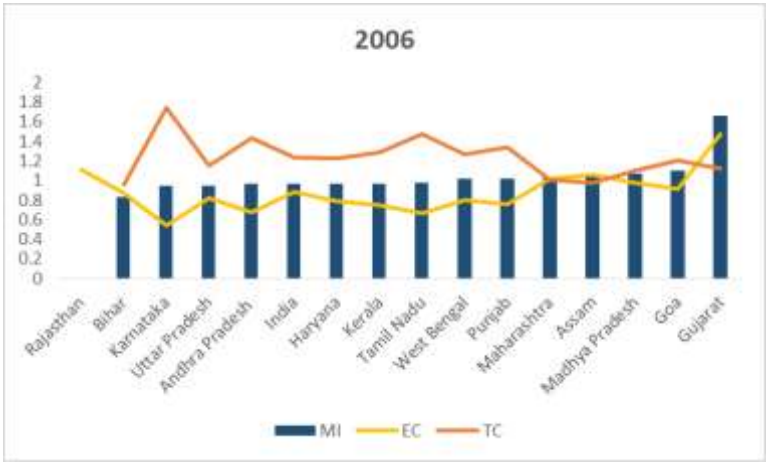
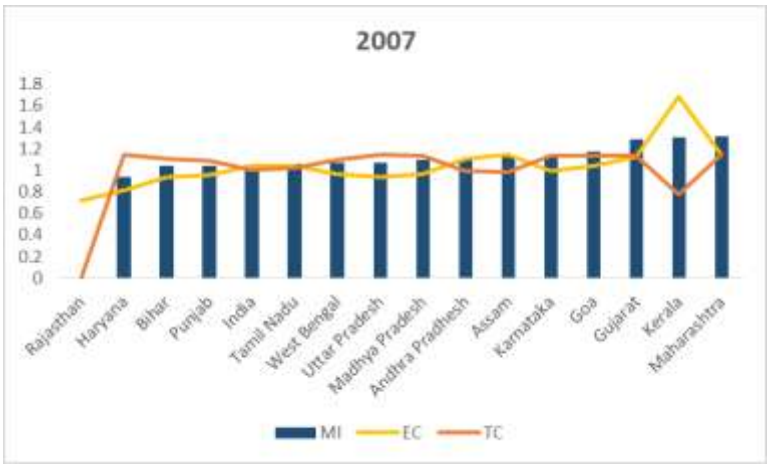
Log of education is taken to reduce the scale and variation.

Preliminary Analysis



We observe an all India relative change in TFP by 0.969 units as we go from 2006-07. Further, bifurcating this value, we observe an Efficiency score is declining (EC=0.882) which might be pulling down TFP index despite a positive shift frontier (TC=1.235). The best performing state in this period is Gujarat with the highest improvement in productivity (MI=1.656), owing to the fact that it experiences a significant improvement in both efficiency (EC=1.476) and technical (TC=1.122) parameters. On the contrary, Bihar shows the lowest performance (MI=0.833) because a dip in both efficiency (EC=0.872) and technical(0.955) scores.



On an all India level, we see an improvement in productivity from 2007 to 2008 (MI = 1.05) with positive changes in both efficiency (EC= 1.039) and technical (TC= 1.004) parameters. Maharashtra, with the best performance (MI= 1.317) shows a similar pattern, with both EC and TC being greater than 1.

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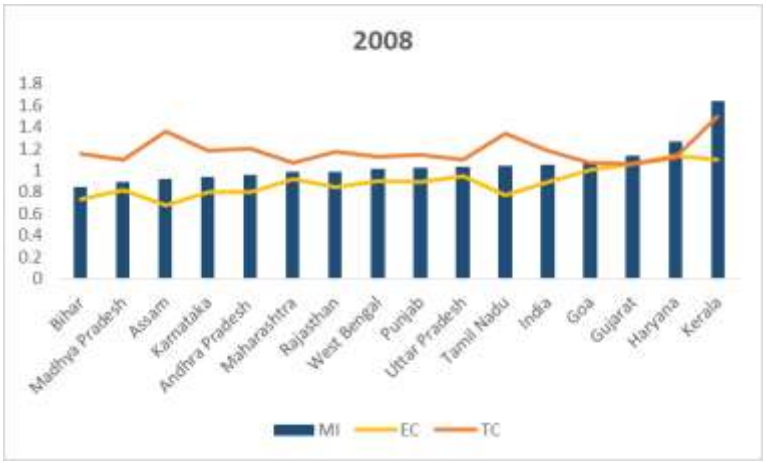
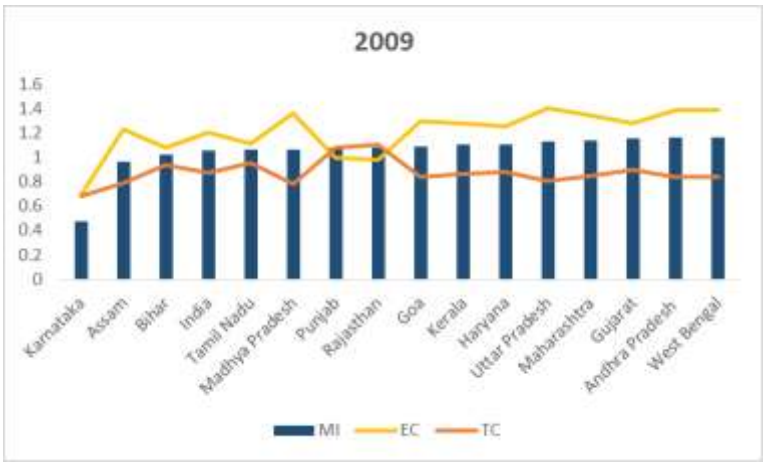
However, Haryana witness a fall in relative efficiency index leading to the decline in productivity.



