Measuring Efficiency of Selected Indian Commercial Banks : A DEA-Based MPI Approach

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Abstract

This paper attempted to measure the change in productivity of 19 commercial banks in India from 2013 – 2018. The nature of efficiency and productivity change was investigated with the help of the output - oriented Malmquist Productivity Index (MPI) through intermediation approach. The MPI has components that are used in performance measurements, such as changes in technology efficiency, technical efficiency, pure technical efficiency, scale efficiency, and total factor productivity. The results of the study demonstrated that Ratnakar Bank Limited had the highest MPI score against both the technological change and total factor productivity change ; whereas, State Bank of India and Punjab National Bank had the lowest MPI scores. Overall, the private sector banks were found to be more productive compared to the public sector banks for the period under consideration.

Keywords : **Malmquist Productivity Index, pure technical efficiency, scale efficiency, technical efficiency, technological change**

JEL Classification : C43, C44, G21, G28

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Commercial banks play a vital role in the financial systems of most economies, specifically the developing countries, where participation in the secondary market is low and most people prefer to keep their money with the banking system. Generally, banks act as the financial intermediary between the savers cum investors and the borrowers and are associated with different banking related businesses. Globalization has brought in substantial changes in the banking business in the developing and less developed countries, which have opened up domestic markets to foreign banks that are more productive and efficient. Consequently, in the face of stiff competition with foreign banks, domestic banks are affected negatively. Further, following the global financial crisis (GFC) of 2007 – 09, it has become more pertinent to monitor the banking sector's efficiency and performance. Monitoring helps potential investors, depositors, owners, and managers to have confidence in the banking system as well as facilitates overall implementation of banking regulations in the country (Desta, 2016). Hence, it is essential to monitor banks' productivity and efficiency.

A debate on whether the GFC affected the Indian banking system or not has finally settled with the view that it did not have an impact much due to the high amount of foreign exchange reserves (Sharma & Sharma, 2015). Gulati and Kumar (2016) also found no long-lasting adverse effects of the GFC on Indian banks' efficiency. This could be because of the stringent macroeconomic policies adopted to infuse sufficient liquidity into the

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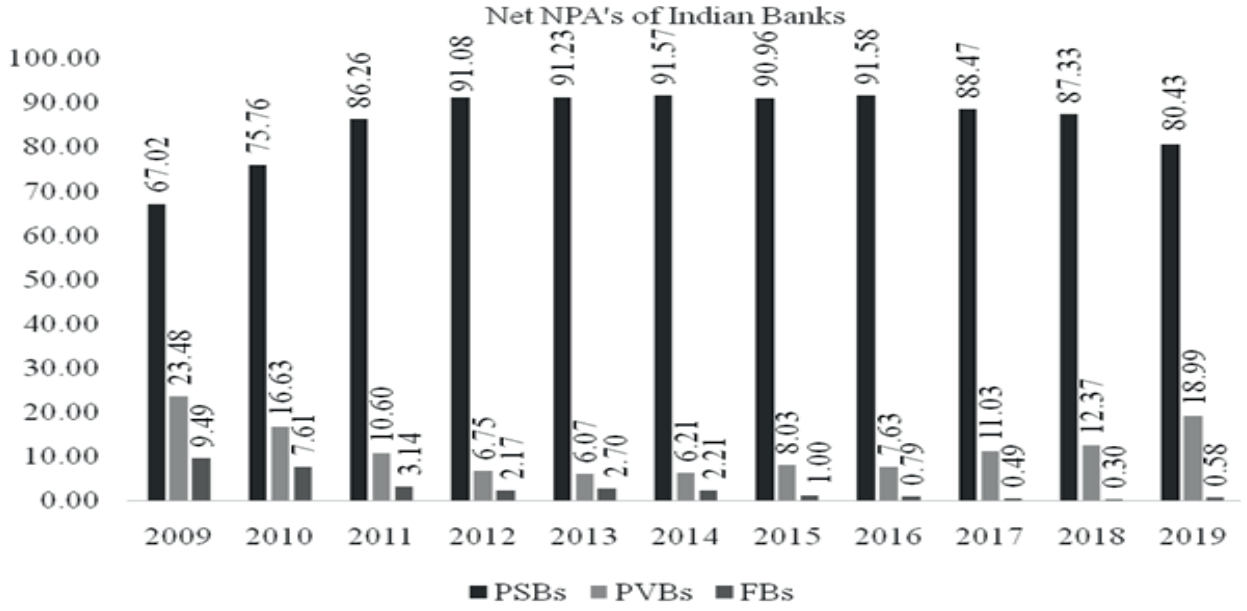
Figure 1. ***Annual Net Non-Performing Loans for All the Banks (in Percentages)***



Note. PVBs : private banks ; FBs : foreign banks.
Source : Reserve Bank of India (2020).

system. Banerjee (2018) also argued that GFC has a little impact over the Indian banking sector ; this view was supported by Eichengreen and Gupta (2013) in their study. During the crisis period, deposits from foreign and private sector banks shifted to the nationalized banks (Tzeremes, 2015). However, Kumar et al. (2016) observed that the financial market declined, and both public and private banks witnessed negative productivity growth due to the global financial crisis. Further, due to managerial inefficiency and economic volatility, bad loans got accumulated in the Indian banking companies' financial statements. Specifically, during the last 10 years, public sector banks had more bad loans relative to the private and foreign banks (see Figure 1) (Reserve Bank of India, 2020). Since 1992, Indian regulators have made reforms in the banking sector to make it more stable. Nevertheless, the Indian banking sector has been facing a crisis as the Indian Banking Association (IBA, 2018) reported a collective gross non-performing assets (NPAs) of approximately ₹ 10.25 trillion, with the public sector banks having the majority share.

A large quantum of research has been conducted on banking companies' productivity and efficiency, especially in the developed economies (Dell'Atti et al., 2015 ; Sufian & Kamarudin, 2014). However, the number of studies on emerging economies is less. Moreover, efficiency and productivity keep changing over the years for every segment of the economy. Financial institutions and banks are expected to show changes in productivity as an outcome of deregulation in the financial sector. Therefore, technical efficiency and technological efficiency should be measured properly. In this regard, measuring efficiency through MPI is the best method as it assumes the competitive behavior of decision-making units (DMUs) with respect to inputs as suggested by Desta (2016) and Sufian (2011). In the Indian context, this paper seeks to examine the technical efficiency change, pure technical efficiency change, scale efficiency change, technological change, and total factor productivity change of public and private sector banks from 2013 – 2018. This period witnessed Indian banks suffering from bad loans, which led to capital injection by the exchequers, government plans for merging public sector banks, and introduction of Insolvency Bankruptcy Code (IBC) (2016) for resolving bad loans. Therefore, it is quite pertinent to analyze how

efficiency changed during and after the aforementioned tenure and to distinguish the productive banks from the unproductive ones.

