



International Journal of Applied Business and Economic Research

ISSN : 0972-7302

available at <http://www.serialsjournal.com>

© Serials Publications Pvt. Ltd.

Volume 15 • Number 17 (Part-II) • 2017

Analysis of Infrastructure, Economic Inequality & Growth for Indian States Using Data Envelopment Analysis and Identify Broad Reasons for their Present Status

JK Sharma¹, Revti Raman² and Skandh K Tyagi³

¹ Professor, Director-ASB, Amity University Uttar Pradesh

² Research Scholar, ABS, Amity University Uttar Pradesh

³ NTPC Ltd.

Abstract: The economic reforms process started in a systematic way in India in 1991. India's economic performance has considerably improved when we look back for the last 25 years (1991 to 2016) for indicators such as GDP, per capita income, per capita electricity consumption. India is a big country with a population of around 121 crore as per 2011 census. In this diverse country, although the country as a whole has shown quite good progress but has it really touched every Indian in the same proportion. The economic benefits of the boom was spread but it was very uneven. There can be many socio-economic factors which are leading this uneven distribution of growth. In this paper, study is conducted for 10 states on the basis of Availability of power, Economic inequality and growth of the state to find the comparative growth. Data Envelopment Analysis (DEA) which is a non-parametric method and used to find efficiency of systems is being used in this paper to measure the relative position of states in terms of defined factors as Infrastructure, Economic inequality and Growth. The data for the study is collected in terms of GDP, power development and inequality (Gini).

Key Words: Ginni Coefficient, DEA, Self-efficiency, Cross efficiency

INTRODUCTION

India is a vast country with population of 121 crore (census 2011) which is 2nd highest in the world. The country is 7th largest in area (3287263 sq. kilometers). It is most populous democracy in the world. In 2015, Indian economy was 7th largest in terms of nominal GDP and 3rd largest in terms of Purchasing power parity. Market based economic reforms started in 1991 and it became one of the fastest growing economies. India is a federal constitutional structure governed under the parliamentary systems. The country consists

of 29 states and 7 union territory. The Prime Minister of India, the chief of government, chief adviser to the President of India, head of the Council of Ministers and the leader of the majority party in the parliament. The prime minister leads the executive branch of the Government of India. The State Government rule states of India and Chief Minister is the head of state. Power is divided between Union and State Government. The Union Government has 100 items such as Defense, Post and telegraph, Telephone, railways, Foreign affairs, currency, banking, income tax, custom duty etc under its control. The state Govt. has 66 departments such as police, law and order, education, electricity, health care, transport etc under its control. There is a concurrent list that has 52 items such as marriage, civil, economic planning, education etc. With this kind of distribution of power there is a huge demarcation between the states in terms of Growth, Infrastructure development and living standard of its people and inequality that exists within. These factors were the main motivation for a paper of this nature.

Infrastructure defines itself as the basic physical and organizational structures and facilities (e.g. buildings, roads, power supplies) needed for the operation of a society or enterprise. India needs Rs 31 trillion (US\$ 454.83 billion) to be spent on infrastructure development over the next five years, with 70 per cent of funds needed for power, roads and urban infrastructure segments. Growth defines itself as the process of increasing in size and economic growth is an increase in the amount of goods and services produced per head of the population over a period of time. India is projected to grow by 7.7 per cent in fiscal 2017, remaining the fastest growing large developing economy, as it benefits from strong private consumption and gradual introduction of significant domestic reforms, a United Nations report said. The report said India has positioned itself as the most dynamic emerging economy among the largest countries and is expected to remain the fastest growing on the back of robust private consumption and significant domestic reforms gradually being implemented by the government.

Hence, Infrastructure and Growth becomes the pivotal parameters that will become most significant but its reach and distribution is the topic of contention.