Just like the previous years, there is an improvement in efficiency as one moves from 2008 to 2009 (MI=1.05). However, only the shift in frontier (TC=1.178) is causing this increase since, the country actually witnesses a decline in efficiency (EC=0.894). The best performing state Kerala shows a relative increase in both components of TFP index (MI = 1.642). Bihar (MI=0.8445) as the worst performing state, though shows a positive shift in frontier but is characterized by a significant fall in efficiency.



Despite the poor performance shown by Karnataka (MI= 0.471), the aggregate productivity marks an improvement due to the performance of majority of the states with an MI greater than unity. The all India aggregate index is equal to 1.051 with the efficiency change (EC = 1.025) being the only reason for its improvement. Out of all the states, West Bengal is the star performer. Another feature of this period is the dip in TC in all the states, barring just two

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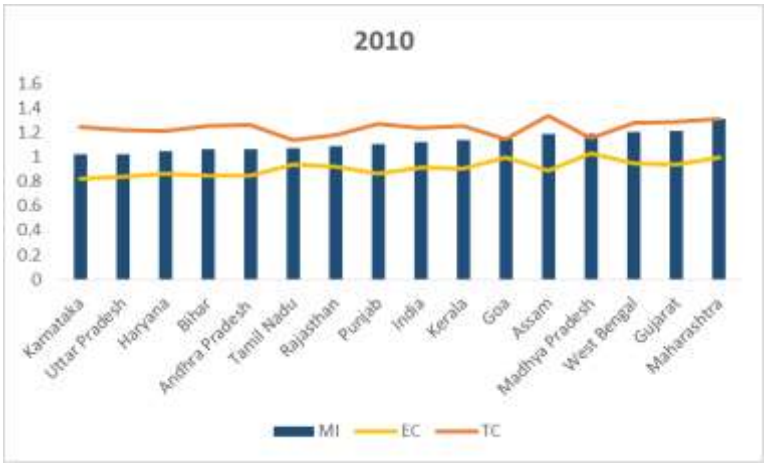

Improving upon the trends of 2009, 2010 witnesses increasing efficiency for all the states. Even the lowest performing state Karnataka has an MI of 1.02. All the states witnessed a positive shift in the frontier. In contrast, none of the states experienced increase in efficiency.

Results

VARIABLES	NATURE OF IMPACT
ROADS	POSITIVE AND SIGNIFICANT
POWER	INISGNIFICANT
TELE100	INSGINIFICANT
CORRUPTION	NEGATIVE AND SIGNIFICANT
CREDIT	POSITIVE AND SIGNIFICANT
HEALTH	POSITIVE AND SIGNIFICANT
EDUCATION	INSIGNIFICANT

Table 1 gives the results of the primary regression in which TFP obtained from the Data Envelopment Analysis Approach is regressed on Length of State Highways (ROADS), Electricity Generation in MWh (POWER), Telephones per 100 population (TELE100), Corruption captured by number of cases reported for Economic offences in states (CORRUP), Credit Extended to Industrial Sector (credit), Per capita Expenditure on Health by State (HEALTH) and Education captured by numbers of Gross Enrolment in undergrad program in the State.

Effects of Physical Infrastructure on TFP

ROADS, POWER and TELE100 reflects the quality of physical infrastructure of a state. Our regression results show that out of these 3 variables, ROADS has a positive sign and is significant (5%). The coefficient shows that a 1 km increase in length of state highways leads to .0031941 units increase in TFP change. The coefficient has the anticipated sign and it implies that states with better roads and highways have higher efficiency of production.

However, TELE100, though with the correct signs as predicted by the theory, turns out to be insignificant. POWER also does not come out as a significant variable in explaining the results.

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Effects of Social Infrastructure on TFP

Education and Health are two of the most important metrics of Social Infrastructure of State, responsible for augmenting Human Capital. HEALTH positively impacts TFP as can be seen by table 1, with every one unit increase in per capita expenditure on Health by States, translating into .00029 units increase in TFP change. Though with a positive sign, the impact of education turns out to be insignificant, possibly because of poor quality of educational institutions and high drop-out rates.

Effect of Financial Infrastructure on TFP

The credit extended to industries acts as a proxy for the access to financial services. As expected, the sign of the variable is positive and significant at 5%. One unit increase in Credit to Industries results in a rise in TFP by .00000856 units. This signifies that a more integrated and developed financial infrastructure of state gives boost to industrial productivity.

