



PERFORMANCE EVALUATION OF INDIA'S SOFTWARE INDUSTRY USING DATA ENVELOPMENT ANALYSIS: A LONG-TERM FIRM-LEVEL STUDY

Sajal K Das^{*1}, Jamal Hussain²

^{1,2}Department of Mathematics and Computer Science, Mizoram University, Mizoram, India.

¹<https://orcid.org/0000-0002-5427-7799>^{id}, ²<https://orcid.org/0000-0001-5553-3654>^{id}

Email: sajalhere@gmail.com

ARTICLE INFO

Article History

Received: March 27, 2026

Reviewed: April 27, 2026

Accepted: July 27, 2026

Published: August 31, 2026

Keywords:

Software firms,
performance trends,
resource utilization,
efficiency analysis,
India.

ABSTRACT

The software industry in India has emerged as a major driver of economic growth, export expansion, and structural transformation within the service sector. In this context, assessing firm-level efficiency is essential for understanding the sector's contribution to economic development. This study empirically examines the technical efficiency of selected Indian software companies over the period 1992–2023 using an input-oriented Data Envelopment Analysis (DEA) model under variable returns to scale (VRS). Firm-level panel data are utilized, with total liabilities and fixed assets as inputs and net sales and profit after tax as outputs. The findings reveal substantial heterogeneity in efficiency performance across firms over time. While leading firms operate close to the efficiency frontier, several firms exhibit persistent inefficiencies, indicating significant scope for improved resource utilization and scale optimization. The results highlight the importance of managerial capability, financial structure, and efficient capital allocation in sustaining the long-term contribution of the software sector to India's economic development.



Copyright ©2026 by authors and Galileo Institute of Technology and Education of the Amazon (ITEGAM). This work is licensed under the Creative Commons Attribution International License (CC BY 4.0).

I. INTRODUCTION

The software industry in India has made a significant contribution to the country's gross domestic product as well as has a remarkable share in the service sector. The software industry, also referred to as Information Technology (IT) or Information and Communication Technology (ICT) is capable of influencing various production sectors such as healthcare, transportation, finance, banking, insurance, logistics, retail, manufacturing, communication and media, entertainment and education [1–5]. In a study Jain et al. [6] conclude that fast delivery, internationalization and adaptation to evolving technologies are key drivers of the growth of the software industry. In 2007, global IT services expenditure amounted to USD 747 billion which grew about 32.13 % in 2018 to 987 billion (USD) [7], [8]. At the end of 2026, the IT industry is expected to reach approximately USD 1.65 trillion, with continued expansion which is influenced by digital transformation initiatives, hybrid cloud migrations, and AI-related service demand. With the global adoption of IT, the Indian software sector is crucial in catering to the demand of the global market. Many Indian IT firms had a global presence. In the Indian economy, the software sector is one of the most dynamic and emerging industries, contributing significantly to economic growth, export earnings, employment generation, and service-sector expansion since the early 1990s. Indian software sector grew rapidly in post-economic liberalization, in 1991-92 from a tiny domestic activity, catering to the domestic market demand to a global competitive industry with huge world market share [9], [10]. It began to play a role in the productivity growth and structural transformation [11]. The significance of the IT sector can be gauged by the contribution to nation's Gross Domestic Product (GDP) which was 1.2% in 1998 growing to 7.9 % in 2018. The Indian IT and IT-enabled services (IT-BPM) sector kept on growing as a sole contributor to the economic growth and exports. The sector generated 91 billion USD as total revenue in 2019, expanded significantly contributing around 7.4 percent of India's GDP and about USD 245 billion in revenues by FY 2022 (CEIC; ESC India Statistical Year Book). Similarly, in FY 2023–24, the industry's overall revenues were roughly USD 253.9 billion, with software services exports constituting the majority of the earnings and maintaining a GDP share of about 7.5–8 percent (ESC India Statistical Year Book). In FY 2024–25, industry expanded nearly USD 283 billion in total revenues, with export earnings near USD 224.4 billion.