Since Independence our country has progressed slowly. Most of the manufacturing, banking etc were Government controlled and private participation was not much. India was a latecomer to the economic reforms, embarking on the process in earnest only in 1991, in the wake of an exceptionally severe balance of payments crisis Ahluwalia [1]. India opened its economy to market forces, inviting foreign direct investment and increasing participation of private sector. India's economic performance has increased and when we the look for the last 25 years (1991 to 2016) for some of the indicators, we find the following-

- a) The GDP has grown from US \$ 274.8 billion to 2073.54 Billion (2015)
- b) The GDP per Capita (Nominal) rose from US \$ 310.08 to US \$ 1805.57
- c) Per capita income from Rs 11535 to Rs 93293
- d) The per capita electricity consumption from 253 kwh to 1081 kwh

In this diverse country, although the country as a whole has shown quite good progress as per the figures at a) to d) but has it really touched every state in the same proportion. The per capita consumption has although increased to 1081 kwh but if we see state wise, the per capita power consumption ranges between 203 to 2175 kwh. The economic benefits of the boom were spread but it is very uneven Petcu [2]. There can be many socio-economic factors which are leading this uneven distribution of growth.

The study in this paper is for comparing different states (10 nos.) for the following factors-

<i>SlNo</i>	<i>Factor</i>	<i>Parameter</i>
1	Infrastructure	Electricity, Roads
2	Economic Inequality	Education, Gini Coefficient
3	Growth	Industrial output

METHODOLOGY

Each state has its own State Government, although all the states are governed by similar rules/laws framed by Union Government. If we want to compare these states it becomes very difficult as each state has its pluses and minuses. Some states are very good in terms of education and some are having high GDP. For comparison we have a no. of inputs and outputs. For this study 10 states are considered (2 states each from East (Bihar, West Bengal), West (Maharashtra, Gujarat), North (Uttar Pradesh, Punjab) and South (Tamil Nadu, Karnataka) of India, one state from Central India (Madhya Pradesh) and one from North-East (Assam) part of the country.

For this study, we selected three main factors- Infrastructure, Economic inequality and growth. For measuring the efficiency of states 5 inputs from the three factors and 1 output is considered. Normal practice for measuring the efficiency was least square regression analysis but in recent times Frontier method such as Data Envelopment Analysis (DEA) can be used.

DATA ENVELOPMENT ANALYSIS

The concept of DEA was first introduced by Farrel in 1957. The recent development in DEA were started by an article by Charnes et al (1978). Further study on DEA was given by Norman and Stoker in 1991.

The paper Somogyi [12] and Chander V & Prabakaran [14] mentions that Data Envelopment Analysis is a nonparametric method used in operations research. It is a decision making tool based [13] on linear programming to measure relative efficiency of comparable units. Apart from identifying efficient and inefficient units, DEA also identifies sources and level of inefficiencies for each of inputs and outputs. DEA is an established method to compare performance of a no. of similar units. The individual units for which comparison is required are known as Decision Making Units (DMUs). The comparison can be done for different type of establishments such as banks, schools, universities, states in a country etc. The performance of DMUs is assessed by using the concept of efficiency Cooper et al [3] which is a ratio of output to input.

$$\text{Efficiency} = (\text{Output}) / (\text{Input})$$

The mathematical techniques for solving the problem by DEA were introduced by Charnes et al in 1978. We assume that there are i inputs and j output, then inputs can be denoted by x_i and output as y_j where $i, j > 0$. In DEA multiple inputs and outputs are linearly aggregated by using weights and virtual input Emrouznejad et al [11] is expressed as –

$$\text{Virtual input} = \sum_{i=1}^i u x_i$$

In this u is the weight assigned to x input during the aggregation.

Similarly, for output virtual out is calculated as-

$$\text{Virtual output} = \sum_{j=1}^j v_j y_j$$

The v are the weight for output y . The efficiency for DMU is given as –

$$\text{Efficiency} = \text{Virtual output} / \text{Virtual input}$$

The typical issue for DEA is assigning of weights, these weights are not static but calculated by linear programming. The weights of a DMU are such calculated that these will maximize its efficiency subject to the condition that efficiencies of other DMUs is kept between 0 and 1. The DMU whose efficiency is maximized is termed as Reference DMU.

