Journal of Operational and Strategic Analytics
https://www.acadlore.com/journals/JOSA

Efficiency and Fiscal Performance of Indian States: An Empirical Analysis Using Network DEA

Ram Pratap Sinha[1*], Seyyed Ahmad Edalatpanah[2]

[1] Economics Government College of Engineering and Leather Technology, 700106 Kolkata, India
[2] Department of Mathematics, Ayandegan Institute of Higher Education, 4681853617 Tonekabon, Iran

[*] Correspondence: Ram Pratap Sinha (rampratapsinha39@gmail.com)

Received: 01-28-2023 **Revised:** 03-10-2023 **Accepted:** 03-15-2023

Citation: R. P. Sinha and S. A. Edalatpanah, "Efficiency and fiscal performance of Indian states: An empirical analysis using network DEA," *J. Oper. Strateg Anal.*, vol. 1, no. 1, pp. 1–7, 2023. https://doi.org/10.56578/josa010101.

Abstract: The purpose of this empirical study is to evaluate and explain the fiscal performance of Indian states from 2009-10 to 2014-15 using a network DEA approach. While previous research has compared India's fiscal and developmental performance at the sub-national level, this study departs from the extant literature by evaluating state-wise performance at a disaggregated level. The states are first compared based on their tax mobilization and then evaluated in terms of development spending and overall financial performance. Censored regression analysis is also used to explore the impact of outstanding liabilities on GDP ratio, Gross Capital Formation, and GDP growth rate. The results indicate a positive association between efficiency scores and GDP growth rate and log of Gross Capital Formation. However, the linkage between efficiency and the outstanding liabilities ratio is negative. These findings suggest the need for a balanced approach to government spending to avoid the recurrence of the debt crisis in the future.

Keywords: Network DEA; Technical efficiency; Indian states; Sub-national fiscal performance; Development spending

1 Introduction

The objective of sub-national governments is to spend resources on developmental activities, which requires financial resources generated in a two-stage process. The first stage involves the generation of financial resources, while the second stage involves the expenditure of such resources on developmental activities. However, the limited ability of governments to mobilize taxes, coupled with other factors, means that financing government spending through taxation and borrowing may not have equivalent effects on the economy as posited by the Ricardian equivalence proposition.

In India, states have limited power to mobilize taxes independently, and financial constraints arising from limited tax mobilization capacity remain a major area of concern. The fiscal situation of Indian states gradually worsened up to the end of the preceding century. However, in the current millennium, the central government and the Indian states have adopted rule-based paths toward fiscal consolidation through the passage of Fiscal Responsibility and Budgetary Management legislations. State governments have also initiated necessary measures to promote revenue mobilization and reduce unproductive expenditures. Efforts have also been made to improve the quality of expenditure to foster long-term economic growth.

The majority of research studies on public finance have focused on addressing the problem of sub-national fiscal deficit and debt sustainability. In India, Dholakia and Karan [1] and Goyal et al. [2] are notable examples of such studies. However, there are fewer research studies that have examined the comparative fiscal or macroeconomic performance in the national or sub-national setting.

In the national and international context, a few research studies have estimated the tax administration efficiency of governments. In the global context, studies such as [3–7] have examined tax performance in various countries. In the Indian context, notable research studies include [8] and [9]. Chatterjee and Chitkara [9] applied a stochastic frontier approach to evaluate the tax mobilization efficiency of fifteen Indian states covering the period from 1980-81 to 1992-93. The study identified a moral hazard problem in the allocation of grants, which reduces sub-national tax effort. The relatively affluent states mobilize tax more efficiently since they receive fewer grants. The study thus suggested providing more weightage to own tax performance for releasing more grants. Tax efficiency was evaluated using Gross State Domestic Product (GSDP), the share of agriculture in GSDP, and the poverty index. Variations in tax efficiency were found to be due to size differences in tax jurisdiction.

