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AN EXTENSIVE ANALYSIS OF THE SOFTWARE COMPANIES EFFECTIVENESS IN INDIA

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Abstract

India's software sector contributes significantly to GDP and has a substantial share of the export market. This study ranks the performance of selected Indian software companies according to their technical efficiency. The company's efficiency is evaluated using the input-oriented DEA technique over an extended period, from 1992 to 2021. Performance trends are generated. Companies that perform best are compared with those that perform poorly or inefficiently. To increase efficiency, firms can follow the business strategies, techniques, ethics, and best practices of efficient companies. The results of the present study could assist in managerial decision-making.

Keywords:

Performance Analysis, Software Industry in India, Data Envelopment Analysis, Benchmarking

1. INTRODUCTION

The service sector in India has contributed nearly half of its GDP over the last few years. The service sector has contributed to the Gross Value Added (GVA) over the years, with its share showing steady growth from 50.6% in the Fiscal Year 2015-16 to nearly 55% in FY 2024-25. The IT-BPM sector is a major driver of economic growth in India and contributes significantly to the country's GDP. In FY23, it accounted for 7.5% of India's GDP and is projected to reach 10% by FY25. The hardware and the software industry received 16% of total FDI inflow in FY2025. In 2023, the revenue generated by the IT service market was 69,201.6 million in India.

The IT sector in India is highly diverse and is mainly supported by the availability of a vast pool of skilled IT professionals, cheap labor, and favorable government policies. Indian IT services have boomed due to the demand of outsourced-based service for the global software markets. Indian entrepreneurs set up software development firms to service the needs of clients in developed countries. Major software companies like Tata Consultancy Services (TCS), Cognizant Technology Solutions, Infosys Technologies, Wipro, HCL Technologies have a global presence and are among the largest software companies in the world. The Indian software industry is a fast-growing service sector that continues to evolve and catching up more momentum with times. The software sector supports software development across various domains such as finance, healthcare, banking, insurance, e-commerce, education, retail, manufacturing, telecommunication, ERP, e-governance, etc. The software industry comprises IT services with Application Maintenance and Support which mainly provide services to maintain and support existing software applications for clients worldwide and also Indian companies excel in providing system integration services. Various services such as customer support, technical support, data entry, and other non-core business processes are being outsourced; hence, the software sector includes Business Process Outsourcing (BPO). Product development is an integral part as many Indian companies focus on developing and marketing their software products ranging from enterprise solutions to consumer applications. The software industry also provides engineering services such as product design, prototyping, and testing for clients in industries such as automotive, aerospace, and telecommunications. The industry has seen an increase in R&D activities, with companies investing in innovation and technology-driven solutions. The software industry in India has a vibrant startup network, with numerous startups focusing on innovative solutions and disruptive technologies including evolving areas like artificial intelligence, machine learning, blockchain, etc. Indian IT companies are significant and popular across the globe, with a large portion of their revenue coming from international markets. North America, Europe, Asia-Pacific, and other regions are being served. A vast number of computer science engineering graduates graduate each year in India, contributing to the workforce in the software industry. Several initiatives to promote the IT sector, including tax incentives, infrastructure development, and policies to facilitate ease of doing business, have been implemented by the government. Given its significance for foreign exchange and exports, the performance and efficiency of the software sector are crucial.

Speedy delivery, internationalization, and adapting the pace with evolving technology are the facts behind the growth of the software industry, Jain et al. (2019). In the literature on performance assessment of the software industry, efficiency is analyzed over different periods employing the frontier and non-frontier-based methods. This study aims to assess the technical efficiency of selected Indian software firms over the longitudinal period from 1992 to 2023 using DEA. Proceeding further, Section 2 presents an extensive literature on software firms efficiency. Section 3 describes some underlying theoretical notions, followed by Section 4 which presents the results and Section 5 is the conclusion.