Outlooks for 2025 indicate that the IT sector's contribution to GDP may approach around 10 percent, supported by accelerating digital transformation, cloud adoption, and AI-enabled services across the economy. Behind this trajectory of expansion, the Indian IT also passed through major setbacks due to 2008 financial crisis on the technological front [9], [10]. The success of the software sector is enhanced by skilled workers as Indian IT sector is human capital-intensive. Many studies [2], [5], [12–14] suggest the association of the workers' skills, health, efforts and individual performance. It is essential to assess the efficiency of the IT sector in applied economics and development studies. Sales maximization is the guiding principle for software companies [15] as it leads to maximization of market share. The performance of the Indian software/IT sector has been assessed using both parametric and non-parametric approaches. Data Envelopment Analysis (DEA), introduced by [16], is a widely applied non-parametric frontier technique for measuring the relative efficiency of decision-making units (DMUs) characterized by multiple inputs and outputs. DEA is employed to assess the performance of IT/software sector across the globe. The studies [17–20] used DEA to analyse the efficiency of the IT sector in India. The efficiency reflects the extent to which firms optimally utilize available financial and capital resources. To hold on a progressive long-term growth it is essential to enhance the efficiency and productivity with focus on international competitiveness, particularly in a developing economy like India [21]. The underlying insights essential for policymakers and industry stakeholders is inferred from such empirical evaluation of efficiency. Although the Indian software industry has grown rapidly, there is a lack of long-term empirical evidence on firm-level efficiency in the Indian context. Literature is largely dominated by short-term assessments, which offer only partial insights into the sector's evolution [22]. Although several studies have examined efficiency in the Indian IT sector, most are confined to short time spans or specific sub-periods. There is limited empirical evidence based on long-term firm-level data covering more than three decades, including phases of liberalization, global expansion, financial crises, and post-pandemic recovery. This study addresses this gap by providing a comprehensive static DEA-based efficiency assessment for the period 1992–2023. Since the Indian software sector accounts for a significant share of service-sector value added and export earnings, improvements in firm-level efficiency directly influence aggregate productivity, employment generation, and foreign exchange earnings. Therefore, analyzing technical efficiency is not merely a firm-level exercise but also a development-oriented investigation with macroeconomic relevance.

II. RELATED WORK

The significance of liberalization, globalization, and technological advancement in improving the performance of Indian firms has been addressed in several studies [11], [21]. Efficiency analysis has long occupied a central place in applied economics, particularly in studies examining firm and industry performance. Data Envelopment Analysis (DEA), introduced by [16] and extended by [23], has been widely used to estimate the technical efficiency in situations involving multiple inputs and outputs without imposing restrictive functional form assumptions. DEA has been widely applied to assess the performance in the service sector and knowledge-intensive industries, where production processes are complex and heterogeneous [24]. Numerous studies on software as well as information technology firms have reported considerable variations in efficiency and productivity dynamics across firms, which are often attributed to firm size, resource utilization, and managerial competence [20], [25]. In the Indian context, ample evidence exists concerning IT/software firms. In an analysis, Mathur [17] used an input-oriented Data Envelopment Analysis (DEA) model to assess the technical efficiency of 92 Indian software companies for the year 2005–2006 and concluded that only 16 companies were efficient. Mathur [18] assessed the technical efficiency of the Information and Communication Technology (ICT) sector in 12 selected countries using Data Envelopment Analysis. In this study, it was found that the IT sector of Taiwan was the most efficient, while the Indian IT sector was the least efficient. Later, Bhattacharjee [26] estimated the technical efficiency of Kolkata's Software Technology Parks (STPs) for IT–ITeS firms under the variable returns to scale (VRS) assumption using an output-oriented DEA model. The study included all IT and IT-enabled service firms in eastern India for the period 1993 to 2007. The study revealed that the efficiency of large firms improved during the study period and further concluded that segment-specific policies may lead to improved productivity compared with uniform policies. Overall Technical Efficiency (OTE), Pure Technical Efficiency (PTE), and Scale Efficiency (SE) were estimated using DEA. Total sales were considered the output, while employment, expenditure on computers and electronic equipment, operating expenditure, and power, fuel, and water charges were used as inputs.

The mean PTE score is observed to be around 0.6, indicating nearly 40% pure technical inefficiency among the firms. Poor infrastructure, particularly inadequate power supply, is identified as a major constraint affecting performance. The percentage of efficient firms in terms of PTE is lowest in 2003–04 (20.83%) and highest in 2005–06 (40.28%), thereby showing a cyclical pattern over the period. Scale inefficiency increased over time. By [22] analyzed productivity growth trends for 72 Indian software companies from 1999 to 2008. It was found that only 65% of the inputs were optimally utilized by the software firms in India. It was also inferred that larger software firms tended to operate closer to the efficiency frontier, while smaller firms exhibited greater inefficiency and volatility. Domestic software firms were found to be more efficient than the foreign-owned firms. Das [27] evaluated the performance of Indian ITeS industry during 2000-01 to 2014-15 by using a two-stage empirical method to estimate technical efficiency through Data Envelopment Analysis (DEA). The DEA results revealed that managerial inefficiency is the major contributor to overall technical inefficiency compared with inefficient scale of production. Das and Datta [20] applied a two-stage data envelopment analysis method to assess the trends and determinants of technical efficiency in the Indian IT and ITeS industry from the year 2000-01 to 2014-15. In the first stage, output-oriented technical efficiency scores were estimated using CCR, BCC and PK DEA models. In the second stage, the determinants of PK-efficiency were estimated using a random-effects Tobit regression model. The investigation revealed that managerial underperformance was the root cause of overall inefficiency in ITeS companies. By [28] examined the relative efficiency of the top 18 Indian IT software service companies using an output-oriented DEA model. The study assessed overall technical efficiency, pure technical efficiency, and scale efficiency for the period 2010–2017 using CMIE data. Sales expansion and market share growth were considered as the strategic objectives guiding the operations of IT companies. Workers' effort was used as the primary input variable, while net sales turnover and net profit after tax were selected as output variables, with profit after tax serving as an indicator of cost-effectiveness. The results indicated a very high average efficiency score of 96%, suggesting only a limited potential improvement of approximately 4% in output levels at the existing input configuration.