Coondoo et al. [10] estimated the comparative tax performance of Indian states from 1986-87 to 1996-97 using the quantile regression method. The study linked the Aggregate Tax Revenue-Net State Domestic Product ratio with per capita Net State Domestic Product based on 1980-81 prices. Based on the outcome, the study grouped the observed states into four categories: best, medium, declining, and worst. Garg et al. [8] evaluated the tax capacity and tax effort of fourteen states (from 1992-92 to 2010-11) using the Battese-Coelli stochastic frontier model. In their estimated model, explanatory variables were linearly related to the inefficiency term. Tax efficiency was analyzed using a series of explanatory variables in a second-stage regression, and it was found that economic and structural variables contribute significantly to tax efficiency.

Sinha [11, 12], Mundle et al. [13], and Mohanty and Mishra [14] have constructed fiscal performance indices in the Indian context. Bhide and Panda [15] have presented a budget quality composite index based on several indicators, including net interest payments, subsidies, and defense, net of defense, the ratio of net tax revenue of the center, the fiscal deficit-GDP, and the revenue deficit-GDP ratio.

Dholakia and Karan [1] eveloped an index of fiscal performance by combining three indices - a deficit index, an own revenue effort index, and an expenditure and debt service index. From 1990-91 to 2002-03, Dholakia and Karan [1] ranked the performance of Indian states using the Fiscal Performance Index.

Mundle et al. [13] examined subnational governance performance from 2001-02 and 2011-12 as measured by services, infrastructure, social services, fiscal performance, justice, law and order, and quality of law-making. Several indicators were used to assess fiscal performance, including the ratio of development expenditures to total expenditures and the ratio of own tax revenues to total tax revenues. Among the states with the best fiscal performance, three were high-income, two were middle-income, and one was low-income. Five major sub-indices contribute to the Fiscal Performance Index: the Deficit Index, Revenue Efficiency Index, Expenditure Quality Index, Debt Index, and Debt Sustainability Index. The study found significant inter-state variations as reflected by the respective indices.

In the international context, Lovell et al. [16, 17] constructed macroeconomic performance frontiers of OECD and Asian economies, respectively. Other notable international studies related to the estimation of macroeconomic performance indicators include Sinha [11, 12, 18], and Acharya and Sahoo [19]. In India, Sahoo and Acharya [20] constructed macroeconomic performance indices at the sub-national/national level.

Sahoo and Acharya [20] developed a macroeconomic performance index for twenty-two Indian states applying radial and non-radial approaches from 1994-1995 to 2001-2002. The index incorporates three output indicators: the Gross State Domestic Product (GSDP), the fiscal balance, and the price index. The radial and non-radial models provided significantly different rankings according to Kendall's tau-b rank correlation score of 0.777 at the 1 percent significance level.

Acharya and Sahoo [19] used three macro indicators, namely GSDP, fiscal deficit as a percentage of GSDP, and inflation expressed in the GSDP deflator, to estimate Dynamic Macroeconomic Performance (DMEP) for fifteen major Indian states. The study found that states with higher macroeconomic performance had lower levels of poverty and inequality.

Non-parametric frontier estimation techniques were used by Sinha [11, 12, 18] to estimate state fiscal performance efficiency using outstanding liabilities and gross capital formation as independent variables. Data envelopment analysis was applied to the Indian economy by Mohanty et al. [21] to construct a measure of macroeconomic performance (MEP). The study estimated the Indian economy's MEP and Eco-MEP indices from 1980-1981 to 2018-2019 based on macro indicators such as international terms of trade, economic growth rate, pollution, fiscal deficit, employment rate, inflation rate, and climate change. The two indices have captured the major events that adversely impacted the Indian economy simultaneously.

The current research differs from previous studies in several ways. Firstly, the study employs a two-stage relational network model of the production process for efficiency evaluation, which allows for performance estimation at a disaggregated level. The study computes both tax mobilization (first stage) and composite efficiency (indicating development spending and fiscal stability) in the second stage, while also assessing the impact of GDP growth rate, outstanding liability (to GDP) ratio, and Gross Capital Formation using censored regression.