Avkiran (2011) argued that DEA has the ability to capture the efficiency of commercial banks. It has a distinct advantage over the typical ratio analysis like CAMEL for commercial banks. CAMEL ratios give an overall financial performance, while MPI gives segment-wise analysis like a short run, long run, change in performance due to technology, and other structural changes. The DEA analysis has been the benchmark approach for evaluating individual bank's performance since the last two decades (Liu et al., 2013 ; Paradi et al., 2011). The approach is presented in detail in the study of Charnes et al. (1978). According to Yeh (1996), DEA is a simple methodology to evaluate the efficiency of financial institutions with single or multiple inputs and outputs. It does not require as many assumptions as a parametric method.

The literature on measuring efficiency and productivity employs two prominent methodologies, namely the DEA and MPI. MPI is one of the concepts in DEA and works as an index measurement method. It shows how individual DMUs, for instance, banks and financial institutions, progress or regress over certain periods. The concept of MPI was pioneered by Caves et al. (1982) and is also known as CCD (named after Caves, Christensen, and Diewert, 1982) model. Though many studies have been conducted all across the world using MPI to measure the banking sector's efficiency, only a few are there on the Indian context. Additionally, as mentioned above, the banking industry in India has experienced substantial changes in recent years with a few significant mergers, introduction of IBC in 2016, and privatization of public sector banks (PSBs). Against this, we expect a change in the overall banking sector's efficiency and performance in the recent years, and hence, an attempt has been made to comment on the same.

Literature Review

Most of the studies on bank efficiency can be classified in two groups. The first group has evaluated the performance of Islamic and conventional banks through ratios analysis, and the second group compares efficiency through frontier approach between Islamic and conventional banks. This study focuses on the recent literature on single and cross-country analysis using MPI approach as a tool for evaluating efficiency of banks.

Efficiency and productivity changes in the banking industry are primarily examined using MPI. An MPI score of one states no change, while a score of more than one implies improvement in productivity and a score less than one refers to a decline therein. Following this approach, the commercial banks in Turkey experienced a productivity increase by 2.4% between 2010 and 2011 (Şahin et al., 2013). Further, Yilmaz and Gunes (2015) showed that both the commercial banks and Islamic banks had technical inefficiency due to lack of managerial skills in Turkey.

Sufian and Kamarudin (2014) showed that foreign banks in Malaysia were better in terms of technical efficiency than their domestic counterparts (i.e., minimize inputs cost while maximizing income). Further, Lu et al. (2013) noted that 12 commercial banks experienced a steep decline in total factor productivity (TFP) due to the global financial crisis in Taiwan. Desta (2016) reported that 14 out of 30 banks in South Africa scored more than one and the rest scored less than one in MPI. In Ethiopia, out of 15 banks, three banks regressed and the rest progressed in terms of total factor productivity (TFP) (Lema, 2016). Repkova (2012) argued that excess deposits resulted in the decline in MPI by 4.7% for the Czech banking sector. According to Adjei - Frimpong et al. (2015), the retail banks in New Zealand were more efficient than the foreign banks and the small banks. Further, Lee and Kim (2013) noted that commercial banks performed better than the regional and specialized banks in New Zealand over a sample tenure of 2003 – 2010.

Besides studies examining bank efficiency in a single country, there are studies on international comparison of

productivity changes over time. Among the Middle East and North African nations, out of 33 micro-financial institutions, only 12 improved in terms of productivity (Bassem, 2014). Working on the efficiency of the European banking group consisting of Germany, Italy, France, Spain, and U.K, Dell'Atti et al. (2015) observed that only the German economy was profoundly impacted by the subprime crisis and the rest were not.

Since 1992, India embarked on its liberalization and privatization programme. Following this, every sector underwent significant changes in terms of competition, growth, and structure. The banking industry was not an exception either. This sector opened upto domestic and foreign private sector banks and other structural changes in the banking organizations. Sekhri (2011) noted that the MPI score of Indian public and private banks for 2004 – 2009 was 1.03, which was higher than those of the foreign banks. Better performance and efficiency were ascribed to the reforms the Indian economy went through after the 1990s. Kumar et al. (2016) noted that after the economy opened upto privatization and liberalization, private banks in India became more efficient than the nationalized banks, which got reflected in the MPI score of 0.55 from 1996 – 2010. The reason behind this was a lag in technology adoption by the banks. They were also more enthusiastic in adopting new technology than the PSBs (Narwal & Pathneja, 2015).

Narayanaswamy and Muthulakshmi (2014) examined the efficiency of private banks through MPI and found that Kotak Mahindra Bank, ICICI Bank, and Axis Bank were more efficient throughout the study period. After examining the productivity and cost efficiency of public, private, and foreign banks, Narayanaswamy and Muthulakshmi (2016) found that the foreign banks were better than both public and private banks in terms of productivity and the private banks were far better than the foreign banks and the PSBs in terms of cost efficiency. Syed and Tripathi (2020) conducted a study on Indian banks to understand the reason behind NPAs and showed that foreign and private sector banks over the years reduced NPAs through proper management of disbursement of loans. But the PSBs involved political influences at the time of loan disbursement. With regard to productivity of the Indian banking sector in the second phase reforms, Sharma and Sharma (2015) found that the internal factors were the main contributing factor behind the accumulated NPAs from 2000 – 2010. A similar study by Das and Patra (2016) reported that the overall productivity of the Indian PSBs was 1.06 (MPI score), but they did not find any evidence of GFC's impact on the Indian economy.

This paper extends the literature by examining the efficiency of banking groups of India in the recent years with regard to Indian banking crisis by focusing exclusively on bank based ownership and the highest market capitalization of banks. Thus, the paper analyzes the efficiency through MPI.