The concept of Functional Efficiency Quality (FEQ) is proposed by [29]. They estimated FEQ for Indian software firms using a sensitivity function-based approach. It is observed that existing literature lacks a comprehensive long-term firm-level static DEA assessment which captures the structural evolution of the industry across the liberalization, global financial crisis, and post-pandemic periods (1992–2023).

III. DATA AND METHODOLOGY

III.1 OBJECTIVE OF THE STUDY

The objectives of the paper are as follows: i) To estimate the technical efficiency of selected Indian software firms using an input-oriented Data Envelopment Analysis (DEA) model under variable returns to scale (VRS) for the period 1992–2023. ii) To examine long-term industry-level efficiency trends across different structural phases of the Indian software industry. iii) To analyse firm-level efficiency heterogeneity and discuss its implications for India's economic development.

III.2 METHODOLOGY

To determine the trends in performance, the notion of technical efficiency is adopted and estimated using an input-oriented Data Envelopment Analysis (DEA) technique. DEA is a non-parametric approach used to evaluate the relative efficiency of similar entities, known as decision making units (DMUs), that employ multiple inputs and multiple outputs [30–32]. The efficiency of a DMU is measured as the relationship between inputs and outputs. It is measured as the ratio of weighted sum of outputs to the weighted sum of inputs when multiple DMUs are involved, as shown below.

$$Efficiency(e) = \frac{\sum_{i=1}^n O_i}{\sum_{i=1}^n I_i} \quad (1)$$

In the above equation, e denotes the efficiency; O_i and I_i represent outputs and inputs respectively, and n denotes the total number of DMUs considered. DEA has evolved significantly over the past five decades and has been extensively used in diverse fields to assess performance as well as for benchmarking [33]. A DEA model proposed by Charnes et al. [16] uses a linear programming technique known as the Charnes, Cooper and Rhodes (CCR) model, which assumes constant returns to scale (CRS). The efficiency score estimated using the CCR model is referred to as overall technical efficiency. Another variation of DEA model, based on the assumption of variable returns to scale (VRS), was proposed by incorporating a convexity condition into the CCR linear programming model. This model is known as Bankers-Charnes-Cooper (BCC) model [23]. Three types of efficiency – pure technical efficiency (PTE), scale efficiency (SE) and overall technical efficiency (OTE) can be estimated using the DEA method. Efficiency can be estimated using either of these two DEA models [24], [32], [34]. In the present empirical study, technical efficiency is estimated using an input-oriented Data Envelopment Analysis (DEA) framework under variable returns to scale (VRS). The input orientation is considered appropriate as software firms have greater managerial control over resource utilisation rather than output levels, which are largely influenced by market demand and global outsourcing trends. The VRS specification enables separation of pure technical efficiency from scale efficiency, thereby capturing the heterogeneity in operational scale at the firm level.

III.3 DATA AND VARIABLE SPECIFICATION

Data for software firms in India were collected for the period 1992–2023. To obtain a comprehensive long-term overview of the performance of the software sector, twelve companies that operated continuously from 1992 to 2023 were selected for the empirical analysis. The basis for selecting these companies is their continuous survival in the market over three decades, including the periods of global crises. This selection was made to meet the objectives of this study. The literature considers different variables for efficiency assessment in software/IT firms. Profit (net profit or profit after tax) has been considered as an output variable in several studies [28], [25]. Income has also been used as an output variable in some studies [10], [25]. Several empirical studies have assessed firm performance using sales as the output variable [17], [22], [28]. In our study, input and output variables reflecting financial performance are used. The two input variables selected are total liabilities (I_1) and fixed assets (I_2). The output variables used in this study are net sales (O_1) and profit after tax (O_2). Profit after tax is a good measure of corporate profitability. The DEA Program (DEAP) software was used for estimation of efficiency [34].