2. LITERATURE REVIEW

The software companies rooted in India have witnessed faster growth with significant contributions to the country's GDP and employment. Efficiency is an important factor for the growth and development of this industry. Several studies have assessed the efficiency of the Indian software industry using different approaches. An input-oriented data envelopment analysis (DEA) model was applied in [2] to assess the technical efficiency. The study considered 92 software companies in India during 2005-2006 and analyzed the effect of various determinants of technical efficiency for these companies. The technical efficiency of the Information and Communication Technology (ICT) sector for selected 12 countries employing data envelopment analysis was assessed in [3]. The study suggested that ICT infrastructure

should be strengthened in India. Taiwan was the most efficient country with a score of 1 and India being the most inefficient with technical efficiency scores of 0.72.

DEA was used to assess the managerial, technical, and scale efficiencies for 73 listed Chinese Information Technology (IT) companies in [6]. The study period was from 2005 to 2007. In those IT organizations, Total Factor Productivity (TFP) and its sources were estimated using the Malmquist Productivity Index (MPI). Operating costs, staffing levels, fixed assets, and intangible assets were input variables, whereas net profit and yearly sales were output variables. With a mean of 0.6, the years 2000–2005 had the lowest pure technical efficiency, with companies only 40 percent efficient, according to the study by Sahoo, D. in [5].

Bhattacharjee (2012), technical efficiency of Kolkata's Software Technology Park (STP)'s for IT-ITeS firms was assessed under variable returns to scale (VRS) assumption and employing an output-oriented DEA model. Sridhar and Srinivasan (2012) found that the key factors for the efficiency and competitiveness of the Indian software industry are innovation and the ability to adapt to changing market conditions.

Sahoo (2013) estimated total factor productivity growth for selected 72 software companies in India from 1998 to 2008 by employing Malmquist productivity index. While estimating the determinants of TFP growth they found that most of the software industry had TFP growth by 0.4 percent in that period in India. In a study Sahoo and Nauriyal (2014) assessed the patterns in technical efficiency of Indian software companies. The span of the study was 1999-2008 and an input-oriented DEA model under the Variable Returns to Scale assumption was used. Market structure and competition have a significant impact on the efficiency of the Indian software industry.

Das (2017), Das and Datta (2017) applied a two-stage data envelopment analysis method to assess the trends and determinants of technical efficiency in Indian IT and ITeS industry, from the year 2000 to 2014. The Pareto-Koopmans efficiency using CCR and BCC models introduced in Banker et al. (1984) efficiency scores was estimated in both studies to take care of the input and output slacks. Furthermore, Chakrabarti and Gupta (2018) analyzed the impact of tax incentives and subsidies on the efficiency of the Indian software industry and found that these policies can have a positive impact on the industry's efficiency. Similarly, Dutta et al. (2019) found that the Indian software industry has a high level of total factor productivity (TFP), which is a measure of how efficiently the industry is using its inputs to produce output. In a study, Goyal et al. (2020) evaluated the relative efficiency of 18 IT software service companies from India. The period of study was from 2010 to 2017 and the DEA method was used with workers' effort as the sole input. The result concluded that in 2017, the top five IT companies revealed higher efficiency with respect to other companies.

3. THEORETICAL CONCEPTS

3.1 EFFICIENCY

Efficiency is a fundamental concept in industrial production, encompassing various dimensions that contribute to the optimal use of resources. The efficiency assessment is widely undertaken as a benchmark for identifying the inefficient companies in various industries. Efficiency is significant for achieving a competitive market edge and also for ease of living with lower cost involved in daily life. Efficiency is defined as the ratio of total output to the total input. Efficiency can also be understood in terms of the cost of the product with respect to the total cost incurred in its production. Efficiency can be represented as in Eq.(1).

$$Efficiency(e) = Output / Input \quad (1)$$

3.2 TECHNICAL EFFICIENCY

Technical Efficiency (TE) is defined as the ability to produce maximum possible output using a specified level of input. It focuses on optimizing processes and resources to achieve the highest possible production level with the available technology and resources. This helps organizations minimize waste, reduce costs, and improve overall productivity and growth. Achieving the highest output from a specific set of resources or inputs without wasting or using them inefficiently is known as technical efficiency. Technical Efficiency involves achieving the maximum possible output from a given set of resources or inputs, without wasting or inefficiently using them. Essentially, it is about optimizing the production process to ensure that resources are employed in the most effective manner, resulting in higher productivity and output for a given level of input. This concept is often applied in economics, business, and various industries to assess and improve the operational performance. Technical Efficiency is measured by a simple ratio of outputs to inputs. A company is considered more technically efficient when it produces a higher level of output than another company with the same level of input and technology. Data Envelopment Analysis (DEA), Stochastic Frontier Analysis (SFA), Total Factor Productivity (TFP), Benchmarking, Input-Output Analysis, process optimization models, etc. can be used for estimating technical efficiency.