Statement of the Problem, Objectives, and Hypotheses

The literature review presented above makes it evident that the DEA – Malmquist Productivity Index helps to evaluate the efficiency of the banking industry for certain periods. During 2015 – 2018, the Indian government injected a lump sum amount into the PSBs and encouraged merging of smaller banks with larger banks to ensure sustainability in the face of intense competition with the private banks. Efficiency of a bank is typically measured through asset growth and profitability. A bank's asset can grow through an increase in capital and deposits, which are investors' and borrowers' money. However, profitability has become a standard measure of performance, and some argued that it is a discretionary concept (Ray, 2004). For instance, Das et al. (2012) showed that by reducing loan loss provision against loan default amounts, banks could report profits. There are many tools for firms to maintain smooth earnings or profitability, and loan loss provision is one of them.

A bank is said to be operationally sound if the resources are used optimally to ensure high profitability and sustainable expansion. The DEA – MPI method is the most widely used quantitative model for evaluating the efficiency and operational soundness of banks since 1970. The Indian banking sector has been struggling with NPAs since the last two decades. The government has backed up the public sector banks through infusion

of capital and reforms on several occasions to ensure the sustainability of the banking sector. Albeit that, the public sector banks have been suffering a lot due to NPAs (refer to Figure 1 and Figure 2). One reason is government directives on lending to the MSMEs, but MSMEs are not rated by the credit rating agencies. Consequently, their creditworthiness is never properly assessed or is not taken into consideration. Recent reports of RBI and newspapers have claimed that Micro Units Development and Refinance Agency (MUDRA) bank loans are also turning out to be non-performing. Although research studies have been conducted since the introduction of deregulation, there is no clear evidence in favor of either progress or decline in terms of productivity and efficiency of the banking sector. Further, it is more complex to measure the efficiency and productivity of service-oriented companies (Fujii et al., 2014).

The above discussion makes it evident that there is a need to assess the efficiency and the productivity of the Indian banking industry following the DEA – MPI approach for the recent years. Our study period is from 2013 – 2018 during which the Indian economy experienced emergence of domestic-systematically important banks (D-SIBs), and a few banking sector mergers of strategic and economic significance. First, the Government of India (hereafter, GOI) has taken few reforms like Insolvency and Bankruptcy Code (2016) for resolving the stressed assets in banking companies. Second, revision of the prompt corrective action (hereafter, PCA) in 2017 was undertaken because of the operational losses of most of the banks due to inefficiency (RBI, 2017). Therefore, the study period is highly important for investigation ; hence, the objectives and hypotheses are :

- To assess the overall productivity and efficiency of the top 19 commercial banks (both public and private sector),
- To compare the annual productivity changes over the study period across PSBs and private banks,
- To analyze the productivity changes between PSBs and private banks for the entire sample period, and
- To suggest the changes required to improve the performance of these banks.

Hypotheses

- **H0 :** Productivity and efficiency of both public and private banks are the same.
- **Ha1 :** Productivity and efficiency of public banks is higher than that of private banks.
- **Ha2 :** Productivity and efficiency of private sector banks is higher than that of public sector banks.

Methodology and Data

It has already been mentioned above that the paper uses MPI as a tool for measuring the efficiency of the Indian banking sector. MPI, though by now a fairly common method, is briefly explained below.

In the literature, several methods are used for measuring productivity such as Fisher index, Tornqvist index, and MPI. Of all, MPI is the most commonly used method. It facilitates estimating productivity changes in individual DMUs over a period of time and helps to assess the firm's progress against its peers (Patel & Ranjith, 2018). According to Grifell - Tatze and Lovell (1996), MPI has three advantages over the Fisher index and Tornqvist index. First, it is not based on profit maximization and cost minimization approaches. Second, it does not require input and output prices. Finally, MPI allows decomposition of productivity changes into technical efficiency change and technological change or innovation effect. Technical efficiency change measures how efficiently a bank converts inputs into outputs, and technological change captures efficiency caused by technological upgradation. Technical efficiency change can be decomposed further into pure technical efficiency

and scale efficiency. Pure technical efficiency talks about how a bank functions in the long run and scale efficiency reflects on how optimally a bank uses its funds.

The advantage with the DEA – MPI approach is that it does not require any prior assumptions about functional forms or weights of inputs and outputs. It makes this approach more comprehensive and straightforward than the ratio analysis of financial statements (Guan et al., 2006 ; Zhu, 2000). There are four approaches under the DEA method for selecting input and output variables, namely, production, intermediation, value addition, and the user cost approach. The production approach considers fixed expenses of banks and uses branch-wise evaluation of banks. Nowadays, banks in most of the emerging and developing economies are expanding branches in the rural areas, which in turn increases the burden of fixed costs on the banks. If a bank wants to evaluate the efficiencies across branches, then the production approach is the best suited one. Intermediate approach considers banks acting as intermediaries between depositors and borrowers (Yeh, 1996). This approach measures how efficiently a bank turns deposits into assets to churn out profits relative to its peers. Hence, it is best suitable for evaluating the efficiency of a group of banks by collecting data from individual banks. Under the third approach of value addition, it considers a bank's output and input variables only from the balance sheet, which implies that banks only accept (demand and time) deposits and offer loans (mortgages and commercial) and do not utilize funds for other investments. Finally, the user cost approach uses the transaction costs of each and every financial transaction taking place between banks and their customers. This approach is more suitable for cooperative banks, where the volume of transactions on a daily basis is much smaller compared to the commercial banks (Camanho & Dyson, 2005). For this study, we have adopted the intermediation approach and further assumed the variable : returns to scale as opposed to constant returns to scale for the banks' operations.

MPI calculations can be based on the input-oriented approach (cost minimization) or output-oriented approach (output maximization). We have adopted the output-oriented MPI as our focus remains on how interest income is maximized through investments and extension of loans and advances. The MPI is employed to measure the productivity change of commercial banks between the two data points by calculating the ratios of the distance of each data point relative to a common technology and it requires the inputs and outputs from one-time period to be mixed with the other time period. The distance function, *D* is defined with respect to two different time periods (Färe et al., 1994).

$$D^{t}_{O}(X^{t+1}, Y^{t+1}) = inf\{\theta \mid (X^{t+1}, Y^{t+1} / \theta) \in S^{t}\} \quad (1)$$

and

$$D_{O}^{t+1}(X^{t}, Y^{t}) = inf\{\theta \mid (X^{t}, Y^{t} / \theta) \in S^{t+1}\} \quad (2)$$

where, *X* and *Y* stand for input and output, respectively ; *O* stands for output oriented approach, *inf* is abbreviation of inefficiency, and θ measures output efficiency rate of DMUs. The distance function in (1) measures the maximal proportional change in output required to make (X^{t+1}, Y^{t+1}) feasible in relation to the technology at time *t*. Similarly, the distance function in (2) measures the maximal proportional change in output required to make (X^{t}, Y^{t}) feasible in relation to technology at time $t+1$.