This study is organized into five sections. Section 1 provides an introduction and a brief review of related literature. Section 2 describes the network DEA methodology and second phase censored regression method used in the present study, as well as the variables used in the estimation process. Results and discussion are presented in Section 3. The final section is the conclusion.

2 Methodology

2.1 Estimation of Efficiency

To estimate the technical efficiency of a productive unit, observed productivity is compared with benchmark productivity. In the econometric approach, observed productivity may deviate from benchmark productivity due to external and internal factors. The mathematical programming approach, including DEA, only accounts for inefficiency due to internal factors. However, DEA has two advantages over parametric approaches: it does not require assuming a parametric functional form of the relationship between inputs and outputs, and it can easily accommodate multiple outputs into the analysis framework.

Both the DEA and econometric approaches consider a one-sector input-output transformation process, which does not allow for identifying divisional performance. To address this weakness, the present study uses the Network DEA method to evaluate the fiscal performance of Indian states.

Performance benchmarking of a productive unit often involves comparing actual output (or input usage) with benchmark levels. An observed dataset is used to construct a performance frontier, and a productive unit's performance is measured based on its proximity to the frontier. DEA is widely used for estimating the frontier (and efficiency) in most research studies due to several associated advantages.

Conventional DEA models use a black-box approach to estimate the efficiency of observed productive units as a whole, without considering their internal sub-processes. This approach assumes that the relative DMU's productive system is a black box, deploying certain inputs to produce certain outputs. However, this approach may make it difficult to identify weaknesses in DMUs properly.

Charnes et al. [22] recognized that the army recruitment process is a two-stage activity that includes creating awareness and executing employment contracts. This is perhaps the earliest DEA study that acknowledges the internal processes of a productive process. The study found that advertisements are used to create awareness among youth, and contracts are executed during the second stage.

Wang et al. [23] considered a two-stage banking production process to capture the impact of information technology on the sector. Färe et al. [24] introduced a network structure of the production process to efficiently estimate the entire production system and its components.

Tone and Tsutsui [25] presented an SBM (Slacks-Based Measure) approach for evaluating the overall (system) and stage (process) efficiencies of productive units having a network structure. The approach compares observed DMUs to efficient points lying on the frontier to assess the productive units' performance.

To explain the SBM network DEA technique briefly, we consider a set of n productive units (DMUs) under observation, where each DMU consists of two divisions. Let pi and qi be the inputs and outputs numbers for division i, respectively. The link connecting the two divisions is denoted by (12). The experimental data on inputs, outputs, and links are represented by Xij (j=1,2,. . . ,n;i=1,2) for the inputs, Yij (j=1,2,. . . ,n;i=1,2) for the outputs, and L(12) for the link. The production structure is graphically displayed in Figure 1.

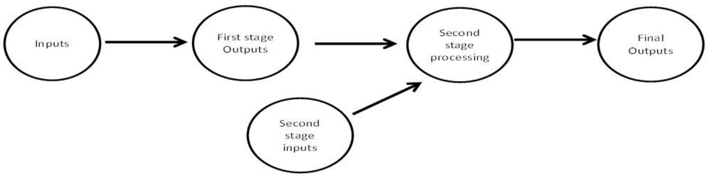

Figure 1. The network of production process

The production possibility set $\left[\left(\mathrm{X^i}, \mathrm{Y^i}, \mathrm{L}^{(12)}\right)\right]$ is characterized by

$$\mathrm{x^1i} \geq \mathrm{X^1}\lambda^1 \quad \mathrm{x^2i} \geq \mathrm{X^2}\lambda^2, \mathrm{y^1i} \geq \mathrm{Y^1}\lambda^1, \quad \mathrm{y^2i} \geq \mathrm{Y^2}\lambda^2 \quad \mathrm{Lj}^{12} = \mathrm{Z}^{12}\lambda^2, \mathrm{e}\lambda^1 = 1, \quad \mathrm{e}\lambda^2 = 1$$