3.3 DATA ENVELOPMENT ANALYSIS

A production unit that transforms inputs into outputs is termed a Decision-Making Unit (DMU). DEA is a deterministic nonparametric mathematical programming method. DEA evaluates the efficiency of a DMU with respect to the 'best-practice' or benchmark production frontier. So, it is a method to measure the relative efficiency with respect to the efficient DMUs. Data Envelopment Analysis (DEA) was developed by Abraham Charnes, William W. Cooper, and Edward Rhodes in the late 1970s. The initial model was called the Charnes-Cooper-Rhodes (CCR) model, which estimates the efficiency of decision-making units (DMU), with multiple inputs and outputs.

Over time, researchers extended DEA to include different variations and models, such as the BCC (Banker, Charnes, Cooper) model. DEA has since become a widely used method in efficiency analysis, applied in various fields such as economics, finance, banking, and management, etc. The original DEA model considers constant returns to scale (CRS). The CCR model was introduced to estimate the relative efficiency of DMUs by evaluating their input and output combinations. It assumes a constant return to scale (CRS) meaning a proportional increase or decrease in inputs and outputs does not affect efficiency. This assumes that the scale of operations is optimal. Efficiency score

with CCR is termed the overall technical efficiency (OTE) reciprocally, the BCC efficiency score is pure technical efficiency (PTE) or managerial efficiency.

Many empirical studies in a variety of domains, including non-profit public organizations, the banking industry, hospitals, airports, health, textiles, and other industries, use both of these models. In the literature, technical efficiency (TE) is mostly measured using two types of orientation, namely input-oriented and output-oriented. The proportionate drop of all inputs given the output set is assessed in input-oriented technical efficiency or technical input efficiency. While a proportional extension of all outputs is expected given the set of inputs is referred to as output-oriented or technical output efficiency. Assuming in a single input-output scenario, both these efficiencies are depicted below in Fig.1.

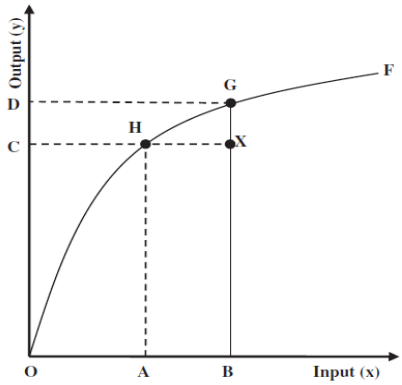


Fig.1. Technical Efficiency

Output-oriented technical efficiency = OC/OD

Input-oriented technical efficiency =OC/OA

The plotted curve OF portrays the frontier i.e. the maximum output that is attainable. DEA assigns efficiency score to DMUs in the closed interval [0,1]. An efficiency score of one designates an efficient DMU and an inefficient DMU to have a score of zero. The simpler single input and single output system can be mapped to multi-input-output scenario representing many DMUs using linear programming optimization techniques.

4. RESULTS AND DISCUSSIONS

Data from the CMIE Prowess database are used for the current study. The DMUs are the twelve selected software companies in India as shown in Table.1. While selecting the companies for the purpose of the study, the companies that existed in business for the period 1990 to 2021 were considered. The emphasis is placed on the longitudinal existence of the companies to understand how these companies performed in their long journey. Input-oriented data envelopment analysis under CRS assumption is employed. Total liabilities and gross fixed assets are considered as input variables, and sales are considered as the output variable to estimate technical efficiency. The selection of the input and output variables are based on the literature. The technical efficiency of the twelve companies is estimated. Graphs of technical efficiency over the 30-year span of the selected companies are presented in Fig.3 to reveal the trends of performance.