The following equations represent calculations of output-oriented MPI, $M_0\lfloor X^{t+1}, Y^{t+1}, X^{t}, Y^{t}\rfloor$ as

$$M_{O}[X^{t+1}, Y^{t+1}, X^{t}, Y^{t}] = \frac{D_{O}^{t+1}(X^{t+1}, Y^{t+1})}{D^{t}_{O}(X^{t}, Y^{t})} \times \left[\frac{D_{O}^{t}(X^{t+1}, Y^{t+1})\, D_{O}^{t}(X^{t}, Y^{t})}{D_{O}^{t+1}(X^{t+1}, Y^{t+1})\, D_{O}^{t}(X^{t}, Y^{t})}\right]^{1/2} \quad (3)$$

$$\frac{D_{O}^{t+1}(X^{t+1}, Y^{t+1})}{D^{t}_{O}(X^{t}, Y^{t})} = \text{Technical Efficiency Change} \quad (4)$$

$$\left[\frac{D_o^{\,t}(X^{t+1}, Y^{t+1})}{D_O^{\,t+1}(X^{t+1}, Y^{t+1})}\,\frac{D_O^{\,t}(X^{t}, Y^{t})}{D_O^{\,t+1}(X^{t}, Y^{t})}\right]^{1/2} = \text{Technological Change} \quad (5)$$

Further, the technical efficiency change can be decomposed into pure technical efficiency change and scale efficiency change. Their formulae are as follows :

$$\left[\frac{D_C^{\,t}(Y^{t+1}, X^{t+1})}{D_C^{\,t}(Y^{t}, X^{t})}\right]^{1/2} = \text{Pure Technical Efficiency Change} \quad (6)$$

$$\left[\frac{D_C^{\,t}(Y^{t+1}, X^{t+1})/D_V^{\,t+1}(Y^{t+1}, X^{t+1})}{D_C^{\,t}(Y^{t}, X^{t}) / D_V^{\,t+1}(Y^{t}, X^{t})}\right]^{1/2} = \text{Scale Efficiency Change} \quad (7)$$

where, *C* stands for constant return scale and *V* stands for variable return scale.

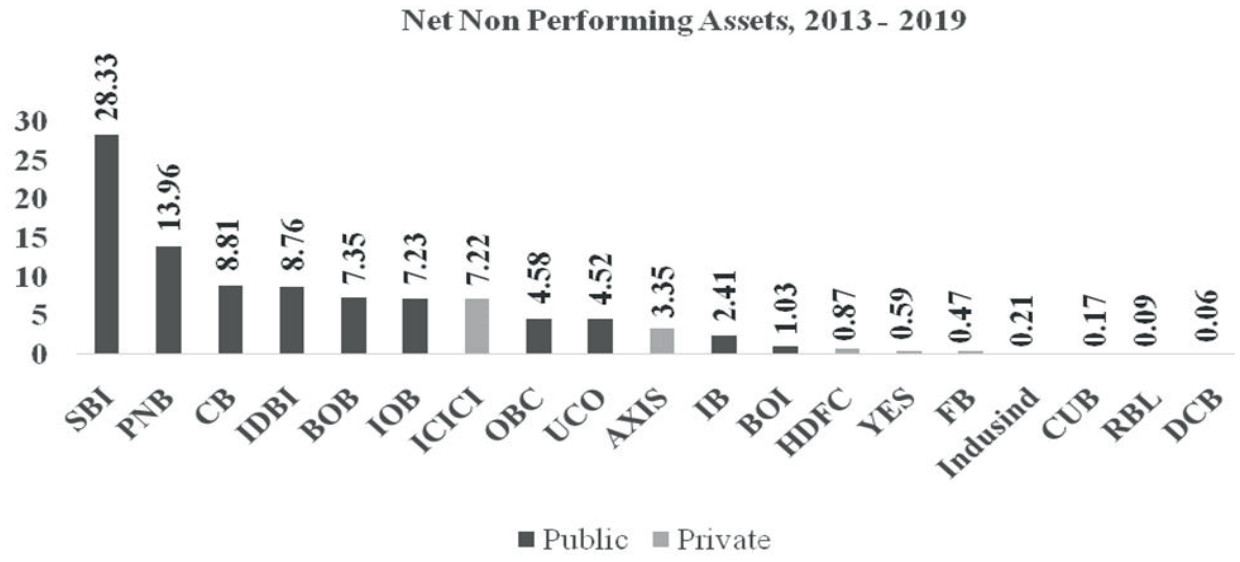
The inputs selected for this study are total cost (which includes interest expenses, fees, and commission), labour related expenses, and deposits ; the outputs are operating profit as a percentage of working funds, loans and advances, and investments. Initially, we considered India's top 21 banks in terms of full market capitalization for the period from 2013 – 2018. However, finally, 19 banks are used as data were not consistently available for all the years for two banks. A list of the banks considered is mentioned in Table 1, where 10 are public sector banks and the rest of the nine are private sector banks. Data on these banks were collected from their financial statements available from the CMIE Prowess IQ Database.

For the Indian banks, the accumulation of NPAs is a major concern. Figure 2 depicts the net NPAs of all the 19 banks from 2013 – 2018. It is evident that most of the NPAs were parked with the PSBs, with SBI having the highest share of NPAs, exceeding the second highest (PNB) by more than double the percentage. The reasons behind such huge NPAs could be the merger with its subsidiaries upon which the NPAs parked with those subsidiaries also get reflected in SBI's balance sheet. PNB's NPAs are caused by the fraudulent activities of the Nirav Modi Case and Bhushan Power Steel Corporation Limited ("CBI raids Bhusan Steel and Power's premises," 2019).