IV. EMPIRICAL RESULTS AND DISCUSSIONS

The overall experimental result is presented under the descriptive performance trends and efficiency trends of Indian software companies. Both these assessments are elaborated in the section below.

IV.1 DESCRIPTIVE PERFORMANCE TRENDS OF INDIAN SOFTWARE COMPANIES

In this section, the performance of Indian software firms is discussed in detail. The performance analysis is carried out using industry-level averages of sales, profit, fixed assets, and total liabilities for the period 1992–2023.

IV.1.1 Growth Trends in Sales and Profit

The analysis carried out on the firm's average sales trend shows a clear and sustained growth throughout the study period. The finding revealed that in the early liberalization phase (1992–2000), sales growth remained relatively modest. During the post-2000 period, a sharp increase is observed, accompanied by the expansion of export-oriented IT services and increased global demand. Significant scalability and market penetration of Indian software firms were observed from 2010 onward, accompanied by rapid growth in Sales. In early 1990s the profit trend remained low, while gradually increasing in the mid-2000s onward which shows a similar pattern to Sales.

Though there is existence of slight ups and downs, profitability increased and remained relatively consistent over years, which suggests improved cost management and greater operational maturity. Steady rise in sales and rising profit indicates that the growth has been as supported by improved financial performance. The post-2010 period is therefore considered as an expansion phase, while the phase beginning around 2010 may be characterized as a period of consolidation and maturity.

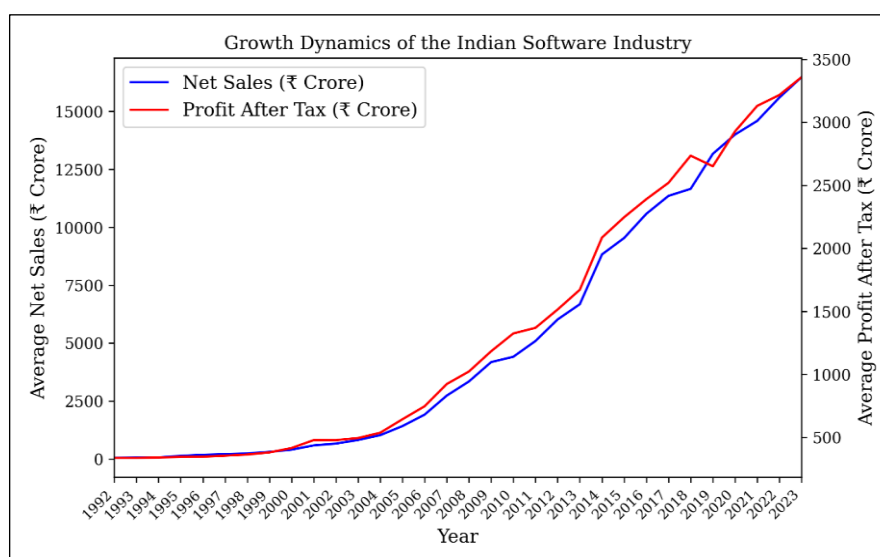


Figure 1: Industry average sales trend for selected software companies.

Source: Author's calculation, CMIE (2026).

IV.1.2 Capital Deepening over Fixed Assets

A remarkable level of capital deepening is revealed by the trend in fixed assets over time. Initially from 1990 to 2003, firms had less fixed assets which indicates low capital intensity in the early phase software sector's evolution. Fixed assets increased from 2004 and continued until 2012, it started to grow more rapidly 2013 onward and the growth continued until 2023. This rise in fixed assets is due to the investments in infrastructure, development centres, and technology platforms. It can be inferred that increased mobilization of advanced IT infrastructure and digital capabilities lead to the rise of fixed assets beyond 2010. A transition toward high-value software services and digital transformation is reflected by this rise.