DMU "0" is denoted by

$$x^1 0 = X^1\lambda^1 + S^{1-}, x^2 0 = X^2\lambda^2 + S^{2-}$$
$$y^1 0 = Y^1\lambda^1, y^2 0 = Y^2\lambda^2, e\lambda^1 = 1, e\lambda^2 = 1$$
$$\lambda^1 \geq 0, \lambda^2 \geq 0, S^{1-} \geq 0, S^{2-} \geq 0$$

The output-oriented technical efficiency can be obtained by solving the following linear program:

$$\theta_0 = \mathrm{Max}\left\{\mathrm{w1}\left[1 + \frac{1}{q_1}\left(\sum_{\mathrm{r}}^{\mathrm{r_1}} = \frac{s_{\mathrm{r}}^1}{y_{ra}^1}\right)\right] + \mathrm{w2}\left[1 + \frac{1}{\mathrm{q_2}}\left(\sum_{\mathrm{r}}^{\mathrm{r_2}} = \frac{s_{\mathrm{r}}^2}{y_{\mathrm{r}}^2}\right)\right]\right\}$$

Output-oriented technical efficiency $= \frac{1}{\theta_0^*}$.

Output-oriented divisional efficiency is calculated as follows:$\theta_{Di} = \frac{1}{1+\frac{1}{q_i}\left(\sum_{r=}^{r_i} \frac{s_r^i}{y_{r0}^i}\right)}$.

where, θ_{Di} is the output-oriented technical efficiency of division i (i=1,2). The overall output-oriented efficiency is calculated as the weighted harmonic mean of divisional scores.

2.2 Contextual Variables Influence

An important aspect of the study is to evaluate the impact of contextual variables on efficiency, which can be achieved through econometric modeling. However, the conventional least square method cannot be used due to the bounded efficiency scores (with lower and upper bounds of 0 and 1). Therefore, data transformation is necessary to compute the efficiency score.

Besides the standard Tobit model, the censored regression model can also be used. This model allows censoring of the dependent variable on the left, right, or both, with no lower or upper limits on the dependent variable. The censored regression model can be represented as follows:

$$\begin{gathered} Y_L = x^2\beta + u \\ Y = m \text{ if } Y^* \leq 0, Y = Y_L \text{ if } m < Y_L < n \text{ and } Y = n \text{ if } y^* \geq 0 \end{gathered} \tag{1}$$

in which Y_L and Y are latent (unobserved) and observed variables, respectively, x is the explanatory variable vector, m and n are dependent variable lower and upper limits, β is the unknown parameters vector, and u represents the disturbance term.

The Maximum Likelihood Estimation (MLE) method is commonly used to estimate censored regression models. Assuming that u is a normally distributed disturbance term with mean 0 and variance σ^2, the log-likelihood function can be expressed as:

$$\log \mathrm{L} = \sum \left[\mathrm{Im} \log \varphi\left(\frac{\mathrm{a} - \mathrm{x}'\beta}{\sigma}\right) + \mathrm{In} \log \varphi\left(\frac{\mathrm{x}'\beta - \mathrm{b}}{\sigma}\right) + (1 - \mathrm{Im} - \mathrm{In})\left\{\log \theta\left(\frac{\theta - \mathrm{x}'\beta}{\sigma}\right) - \log \sigma\right\}\right] \tag{2}$$

Here, $\varphi(.)$ and $\theta(.)$ denote the cumulative distribution and probability density function of standard normal distribution, respectively. On the other hand, Im & In are the indicator functions with $Im = 1$ if $y = m$ and $Im = 0$ if $y > m$ and $In = 1$ if $y = n$ and $In = 0$ if $y > n$.

2.3 Description of Variables

The evaluation of sub-national efficiency performance depends on the input-output framework used by the model. Therefore, appropriate performance indicators need to be identified for efficiency evaluation. Since a state works for public welfare, its ability to undertake developmental activities depends on the devolution of resources and its own tax mobilization. This, in turn, is dependent on the state's Gross Domestic Output (GDP). Thus, we have included State GDP as the input variable and Own Tax Revenue as the output variable in stage one.