These are Fractional DEA program but it is difficult to solve in this form so these fractional DEA programs are converted into Linear programming equations. The models developed in this form are called CCR (Charnes, Cooper and Rhodes) models. The brief description of CCR model is –

Assuming, we want to develop a model for n DMUs having i inputs and j outputs then for a k^{th} DMU which is reference DMU, we have to maximize total output as –

$$\text{Maximize } Z = \sum_{j=1}^j u_k y_{kj}$$

Subject to following constraints-

$$\sum_{i=1}^i v_k x_{ki} = 1$$

$$\sum_{j=1}^j u_k y_{kj} - \sum_{i=1}^i v_k x_{ki} \leq 0$$

Based on the above LP equations, weights for input and output variables can be calculated for the reference DMU. In this weights for all the DMUs can be calculated.

Using these optimal weights of the reference DMU, cross efficiency of other DMUs can be ascertained. The idea of cross-efficiency approach Caklovic and Hunjak [6] is to evaluate the performance of one DMU with respect to the optimal input and optimal output weights of another DMU.

Cross Efficiency-

The paper Cook and Zhu [5] elaborates for cross-efficiency and says that the cross efficiency method was developed as a DEA extension to rank DMUs with the main idea being to use DEA to do peer evaluation, rather than to have it operate in a pure self-evaluation mode. There are mainly two advantages of the cross-evaluation method. It provides an ordering among DMUs, and it eliminates unrealistic weight schemes

The paper Zohrehbandian and Gavgani [4] mentions that if n DMUs, with i inputs and j outputs, the cross efficiency of m^{th} DMU with reference DMU as k , the value can be found out by –

$$\text{Cross efficiency} = \sum_{j=1}^j u_k y_{mj} / \sum_{i=1}^i v_k y_{mi}$$

If cross efficiency of the DMU is one then it is called as peer of the reference DMU. The DMUs can be ranked using the Peer count Chander V & Prabakaran [14]. The DMU with high Peer count is said to be more efficient than the DMU with the low peer count. In case of tie for the peer count, the DMU with higher self-efficiency will termed more efficient.

Infrastructure, Economic Inequality and Growth

In this we want to compare different Indian states based economic consideration. For this study, we have considered three main factors as inputs for the state-

a) Infrastructure-

In this paper, availability of power and roads are considered as parameters for infrastructure development. Power being the backbone of the industry and roads a means of transport of equipment, raw material and finished goods. The smooth availability of these inputs will attract investors in the state. It is said PWC [23] –

“The link between infrastructure and economic development is not a once and for all affair. It is a continuous process; and progress in development has to be preceded, accompanied, and followed by progress in infrastructure, if we are to fulfill our declared objectives of generating a self-accelerating process of economic development.”

Dr. V. K. R. V. Rao [noted Indian economist, early 1980s]

The power availability per capita retrieved from Kseoba.org [17] and roads per unit area retrieved from wikipedia.com [18] of the state are considered in the DEA model as input variable for Infrastructure main factor.

b) Economic Inequality-

In the paper Petcu [2], it is said that too many times the benefit of the growth goes to an elite group whereas the rest of people mainly in rural areas live in poverty. Although some degree of inequality will persist for growth of economy but extreme inequality is a concern as it will effect growth. The economic inequality is the cause of concern in the society. The inequality in a country like India tends to be associated with retrieved from nias.in [22] lower health achievements, high crime rate and bias on public policies and politics for higher/elitist class. There can be many reasons for economic inequality in the country but broadly retrieved from nias.in [22] emphasis of policies on capital and finances and neglect of labour, connect between growing profits and productive sectors .i.e. policies, gender equity, growth in technology and globalization. In India also inequality persists and it is said that 1% population has 58% wealth in the country. The inequality varies among states also. There are many drivers for income inequality and these can be different for different states.

Following are the major reasons for the inequality and some of these factors are inter- dependent.