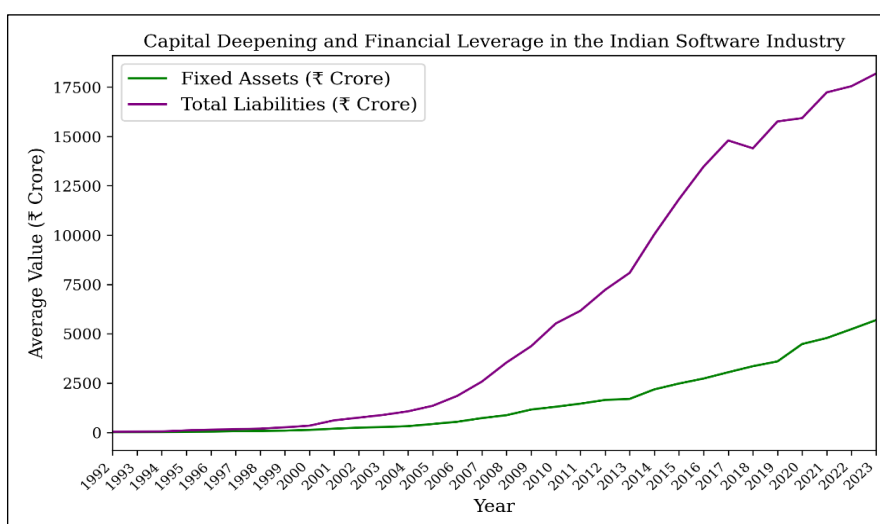


Figure 2: Capital deepening trend estimated on average fixed assets and total liabilities of Indian software companies, 1992–2023.

Source: Author's calculation, CMIE (2026).

IV.1.3 Financial Structure and Liabilities Trend

It can be observed in figure 2, that the company's total liabilities trailed an upward trajectory similar to fixed assets and sales. From 1992-2000, total liabilities of the company were less, but it gradually rose from 2007 onwards. The trend went up till 2017 but sharply went down in 2018. Total liability kept growing continuously until 2023. The dependence of companies on financial leverage is reflected by these rising trends, which also shows its expansion and boosting up in operations. In the periods of global economic stress, particularly around the 2008 financial crisis, company met the setbacks, which is indicated by the ups and down in the trend. It also reflects the company's effort to arise from uncertainty. This reflects an expansion-driven financial structure is depicted by the growth of total liabilities and the intermittent variations point to periods of volatility linked to macroeconomic shocks.

IV.1.4 Software Industry Performance Phases

The trends in all variables are taken together to get an overview of the performance of selected companies. While considering the trends in sales, profit, fixed assets and liabilities, the performance trajectory of the Indian software industry can be broadly classified into three distinct phases. The first phase, Emergence and Stabilization (1992–2000), is characterised by modest growth, limited capital intensity and low financial leverage as the industry established its foundational capabilities. The second phase, Rapid Expansion (2001–2010), shows strong and synchronous growth in sales and profits, with significant build-up of assets and liabilities to scale operations globally. The final phase, Maturity with Periodic Volatility (2011–2023), is marked by sustained top-line growth along with capital deepening, where the maturity of the industry also exposes it to periodic fluctuations in financial performance due to exogenous global economic factors.

IV.1.5 Implications for Efficiency Analysis

It is implied by descriptive trends that output and resource usage have improved substantially, and several economic and technological conditions are responsible for this growth. Therefore, it is significant to assess the relative efficiency instead of absolute performance, which encourages the use of an input-oriented DEA model under variable returns to scale in the consequent analysis.

IV.2 EFFICIENCY TRENDS OF INDIAN SOFTWARE COMPANIES (1992–2023)

An input-oriented DEA under VRS is employed to estimate the technical efficiency scores of selected Indian software companies. The efficiency trends are analysed at three levels: year-wise industry averages, long-term average efficiency, and company-wise efficiency trajectories.

IV.2.1 Year-wise DEA Efficiency Trends

The Technical efficiency score for every year (1992–2023) is estimated using total liabilities and fixed assets as inputs, and sales and profit as outputs. The industry average efficiency trend indicates the presence of many fluctuations over time. There is a gradual improvement in technical efficiency over the study period. The average technical efficiency shows growth from 1993 to 1994 and then continued in a similar manner till 1997. A sharp decrease in 1998 but rose abruptly in 1999 and reached peak at 2000. There was a fall again in 2002 but reversed within a year. The accelerated efficiency during the post-2000 period coincides with export expansion and increased adoption of information technologies. Minor declines are observed during periods associated with global economic uncertainty, particularly around the 2008–09 financial crisis, indicating temporary efficiency disruptions. The ups and downs continued until 2016, presenting a long range of fluctuations. Post-2016, the trend shows a monotonic decrease till 2021. The severe decrease in the year 2020 and with the lowest score 0.70 in 2021 may be attributed to the impacts of COVID-19. The decreasing trend soon reverses by mid-2021 and keeps growing in the later years.