In the next stage, we have considered the Devolution of Funds and the first stage output (Own Tax Revenue) as the two inputs, and Development Expenditure and Revenue-Expenditure Ratio as the final stage outputs. The quality of the state's development expenditure influences the quality of human capital and can play a major role in fostering economic growth. Several research studies have examined the impact of the state's development spending on the economic growth process. Diamond [26] showed that capital expenditure on welfare, housing, and health promotes economic growth. Ram´ırez [27] found a highly significant positive impact of public infrastructure investment and private capital formation on output growth. Erden and Holcombe [28] found that public investment facilitates private investment, and on average, a ten percent public investment growth is linked to a two percent upswing in private investment. A summary view of the evaluation indicators is presented in Table 1.

2.4 Data and Estimation Model

This study is based on data collected between 2009-2010 and 2014-15. The required information on input, output, and contextual variables was obtained from the State Finances-A Study of State Budgets published by the Reserve Bank of India for various years, covering sixteen general category states. We have used the slacks-based network DEA model proposed by [25] to evaluate state-level performance. The model is output-oriented and estimates under variable returns to scale.

Table 1. Key parameters of our model

Variables	Usage in the model
State GDP	First stage input
Own Tax Revenue	First-stage output and second-stage input
Devolution of funds	Second stage input
Development Expenditure	Second stage output
Receipt-Expenditure Ratio	Second stage output
Outstanding liability to GSDP ratio	Environment variable
Log of Gross Capital Formation	Environment variable
GSDP Growth Rate	Environment variable

Source: Author's Selection

3 Results and Discussion

3.1 Descriptive Statistics of Efficiency Scores

Table 2 presents the mean efficiency scores for the two stages of sub-national performance estimated using the SBM network DEA model. It is important to note that since efficiency estimates for each of the in-sample years are derived from individual frontiers, efficiency scores cannot be compared across time. However, the mean efficiency score provides a sense of how far the current year's performance diverges from the frontier.

Table 2 indicates that the variability in performance is more pronounced in the second stage compared to the first stage. The table also shows a growing divergence in performance from 2009-10 to 2013-14. Mean efficiency improved somewhat in 2013-14 but declined again in 2014-15.

Table 2. Mean overall and stage-wise efficiency scores

Particulars	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15
Stage 1	0.9840	0.9623	0.9112	0.8911	0.9726	0.9365
Stage 2	0.8283	0.8189	0.8709	0.8682	0.8253	0.9085
Overall	0.9062	0.8906	0.8910	0.8797	0.8989	0.9225

Source:Calculated

3.2 Impact of Contextual Variables on Sub-National Performance

In this study, the impact of time and two important contextual variables (outstanding liabilities and log of gross capital formation) on sub-national fiscal management and development performance was examined. Due to the bounded efficiency scores, the Tobit model was used for regression estimates, and the results are presented in Table 3 and Table 4.

The regression results for Stage 1 efficiency are displayed in Table 3. The coefficient of the outstanding liability ratio is found to be negative and statistically significant, indicating a negative relationship between the observed state's efficiency and indebtedness. The coefficient of the log of gross capital formation is positive but statistically insignificant. This implies that better tax mobilization performance was exhibited by more industrialized states (as indicated by the quantum of gross capital formation), which is consistent with [9]. The coefficient of the GSDP growth rate is also positive, as expected.

Table 4 presents the regression estimates for Stage 2 efficiency. In this case, the coefficient of outstanding liabilities to GSDP ratio is also highly significant and negative. Additionally, the coefficient of the log of gross capital formation is positive and significant, indicating that better efficiency in development expenditure and revenue-expenditure ratio was observed in states with higher levels of industrialization.