Table 1. ***List of Indian Commercial Banks Considered for Analysis***

	Public Sector Banks		Private Sector Banks
1	State Bank of India (SBI)	11	Housing Development Finance Corporation (HDFC)
2	Punjab National Bank (PNB)	12	Industrial Credit and Investment Corporation of India (ICICI)
3	Bank of Baroda (BOB)	13	Axis Bank (AXB)
4	Industrial Bank of India (IDBI)	14	IndusInd Bank (INDB)
5	Bank of India (BOI)	15	Yes Bank (YB)
6	Canara Bank (CB)	16	Ratnakar Bank Limited (RBL)
7	United Commercial Bank (UCO)	17	Federal Bank (FB)
8	Oriental Bank of Commerce (OBC)	18	City Union Bank (CUB)
9	Indian Bank (IB)	19	Decan Commercial Bank (DCB)
10	Indian Overseas Bank (IOB)		

Figure 2. ***Net Non-Performing Assets (in Percentages)***



Data Source : Prowess IQ Database (2019).

Analysis and Results

This section presents analysis of the data, results, and related discussions. As mentioned above, we have considered a balanced panel data with 114 observations, which consist of 6 years of observations for 19 commercial banks. Figures 3 – 8 show rankings of the 19 banks on the basis of annual averages of the six input and output variables included in the analysis. Few highlights worth of mention are :

Figure 3. ***Annual Average Labour Related Costs for All the Banks (in Percentages)***

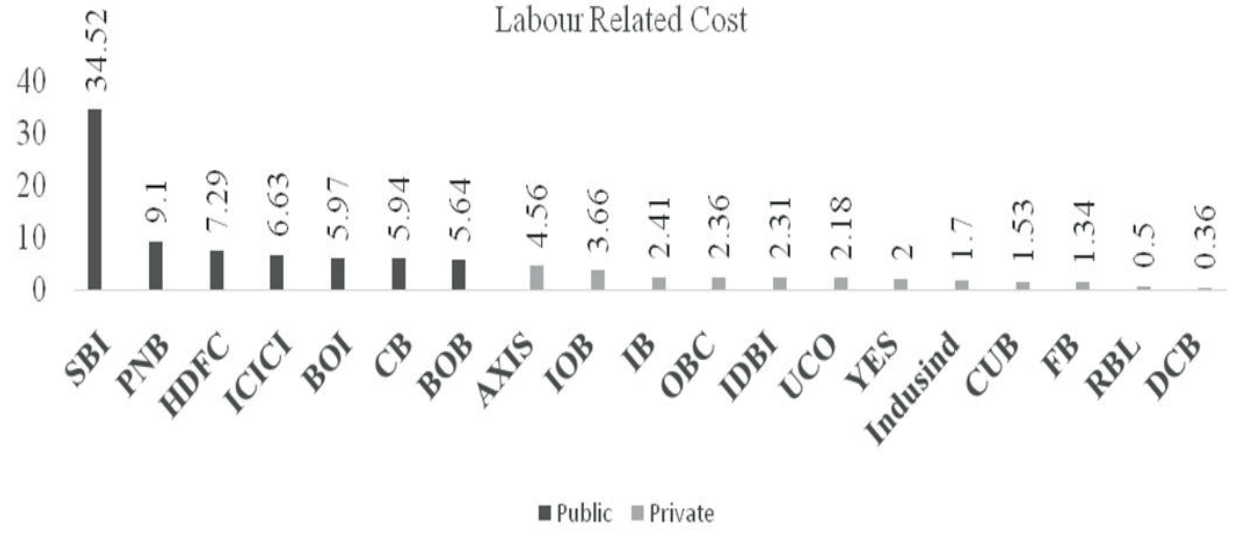


Figure 4. ***Annual Average Total Cost for All the Banks (in Percentages)***

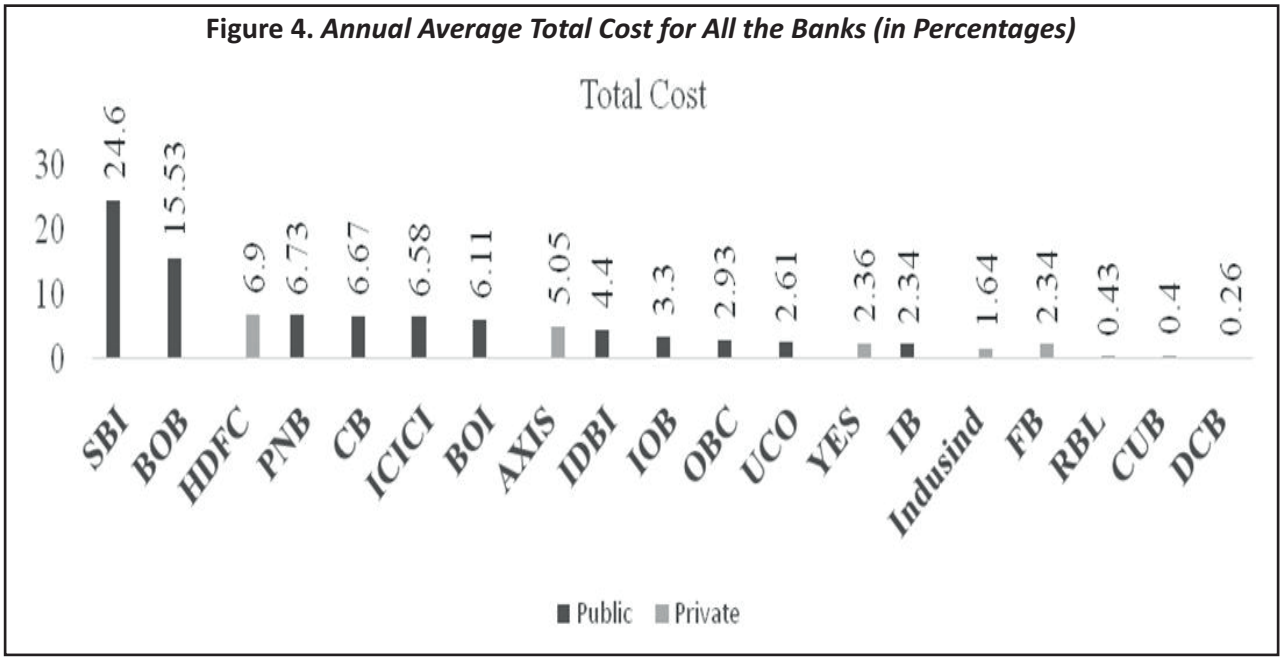
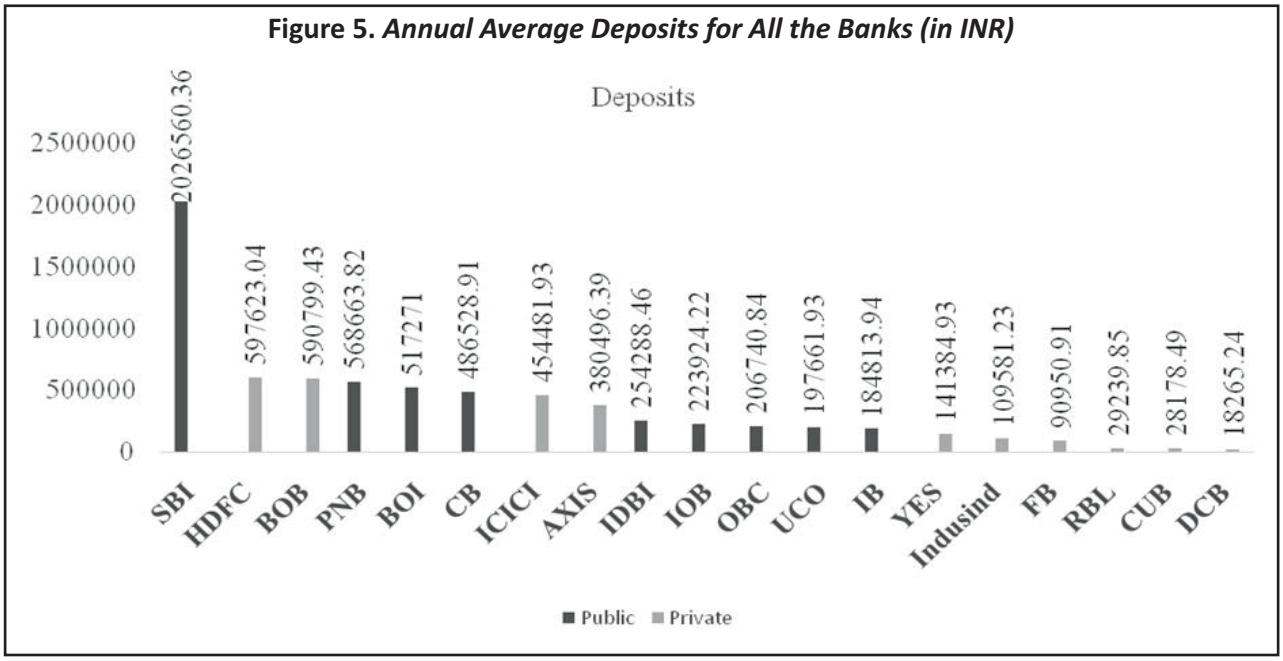