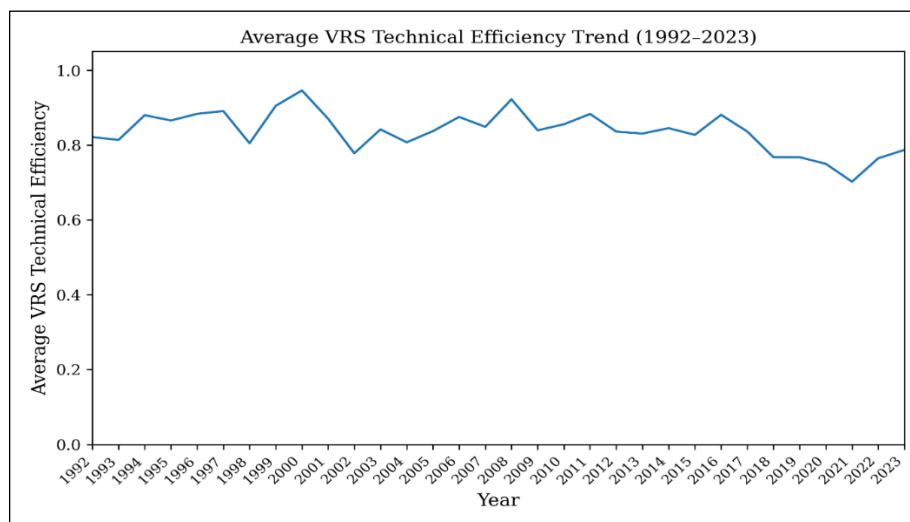


Figure 3: Average VRS technical efficiency trend of selected Indian software companies during 1992–2023.

Source: Author's calculation, CMIE (2026).

IV.2.2 Average Efficiency Trends (1992–2023)

To assess long-term performance, average DEA efficiency scores were computed across the entire period (1992–2023) for the selected software firms. The results show that while several firms consistently operate close to the efficiency frontier, others exhibit persistent inefficiencies. It is observed that the increase in average efficiency leads to the better utilization of financial and capital resources over time. Analysis shows a scope of more improvement, represented by the presence of efficiency gaps across firms, which can be attained through better resource allocation and scale optimization. Rising average efficiency reflects industry maturation, while inter-firm differences highlight heterogeneous managerial capabilities.

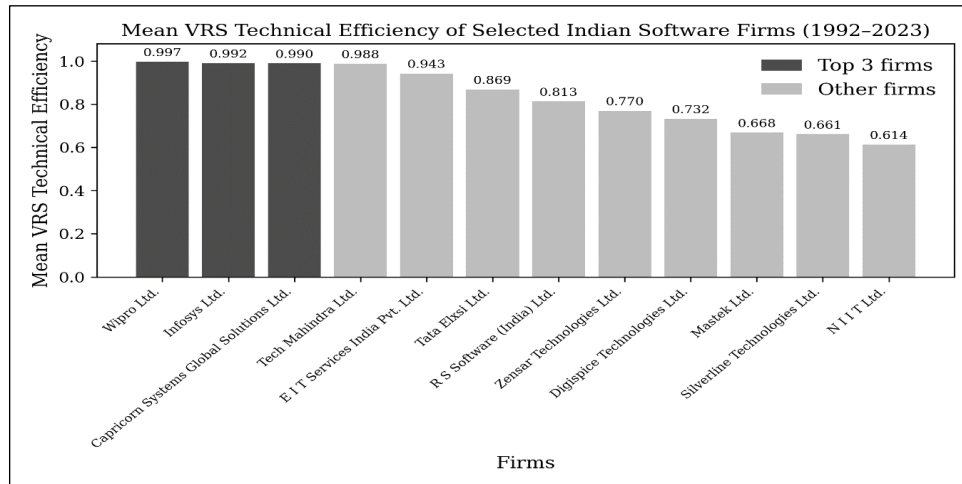


Figure 4: Company-wise VRS technical efficiency of selected Indian software companies during 1992–2023.
Source: Author's calculation, CMIE (2026).

V. CONCLUSIONS

The empirical findings indicate that the Indian software industry has experienced a sustained improvement in technical efficiency over the period under study, albeit with intermittent fluctuations. This upward trend reflects the combined influence of technological progress, industry learning effects, and improvements in financial and managerial practices, leading to enhanced resource utilization capacity over time. However, the efficiency trajectory has not been uniform, as temporary declines are observed during periods of global economic stress, such as the 2008–09 financial crisis and the COVID-19 pandemic, highlighting the industry's sensitivity to external shocks. At the firm level, the analysis reveals a significant degree of heterogeneity in technical efficiency, which persists across time. Larger firms are generally found to operate closer to the efficiency frontier, while small and mid-sized firms exhibit greater inconsistency in efficiency performance. This uneven distribution of efficiency gains suggests that, despite overall progress, substantial scope for improvement remains, particularly among relatively less efficient firms. The presence of persistent inter-firm disparities underscores the importance of factors such as managerial capability, financial structure, and optimal scale of operation in determining firm-level performance. While the gradual rise in average efficiency signifies strengthening operational performance across the industry, continued heterogeneity may have implications for competitiveness, innovation capacity, and long-term sectoral sustainability. In this context, fostering balanced efficiency improvements remains critical for reinforcing the industry's contribution to economic growth and resilience.