- Wages in labour market
- Education
- Growth in technology
- Inheritance
- Globalization
- Policies incl. taxes
- Gender discrimination

These factors will affect the overall growth of the state as human capital is responsible for driving the economy of the state. For the purpose of study education index retrieved from pib.nic.in [19] and gini coefficient retrieved from knoema.com [20] are considered as the possible input variables.

c) Growth-

The growth of the state can be seen by many parameters such as agricultural, industrial, education, mining etc. In this paper, growth is measured by industrial development of the state. The industrial growth is measured by contribution of industrial output and manufacturing in overall GDP retrieved from statisticstimes.com [21] of the state. The parameter is based on per capita contribution in industrial output.

Data Collection

The data for the study is collected by published reports of Government agencies and public records. The power consumption is taken from state regulatory commissions. The road network is acquired through National Highway Authority of India. The education index is acquired from state government records. The state GDP and other data is incorporated from the Data book compiled for use of planning commission.

Analysis

In the study we have 10 DMUs having 5 inputs and one output. The LP equations are formed for each DMU for maximizing the efficiency by forming one objective function and 5 in equality constraints. The LPP is solved by using MATLAB software.

The analysis for the study is based on two phases. In the first phase, optimal weights for input and output variables for each DMU are determined. The self-efficiency of each DMU is found. In this study we found 4 DMUs with self-efficiency as 1.

The second phase of the problem is finding cross-efficiency of each reference DMU. The peers for reference states was found from the cross reference table.

Based on peer count and self-efficiency scores of the states, their relative position can be ascertained.

CONCLUSION

The 5 inputs (Power, roads, industrial output, inequality and education) and 1 output (GDP) are considered for ranking states using Data Envelopment Analysis study applying Linear programming methodology. The study shows top three states out of 10 states considered for the study are Maharashtra, Punjab and Gujarat. The data can be further analyzed by using Principal Component Analysis technique in which data is reduced to single input and single output.

ANNEXURES

Self-Efficiency

Sl No	State	IN1	IN2	IN3	IN4	IN5	OP1	self-efficiency
1	Uttar Pradesh	0	0	1	1	0.0263	0.0702	0.4
2	Punjab	0	0.0001	0.0139	0	0	0.0008	1
3	Gujarat	0	0.0001		0.0217	0	0.0008	1
4	Maharashtra	0.0007	0	0	0.0078	0.0082	0.0007	1
5	Madhya Pradesh	0	0	0	0.0046	0.0033	0.0011	0.79
6	Karnataka	0	0	0	0.0116	0.0012	0.0008	0.9
7	Tamil Nadu	0	0	0	0.0098	0.001	0.0007	0.95
8	Bihar	0.0023	0	0.0225	0	0	0.0026	0.52
9	West Bengal	0.0011	0.0002	0	0	0	0.0011	0.86
10	Assam	0.0045	0	0	0	0	0.0017	1

Cross-Efficiency

	Uttar Pradesh	Punjab	Gujarat	Maharashtra	Madhya Pradesh	Karnataka	Tamil Nadu	Bihar	West Bengal	Assam
Uttar Pradesh	0.4	0.737694299	0.72704869	0.856161304	0.525142687	0.688442701	0.747397865	0.403640937	0.68164263	0.491449564
Punjab	0.289835681	1	0.786749471	0.884393594	0.493627405	0.662780402	0.716182626	0.382587028	0.784582557	0.497847018
Gujarat	0.263810579	1	1	0.984484776	0.426831908	0.751817088	0.85710249	0.286998705	0.6483244	0.481878244
Maharashtra	0.183850924	0.140477807	0.108005593	1	0.176853027	0.161844491	0.147797287	0.255745478	0.225747277	0.231690203
Madhya Pradesh	0.762853531	0.643318906	0.482657706	0.664753383	0.79	0.703027103	0.643445854	0.967325967	0.96959501	0.918730504
Karnataka	0.626566102	0.861752891	0.743483778	0.945312524	0.745349499	0.9	0.903473563	0.635521586	0.949444717	0.820817704
Tamil Nadu	0.651704313	0.900050136	0.777777257	0.987976675	0.776176994	0.948622798	0.95	0.660152958	0.988783141	0.854240942
Bihar	0.673040131	0.65891675	0.617734323	1	0.738470408	0.826874336	0.824868137	0.52	0.99338271	0.991815009
West Bengal	0.308953502	0.697759117	0.564368877	0.840257733	0.482853367	0.673870367	0.673913403	0.494147545	0.86	0.817693531
Assam	0.52935573	0.312470847	0.291083953	0.551832357	0.43966334	0.479843893	0.452249819	1	0.602334251	1