Table 3. Regression of stage-1 efficiency on the contextual variables

Particulars	Coefficient	Std. Error	Observed t ratio	p-value
Intercept	1.0481	0.3755	2.791	0.0052
Outstanding Liability-GSDP ratio	-0.0125	0.0048	-2.584	0.009
Log of Gross Capital Formation	0.0174	0.0243	0.7170	
GDP growth	0.0355	0.0287	1.236	0.4734

Source:Calculated

Table 4. Regression of stage-2 efficiency on the contextual variables

Particulars	Coefficient	Std. Error	Observed t ratio	p-value
Intercept	0.5795	0.5179	1.119	0.2632
Outstanding Liability-GSDP ratio	-0.0161	0.0052	-3.086	0.0020
Log of Gross Capital Formation	0.0616	0.03508	1.755	0.0792
GDP growth	0.0100	0.0285	0.3499	0.7264

Source:Calculated

4 Concluding Observations

The fiscal efficiency of Indian general category states regarding stage-wise performance between 2009-10 and 2014-15 has been analyzed in this study. As mentioned earlier, the variability in performance in the second stage is more pronounced in the second stage efficiency (relating to development spending and fiscal balance) compared to the first stage efficiency concerning own tax mobilization. While development spending is crucial for economic development, a long-term financial planning strategy is necessary for the government. This can be achieved by a two-fold approach, including greater reliance on tax financing of government expenditure and improving the quality of development expenditure to make it more effective.

However, this study needs to be extended in two ways. Firstly, the study period needs to be extended beyond 2014-15. Secondly, more explanatory variables can be added to the regression analysis to explore their impact on the first and second-stage performance. These issues can be addressed more effectively in future studies.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

References

[1] R. H. Dholakia and N. Karan, "Consistent measurement of fiscal deficit and debt of states in india," *Econ. Polit. Wkly.*, vol. 40, no. 25, pp. 2577–2586, 2005.

[2] R. Goyal, J. Khundrakpam, and P. Ray, "Is india's public finance unsustainable? or, are the claims exaggerated?" *J. Policy Model.*, vol. 26, no. 3, pp. 401–420, 2004. https://doi.org/10.1016/j.jpolmod.2004.03.004

[3] J. Alm and D. Duncan, "Estimating tax agency efficiency," *Public Budg. Fin.*, vol. 34, no. 3, pp. 92–110, 2014. https://doi.org/10.1111/pbaf.12043

[4] J. First von Last, F. Second von Previous, T. da Silva, and Q. Quinto, "Título da obra: artigo com quatro autores," *Título da Revista*, vol. 10, no. 2, pp. 15 905–15 913, Mês 2000.

[5] S. L. Ryu and S. Y. Lee, "An exploratory study of efficiency in tax jurisdictions," *Adv. Sci. Technol. Lett.*, vol. 34, pp. 46–49, 2013. https://doi.org/10.14257/ASTL.2013.34.12

[6] M. Katharaki and M. Tsakas, "Assessing the efficiency and managing the performance of greek tax offices," *J. Adv. Manag. Res.*, vol. 7, no. 1, pp. 58–75, 2010. https://doi.org/10.1108/09727981011042856/FULL/XML

[7] R. Jha, B. S. Sahni *et al.*, "Tax efficiency and productivity analysis: The case of canadian fiscal federalism," *Public Financ.*, vol. 52, no. 2, pp. 186–197, 1997.

[8] S. Garg, A. Goyal, and R. Pal, "Why tax effort falls short of tax capacity in indian states: A stochastic frontier approach," *Public Financ. Rev.*, vol. 45, no. 2, pp. 232–259, 2017. https://doi.org/10.1177/1091142115623855

[9] R. Jha, M. S. Mohanty, S. Chatterjee, and P. Chitkara, "Tax efficiency in selected indian states," *Adv. Public Econ.*, pp. 91–104, 2000.

[10] D. Coondoo, A. Majumber, R. Mukherjee, and C. Neogi, "Relative tax performances: Analysis for selected states in india," *Econ. Polit. Wkly.*, pp. 3869–3871, 2001.

[11] R. P. Sinha, "Fiscal performance benchmarking of indian states-a robust frontier approach," *Cent. Eur. Rev. Econ. Manag.*, vol. 1, no. 4, pp. 225–249, 2017. https://doi.org/10.29015/CEREM.527

[12] S. R. Pratap, "Fiscal performance of indian states–a comparison of convex and non-convex frontier approaches," *J. Gov. Public Policy*, vol. 8, no. 2, pp. 2–17, 2018.