VI. AUTHOR'S CONTRIBUTION

Conceptualization: Sajal Kanti Das, Jamal Hussain.

Methodology: Sajal Kanti Das, Jamal Hussain

Investigation: Sajal Kanti Das, Jamal Hussain

Discussion of results: Sajal Kanti Das, Jamal Hussain.

Writing – Original Draft: Sajal Kanti Das.

Writing – Review and Editing: Sajal Kanti Das, Jamal Hussain.

Resources: Jamal Hussain.

Supervision: Jamal Hussain.

Approval of the final text: Sajal Kanti Das, Jamal Hussain.

VII. REFERENCES

- [1] E. M. Ahmed, "ICT and human capital role in achieving knowledge-based economy: Applications on Malaysia's manufacturing", *J. Inf. Knowl. Manag.*, vol. 5, no. 2, pp. 117–128, Jun. 2006.
- [2] S. Arvanitis and E. N. Loukis, "Information and communication technologies, human capital, workplace organization and labour productivity: A comparative study based on firm-level data for Greece and Switzerland", *Inf. Econ. Policy*, vol. 21, no. 1, pp. 43–61, Mar. 2009.
- [3] M. S. Abdullahi, U. R. Shehu, and B. M. Usman, "Impact of information communication technology on organizational productivity in the Nigeria banking industry: Empirical evidence", *Noble Int. J. Bus. Manag. Res.*, vol. 3, no. 1, pp. 1–9, Jan. 2019.
- [4] J. Sandberg, A. Loxbo, and T. H. K. H. Sandberg, "ICT and organizational performance", in *Proc. 6th Int. Conf. Enterprise Inf. Syst.*, pp. 127–133, 2005.
- [5] A. Tarutė and R. Gatautis, "ICT impact on SMEs performance", *Procedia – Soc. Behav. Sci.*, vol. 110, pp. 1218–1225, Jan. 2014.
- [6] N. K. Jain, S. Celo, and V. Kumar, "Internationalization speed, resources and performance: Evidence from Indian software industry", *J. Bus. Res.*, vol. 95, pp. 26–37, Feb. 2019.
- [7] Gartner, "Gartner perspective: IT spending 2010", Gartner Inc., 2009.
- [8] Gartner, "Gartner says global IT spending to grow 3.2 percent in 2019", Gartner Inc., 2018.