Figure 5. ***Annual Average Deposits for All the Banks (in INR)***



↳ PSBs are higher on loans and advances compared to most of the private banks except for ICICI Bank, Axis Bank, and HDFC Bank. This may be due to government's mandate for PSBs to expand their lending activities in rural areas as well as priority sectors.

↳ ICICI Bank tops the list on loans and advances ; this may be because the bank is open to extend loans to all industries instead of restricting loans to a few selected industries.

- Labor related costs and total costs are also higher for the PSBs, again with the above-mentioned private banks as exceptions.

- Similar is the situation with deposits. Again, PSBs are expected to operate in the rural and remote areas where private banks will not venture out expecting greater risks and lower profitability. Moreover, deposits in PSBs have

Figure 6. ***Annual Average Loans and Advances for All the Banks (in Percentages)***

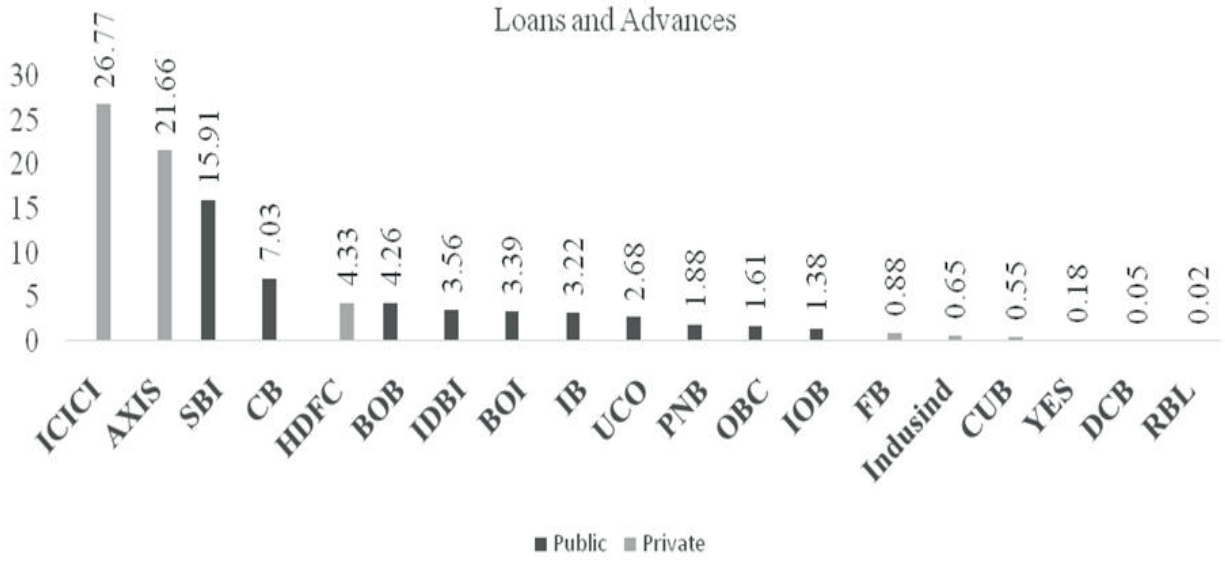


Figure 7. ***Annual Average Operating Profit as a Percentage of Working Funds for All the Banks (in Percentages)***