REFERENCES

- Montek S. Ahluwalia, (2002). Economic Reforms in India Since 1991: Has Gradualism Worked?. Journal of Economic Perspectives.
- Claudia Petcu, (2014). Does Educational Inequality Explain Income Inequality Across Countries?
- WW Cooper, LM Seiford, K Tone, (2007). Data Envelopment Analysis – A comprehensive text with Models, Applications and software.
- M. Zohrebandian and S. Sadeghi Gavgani. (2013). Cross-efficiency Evaluation under the Principle of Rank Priority of DMUs. World Applied Sciences Journal 21.
- Wade D. Cook and Joe Zhu . (2015) DEA Cross reference, Chapter 2. Science and Business Media.
- Lavoslav Caklovic, Tihomir Hunjak. (2012). Measuring DMU-efficiency by modified cross-efficiency approach, Mathematical Communications.
- Nathan Proudlove. (2000). Using Excel for Basic Data Envelopment Analysis, Working Paper.
- Milan M. Martić, Marina S. Novaković, Alenka Baggia. (2009). Data Envelopment Analysis – Basic Models and their Utilization. Organizacija, Volume 42.

- Jill Johnes (2006). Data envelopment analysis and its application to the measurement of efficiency in higher education. *Economics of Journal Review*.
- Timothy R. Anderson, Akin Uslu. (1997). Selecting the “Best” Using Data Envelopment Analysis, 1997 Proceedings of PICMET '97: Innovation in Technology Management.
- Ali Emrouznejad, Rajiv Banker, Heinz Ahn, Mohsen Afsharian. (2015). Data Envelopment Analysis and its Applications, Proceedings of the 13th International Conference on Data Envelopment Analysis.
- Rita Markovits-Somogyi. (2011). Ranking Efficient and Inefficient Decision Making Units in Data Envelopment Analysis, *International Journal for Traffic and Transport Engineering*.
- Nicole Adler, Lea Friedman, Zilla Sinuany-Stern. (2002). Review of ranking methods in the data envelopment analysis context, *European Journal of Operational Research*.
- Chandar V., Edwin Prabakaran, T. (2014). Ranking of Major States in India Using Data Envelopment Analysis (DEA) Approach, *International Journal of Current Research*.
- Gautam Appa and H. Paul Williams (2002). A Formula For The Solution of DEA Models Working paper, London School of Economics and Political Science.
- Planning Commission Report, (2014). Government of India.
- Power consumption per capita retrieved from <http://www.kseboa.org/news/india-per-capita-power-consumption-state-wise-15081730.html>
- Data regarding roads retrieved from https://en.wikipedia.org/wiki/Indian_road_network
- Data regarding Education index retrieved from <http://pib.nic.in/archieve/others/2008/oct/r2008101004.pdf>
- Gini coefficient retrieved from <https://knoema.com/wiwuiff/india-census-data-state-wise-indicators-of-poverty-per-capita-expenditure?tsId=1007770>
- Gross Domestic product retrieved from <http://statisticstimes.com/economy/gdp-of-indian-states.php>
- Addressing Economic Inequality in India, NIAS Campus, Bengaluru Organized by International Centre for Human Development (IC4HD) and National Institute of Advanced Studies (NIAS), 8-9 January 2015.
- Infrastructure in India : A vast land of construction opportunity (2008) PwC.