- [9] National Association of Software and Services Companies (NASSCOM), "Impact of the IT-BPO industry in India: A decade in review", NASSCOM, 2010.
- [10] M. Kumar, V. Charles, and C. S. Mishra, "Evaluating the performance of Indian banking sector using DEA during post-reform and global financial crisis", *J. Bus. Econ. Manag.*, vol. 17, no. 1, pp. 156–172, Feb. 2016.
- [11] B. Bosworth and S. M. Collins, "Accounting for growth: Comparing China and India", *J. Econ. Perspect.*, vol. 22, no. 1, pp. 45–66, Feb. 2008.
- [12] C. C. Chang, S. W. Hung, and S. Y. Huang, "Evaluating the operational performance of knowledge-based industries: The perspective of intellectual capital", *Qual. Quant.*, vol. 47, no. 3, pp. 1367–1383, May 2013.
- [13] K. Harriss, "Book review: In an outpost of the global economy: Work and workers in India's information technology industry", *J. South Asian Dev.*, vol. 5, no. 2, pp. 293–295, Oct. 2010.
- [14] M. H. Kuo and C. Yang, "Does intellectual capital matter? Assessing the profitability and marketability of IC design companies", *Qual. Quant.*, vol. 46, no. 6, pp. 1865–1881, Oct. 2012.
- [15] N. K. Avkiran, "Investigating technical and scale efficiencies of Australian universities through data envelopment analysis", *Socio-Econ. Plann. Sci.*, vol. 35, no. 1, pp. 57–80, Mar. 2001.
- [16] A. Charnes, W. W. Cooper, and E. Rhodes, "Measuring the efficiency of decision making units", *Eur. J. Oper. Res.*, vol. 2, no. 6, pp. 429–444, Nov. 1978.
- [17] S. K. Mathur, "Indian IT and ICT industry: A performance analysis using data envelopment analysis and Malmquist index", *Glob. Econ. J.*, vol. 7, no. 2, pp. 1–25, May 2007. <https://doi.org/10.2202/1524-5861.1259>
- [18] S. K. Mathur, "Indian IT industry: A performance analysis and a model for possible adoption", MPRA Paper No. 2368, 2007. <https://core.ac.uk/download/pdf/6799223.pdf>
- [19] B. K. Sahoo, "Ownership, size, and efficiency: Evidence from software companies in India", *Benchmarking Int. J.*, vol. 23, no. 2, pp. 313–328, Feb. 2016. <https://www.sciencedirect.com/org/science/article/abs/pii/S1463577116000469>
- [20] P. Das and A. Datta, "Performance evaluation of Indian information technology-enabled services (ITeS) industry: An application of two-stage data envelopment analysis", *Int. J. Adv. Manag. Econ.*, vol. 6, no. 2, pp. 52–70, Apr. 2017. <https://managementjournal.info/index.php/IJAME/article/view/49>
- [21] V. Kathuria, R. Natarajan, and K. Sen, "Growth in Indian manufacturing and services since 1980: Evidence from input–output tables", *World Dev.*, vol. 44, pp. 245–257, Apr. 2013.
- [22] B. K. Sahoo and D. K. Nauriyal, "Trends in and determinants of technical efficiency of software companies in India", *J. Policy Model.*, vol. 36, no. 3, pp. 539–561, May 2014. <https://ideas.repec.org/a/eee/jpolmo/v36y2014i3p539-561.html>
- [23] R. D. Banker, A. Charnes, and W. W. Cooper, "Some models for estimating technical and scale inefficiencies in data envelopment analysis", *Manage. Sci.*, vol. 30, no. 9, pp. 1078–1092, Sep. 1984.
- [24] W. W. Cooper, L. M. Seiford, and K. Tone, *Data Envelopment Analysis: A Comprehensive Text with Models, Applications, References and DEA-Solver Software*, 2nd ed., New York, NY, USA: Springer, 2007.
- [25] C. Serrano-Cinca, Y. Fuertes-Callén, and C. Mar-Molinero, "Measuring DEA efficiency in internet companies", *Decis. Support Syst.*, vol. 38, no. 4, pp. 557–573, Jan. 2005.
- [26] S. Bhattacharjee, "Efficiency dynamics and sustainability of the Indian IT-ITeS industry: An empirical investigation using DEA", *IIMB Manag. Rev.*, vol. 24, no. 4, pp. 203–214, Dec. 2012. <https://www.sciencedirect.com/science/article/pii/S0970389612000766>
- [27] P. Das, "An assessment of performance of Indian software industry during 2000–01 to 2014–15 using data envelopment analysis", *Int. J. Eng. Appl. Manag. Sci. Paradig.*, vol. 44, no. 1, pp. 7–21, 2017.
- [28] S. Goyal, A. N. Sah, R. K. Sharma, and J. Puri, "Estimating technical efficiencies of Indian IT companies for setting improvement targets for inefficient companies: An empirical analysis with workers' effort as key input", *Work*, vol. 66, no. 4, pp. 885–900, Aug. 2020. <https://pubmed.ncbi.nlm.nih.gov/32925144/>
- [29] S. K. Das and J. Hussain, "Functional efficiency quality of Indian software industry: A computational approach", *J. Sci. Technol.*, vol. 12, no. 2, pp. 68–72, 2024. <https://stjmzu.org/index.php/journal/article/view/52>
- [30] H. W. Lampe and D. Hilgers, "Trajectories of efficiency measurement: A bibliometric analysis of DEA and SFA", *Eur. J. Oper. Res.*, vol. 240, no. 1, pp. 1–21, Jan. 2015.
- [31] A. Emrouznejad and G. L. Yang, "A survey and analysis of the first 40 years of scholarly literature in DEA: 1978–2016", *Socio-Econ. Plann. Sci.*, vol. 61, pp. 4–8, Mar. 2018.
- [32] J. Puri and S. P. Yadav, "Performance evaluation of public and private sector banks in India using DEA approach", *Int. J. Oper. Res.*, vol. 18, no. 1, pp. 91–121, 2013.
- [33] A. Mergoni, A. Emrouznejad, and K. De Witte, "Fifty years of data envelopment analysis", *Eur. J. Oper. Res.*, vol. 326, no. 3, pp. 389–412, Nov. 2025.
- [34] N. K. Avkiran, *Productivity analysis in the service sector with data envelopment analysis*, 3rd ed., Brisbane, Australia: University of Queensland, 2006.