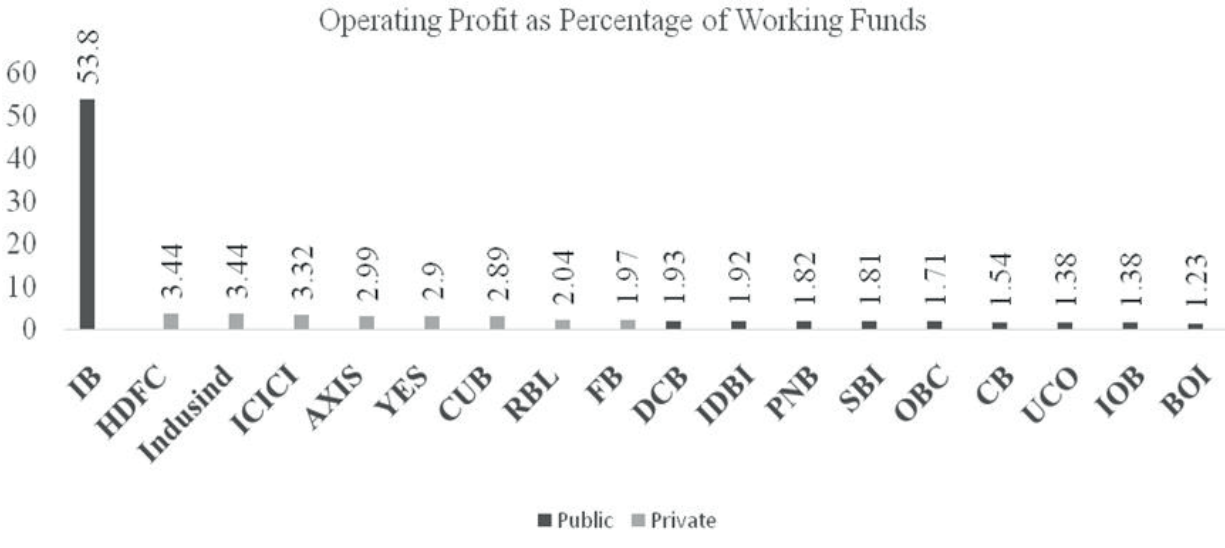
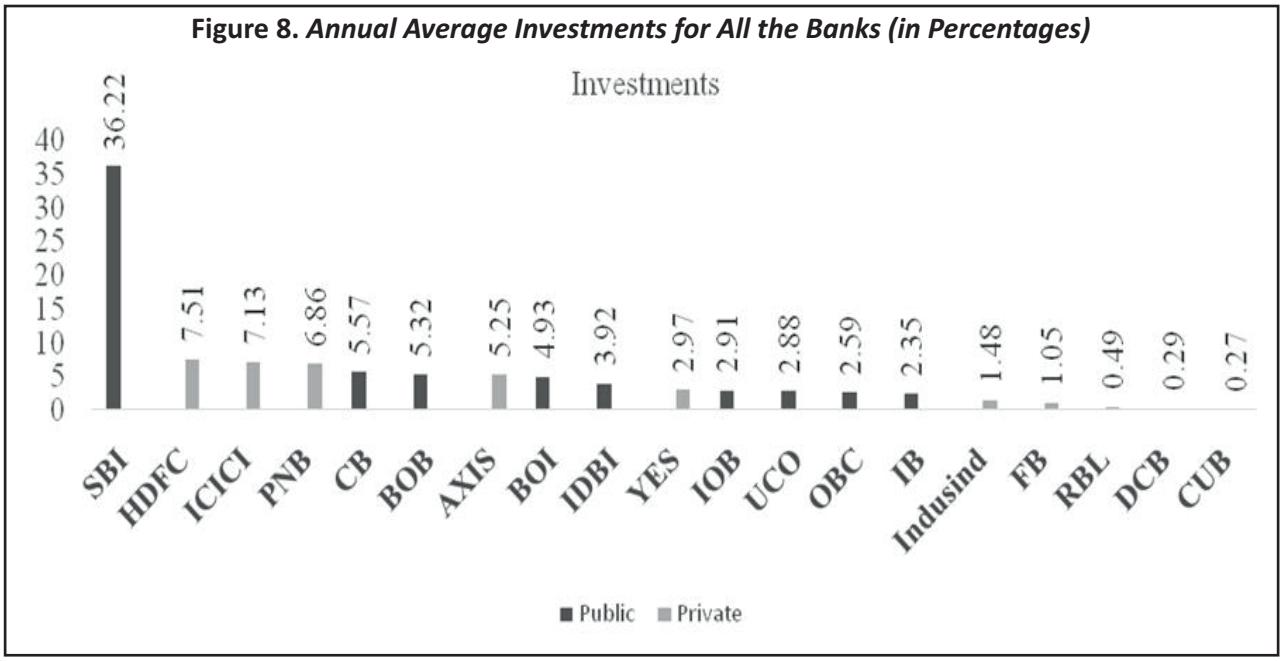


Figure 8. ***Annual Average Investments for All the Banks (in Percentages)***



insurance coverage that incentivizes public to hold deposits with the PSBs. Consequently, the PSBs are higher on deposits as well compared to most of the private banks.

- Priority sector lending at low cost and greater risk coupled with higher total costs, labour related costs, and higher provisions for NPAs make lower profit inevitable for the PSBs. As evident from Figure 7, except for Indian Bank, all the PSBs have lower operating profit as a percentage of working funds compared to the private banks. Indian Bank has the highest average operating profit among the sample; also, it is the only PSB that generated profits during 2016 – 2018.

- With respect to investments (Figure 8), the only observation that comes clear is that SBI commands a whopping 36% of total investments made by all these banks together during the 6 years under consideration. SBI also tops the list for all the variables, except 'Loans and Advances.' This is primarily caused by the merger with its subsidiaries on April 1, 2017.

Now coming to the estimates of MPI, Table 2 presents annual average changes in TFP (MPI score) and in its

Table 2. ***Malmquist Index Summary of Annual Averages***

Year	Technical Efficiency Change		Pure Technical Efficiency Change		Scale Efficiency Change		Technological Change		Total Factor Productivity Change	
	PSBs	PVBs	PSBs	PVBs	PSBs	PVBs	PSBs	PVBs	PSBs	PVBs
2014	1.26	1.12	0.98	1.14	1.27	0.99	1.19	1.18	1.58	1.29
2015	1.02	0.87	1.01	0.95	1.00	0.91	0.94	2.65	**0.98**	2.56
2016	1.01	1.19	1.04	1.05	0.98	1.13	1.07	1.56	1.08	1.96
2017	0.79	0.86	1.01	0.99	0.79	0.86	1.89	0.72	1.2	2.13
2018	1.19	1.19	0.94	0.97	1.27	1.21	0.72	0.96	**0.87**	1.01