Effect of Corruption on TFP

According to the previous literature, Corruption has two contradictory impacts on economic growth, "Grease the Wheels" or "Sand the Wheels". Our regression analysis supports the hypothesis that corruption acts as a barrier to economic growth and productivity. We see a negative sign, which is highly significant implying that rather than removing impediments to production process, Corruption acts as a bottleneck hampering productivity. The data shows that if there is a one unit increase in the number of cases reported against corrupt practices, it would negatively impact TFP by (-.000568).

The overall regression gives an R^2 of 0.5684, thus nearly 57% of the variation in productivity across states is explained by the differentials in the various parameters considered in the paper to explain productive efficiency.

Now, we look at the results from the regression of the two components of TFP on the explanatory variables.

VARIABLES	**NATURE OF IMPACT**
ROADS	INSIGNIFICANT
POWER	POSITIVE AND SIGNIFICANT
TELE100	INSGINIFICANT
CORRUPTION	NEGATIVE AND SIGNIFICANT
CREDIT	INSIGNIFICANT
HEALTH	POSITIVE AND SIGNIFICANT
EDUCATION	INSIGNIFICANT

The regression shows he the positive and significant effect of Health on efficiency change symbolizes that the lesser the expenditure on health made by the state, the more likely it is that individuals are vulnerable to diseases but if these affected individuals continue to participate in the labor force, the productivity will be severely impaired.

The positive and significant impact of power shows that higher energy promotes more effective use of equipments and machines to produce more goods at a faster pace.

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Corruption again comes with a negative and significant impact on EC as effort levels of public servants suffer from adverse incentives as they try to create artificial bottlenecks that can increase the need for paying speed money to facilitate smooth conduct of operations.

VARIABLES	**NATURE OF IMPACT**
ROADS	POSITIVE AND SIGNIFICANT
POWER	INSIGNIFICANT
TELE100	POSITIVE AND SIGNIFICANT
CORRUPTION	NEGATIVE AND SIGNIFICANT
CREDIT	POSITIVE AND SIGNIFICANT
HEALTH	INSIGNIFICANT
EDUCATION	INSIGNIFICANT

The positive and significant impact of credit on technical change can be understood in the light of the fact capital can be raised for enhancing labor productivity but TFP remains unaltered if that capital stock is not directed for improvement in innovation and technical development.

The positive sign on roads and telephone highlight the importance of physical infrastructure as a pre requisite to improve technical innovations. Hence improving connectivity through better transport and communication is a stimulator of productivity.

Corruption, with its negative sign, proves that new innovation incentives can be hurt as corruption leads to higher cost of engaging in innovation by undue grant of patent and quality certificates to the less deserving parties.

Conclusion

The paper successfully identified key determinants that influence TFP-Corruption, Roads as a measure of physical infrastructure, Health as a measure of social infrastructure and Financial Credit availability turned out to be significant. This paper concludes with suggestions for possible policy interventions for enhancing productive efficiency. Corruption proved to sand the wheels of the economy and hence it becomes imperative to take measures to curb it. This can be achieved by creating transparency and increasing accountability by regular auditing. Several steps have been taken by government in this direction by becoming a member of **Society for Worldwide Interbank Financial Telecommunication** (SWIFT) that enables financial institutions worldwide to send a receive information about financial transactions in a secure, standardized and reliable environment. Red Tapism is yet another issue which provides an opportunity for bureaucrats to expropriate individuals during the course of registry of property and obtaining other certificates and licenses.

Health, as expected apriori, turns out to be a significant explanatory variable of productivity. Hence, measures must be taken to increase access to medical facilities, especially public health services. The current level of government spending on Health as a proportion of GDP is a little over 1%, which is highly inadequate given the mass of population in India. Current policies, namely**, AYUSHMAN BHARAT** which aims to provide health insurance cover to over 10 crore poor family with an annual health cover of Rs 5 lakh per family. Tamil Nadu and Kerala too have shown exemplary performance by

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effective implementation of the **ICDS (Integrated Child Development Scheme)** by strengthening public institutions both at primary and secondary level. The aim of the health policies devised by the government should not solely concentrate on treatment line, but rather focus on building an environment conducive to healthy lifestyle and overall nourishment.

Roads which capture physical infrastructure point out to its importance in nation building and production process. Increased Roads implies better connectivity to transport inputs outputs between markets and production units. Investment in physical infrastructure creates sentiments to promote further investments by private sector. Public sector should consider it as its responsibility to ensure provision of appropriate finance for construction related project fetching lagged returns. Though, Power generation turned out to be insignificant for our data but several contemporaries have proposed its importance in enhancing productivity and so electricity generation must be improved.

Ease of credit availability served as an important explanatory variable for productivity. Also, steps have been taken in this direction to increase the provision of credit to Medium and Small Industries by the on-going **Mudra Loan Scheme.**

Thus, positive steps in this direction are expected to enhance productivity across states in India, thereby giving a boost to the economy ensuring long term growth.

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