[13] S. Mundle, S. Chowdhury, and S. Sikdar, "Governance performance of indian states: Changes between 2001-02 and 2011-12," *Econ. Polit. Wkly.*, pp. 55–64, 2016.

[14] A. R. Mohanty and B. R. Mishra, "Fiscal performance index of the states in india," *Prajnan*, vol. 45, no. 3, pp. 247–266, 2016.

[15] S. Bhide and M. Panda, "Evaluating quality of budgets with a composite index," *Econ. Polit. Wkly.*, pp. 1177–1180, 2002.

[16] C. K. Lovell, J. T. Pastor, and J. A. Turner, "Measuring macroeconomic performance in the oecd: A comparison of european and non-european countries," *Eur. J. Oper. Res.*, vol. 87, no. 3, pp. 507–518, 1995. https://doi.org/10.1016/0377-2217(95)00226-X

[17] C. K. Lovell, "Measuring the macroeconomic performance of the taiwanese economy," *Int J. Prod. Econ.*, vol. 39, no. 1-2, pp. 165–178, 1995. https://doi.org/10.1016/0925-5273(94)00067-K

[18] R. P. Sinha, "Indebtedness, fiscal discipline and development spending–a non-parametric approach," *Cent. Eur. J. Econ. Model. Econ.*, no. 2, 2021.

[19] D. Acharya and B. K. Sahoo, "Dynamic macroeconomic performance of indian states: Some post-reform evidence," *New Frontiers in Regional Science: Asian Perspectives*, 2017. https://doi.org/10.1007/978-3-319-27589-5_9

[20] B. K. Sahoo and D. Acharya, "Constructing macroeconomic performance index of indian states using dea," *J. Econ. Stud.*, vol. 39, no. 1, pp. 63–83, 2012. https://doi.org/10.1108/01443581211192116/FULL/XML

[21] R. K. Mohanty, B. K. Sahoo, and P. K. Chaudhury, "Assessing the (eco) macroeconomic performance index of india: A data envelopment analysis approach," *J. Public Affairs.*, vol. 21, no. 1, p. e2122, 2021. https://doi.org/10.1002/PA.2122

[22] A. Charnes, W. W. Cooper, and R. M. Thrall, "Classifying and characterizing efficiencies and inefficiencies in data development analysis," *Oper. Res. Lett.*, vol. 5, no. 3, pp. 105–110, 1986. https://doi.org/10.1016/0167-6377(86)90082-9

[23] C. H. Wang, R. D. Gopal, and S. Zionts, "Use of data envelopment analysis in assessing information technology impact on firm performance," *Ann. Oper. Res.*, vol. 73, no. 0, pp. 191–213, 1997. https://doi.org/10.1023/A:1018977111455

[24] R. Färe, S. Grosskopf, and G. Whittaker, "Network dea," *Model. Data Irreg. Struct. Complex. Data Envelop. Anal.*, pp. 209–240, 2007. https://doi.org/10.1016/S0038-0121(99)00012-9

[25] K. Tone and M. Tsutsui, "Network dea: A slacks-based measure approach," *Eur. J. Oper. Res.*, vol. 197, no. 1, pp. 243–252, 2009. https://doi.org/10.1016/J.EJOR.2008.05.027

[26] J. Diamond, *Government Expenditure and Economic Growth: an Empirical Investi-Gation*. International Monetary Fund, 1989. https://doi.org/10.5089/9781451974157.001

[27] M. D. Ramírez, "Is public infrastructure spending productive in the mexican case? a vector error correction analysis," *J. Int. Trade Econ. Dev.*, vol. 13, no. 2, pp. 159–178, 2004. https://doi.org/10.1080/0963819042000218700

[28] L. Erden and R. G. Holcombe, "The effects of public investment on private investment in developing economies," *Public Financ. Rev.*, vol. 33, no. 5, pp. 575–602, 2005. https://doi.org/10.1177/1091142105277627