Table 3. ***Malmquist Index Summary of Firms' Averages***

DMU	Technical Efficiency Change	Pure Technical Efficiency Change	Scale Efficiency Change	Technological Change	Total Factor Productivity Change
SBI	1.03	1.01	1.02	0.83	0.86
PNB	**1.13**	1.01	**1.12**	0.77	0.86
BOB	1.08	1.00	1.08	1.12	1.21
IDBI	1.06	0.96	1.10	1.06	1.12
BOI	1.05	1.00	1.05	0.99	1.04
CB	0.97	1.00	0.97	0.97	0.94
UCO	0.97	1.00	0.97	1.04	1.01
OBC	1.00	0.99	1.01	1.22	1.21
IOB	1.03	1.00	1.04	1.13	1.17
IB	0.96	0.97	0.99	1.09	1.05
HDFC	1.07	1.07	0.99	1.06	1.13
ICICI	1.09	**1.08**	1.01	1.29	1.40
AXB	1.00	1.00	1.00	1.28	1.28
INDB	1.00	1.00	1.00	1.23	1.23
YB	1.04	1.03	1.02	1.42	1.49
RBL	1.05	1.04	1.01	**1.57**	**1.65**
FB	0.97	0.98	0.99	1.47	1.43
CUB	0.95	0.98	0.97	1.14	1.09
DCB	1.00	1.00	1.00	1.34	1.34
Mean	1.02	1.01	1.02	1.14	1.17
Number of years with MPI > 1	10	6	10	15	16
Number of years with MPI < 1	5	8	5	4	3
Number of years with MPI = 1	4	5	4	Nil	Nil

components for the groups of public sector and private sector banks. Table 3 presents TFP changes for individual banks for all the years together. In 2015 and 2018, the MPI scores for the PSBs are less than one. For those two years, all PSBs also reported negative return on assets (ROA) and negative return on equity (ROE) as reported by IBA (2018). The reasons behind such poor performance could be huge accumulation of NPAs and agriculture loan waiver by a few state governments. However, it has stayed above one for all the private banks taken together.

Table 3 shows that most of the commercial banks improved their performance in terms of technology adoption over the years. Out of 19 banks, 16 banks have more than one MPI score and the rest have less than one. Among the components of MPI, PNB has the highest scores in technical efficiency change and its component, scale efficiency change. From the CMIE Prowess database, we observed that PNB has the lowest funding cost. This might render its technical efficiency as well as scale efficiency to be the highest. ICICI Bank, on the other hand, has the highest score on pure technical efficiency, which implies that it has the highest possibility of surviving in the long run. This is also supported by Figure 6 and a brief discussion on the fact that ICICI Bank has a highly diversified loan book. Therefore, the bank is less vulnerable to sectorial volatility and precariousness, which may facilitate its survival in the long run. Finally, Table 3 shows that RBL has the highest scores in technological change as well as TFP change.

It is a relatively small bank in terms of branch expansion and asset size. We could not get detailed information about the bank's technological upgrade. However, since RBL has the lowest labor-related costs and total cost, this may result in the highest TFP change value for the bank.

The lowest MPI scores are recorded by SBI and PNB among all the banks taken together. For SBI, the reason could be the merger with its associates, which escalated their operating costs, labor expenses, and costs on deposits. However, for PNB, fewer outputs like loans and advances relative to its peers could be the culprit. Overall, we observe that none of the private banks reported an MPI score of less than one, while MPI score has been less than one for three out of 10 PSBs for the years under consideration.

Conclusion

This paper uses MPI to measure productivity and efficiency improvement among 19 Indian banks ; these are the banks with the highest market capitalization. We observe that ICICI Bank has the maximum loans and advances, while SBI tops the lists of total costs, labour related costs, investments, as well as deposits. Further, all the PSBs except for one rank behind the private banks in terms of operating profit as a percentage of working funds. Indian Bank is the only PSB that reported a higher operating profit compared to the private sector banks. The MPI score has been the highest for RBL due to low labor expenses and total cost, while the SBI and the PNB have the lowest MPI scores. The problem with SBI has been the merger with its associates ; whereas, for PNB, fewer loans and advances might render the bank less productive. Overall, the private banks appear to be more efficient compared to the PSBs in terms of annual averages; the private banks have MPI scores higher than one for all the years, while PSBs have scores lower than one on two occasions. Therefore, we reject the H0 and Ha1. This result is consistent with the observations made by Narwal and Pathneja (2015) in India for the period from 2009–10 to 2013–14. Further, individual banks' efficiency assessment has also showed that none of the private banks have MPI score less than one, while three PSBs have scored less than one.

Managerial Implications

Based on our findings, the managerial and policy implications that follow are first, the Indian banking sector, particularly the PSBs, need to minimize labor expenses and total cost as much as possible. Further, the PSBs need to reduce government equity and encourage more private equity participation to increase productivity and to ensure long term survival of the banks. Additionally, the PSBs should offer lucrative remuneration to attract the best senior management professionals and unshackle themselves from bureaucratic hassles to stay in competition with the private banks. Further, the PSBs should concentrate more on generating non-interest income rather than interest income because it facilitates absorption of NPAs. Other strategies to ensure sound health of the PSBs could be to minimize loan waiver for agricultural sector and improve overall credit culture.

Limitations of the Study and Scope for Future Research

The limitation of the present study is that is has considered only domestic banks and can be extended to include foreign banks and future studies may examine the peculiarities, if any, specific to the pandemic tenure. Second, there are three alternative assumptions behind the MPI method for measuring banking sector efficiency, namely CRS (constant returns to scale), VRS (variable returns to scale), and NIRS (non - increasing returns to scale). While measuring the efficiency of a DMU, MPI uses only CRS and VRS type of assumptions. The assumption of NIRS measures super efficiency of the DMUs under the MPI method. Super efficiency means extreme efficiency. Our study deals with efficiency under the VRS assumption. Since banking companies have balance sheets of

different sizes in terms of assets, the VRS is more suitable. However, the application of advanced methods like DEA – NIRS (non-increasing returns to scale), slack based approach, and fuzzy DEA based Malmquist Index approach can help us in getting better insights about the efficiency of the Indian banking system.

Authors' Contribution

Mr. Vijyapu Prasanna Kumar conceived the idea and developed quantitative design to undertake the empirical study. He extracted research papers of high repute, filtered these based on keywords, and generated concepts and codes relevant to the study design. Dr. Sujata Kar verified the analytical methods and supervised the study. The analysis and the numerical computations were done by Vijyapu Prasanna Kumar using DEAP 2.1 for data envelopment analysis. Dr. Sujata Kar wrote the manuscript in consultation with Vijyapu Prasanna Kumar.

Conflict of Interest

The authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest, or non-financial interest in the subject matter, or materials discussed in this manuscript.

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