Table.1. Selected companies (DMUs)

Sl. No.	Company Name
1	Capricorn Systems Global Solutions Ltd.
2	Digispice Technologies Ltd.
3	E I T Services India Pvt. Ltd.
4	Infosys Ltd.
5	Mastek Ltd.
6	NIIT Ltd.
7	R S Software (India) Ltd.
8	Silverline Technologies Ltd.
9	Tata Elxsi Ltd.
10	Tech Mahindra Ltd.
11	Wipro Ltd.
12	Zensar Technologies Ltd.

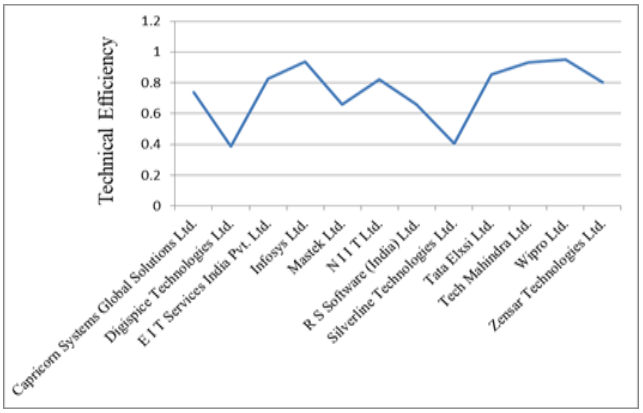
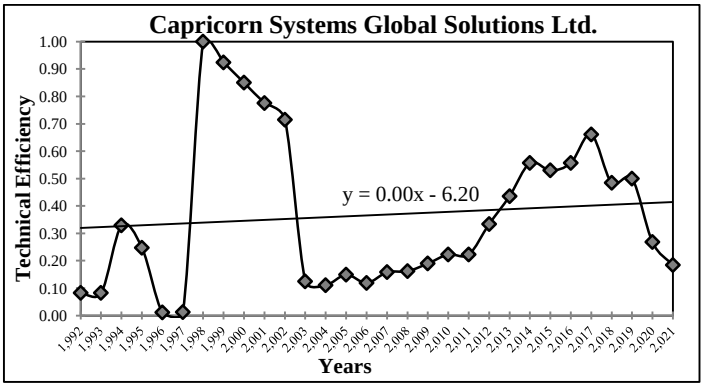
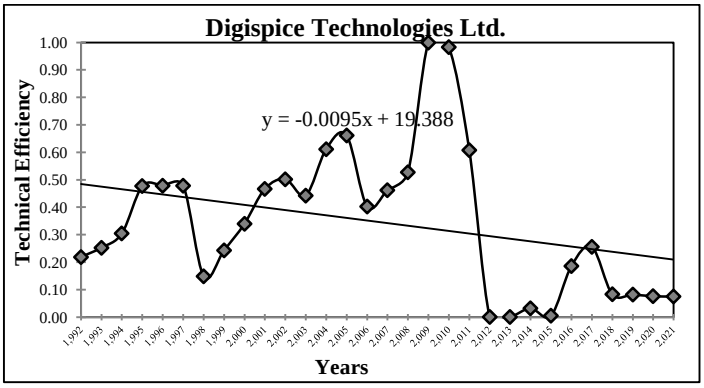
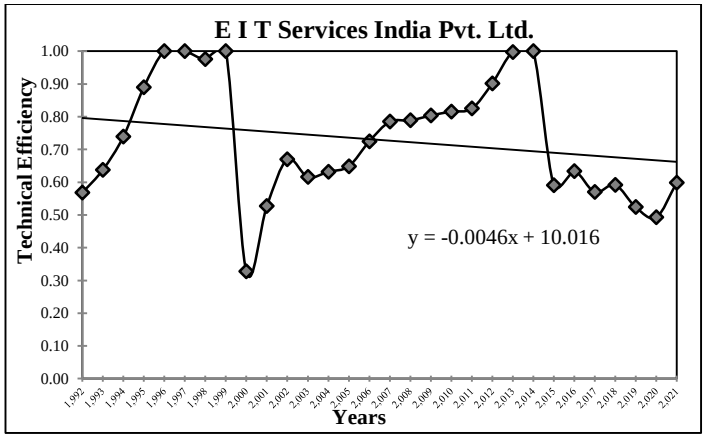
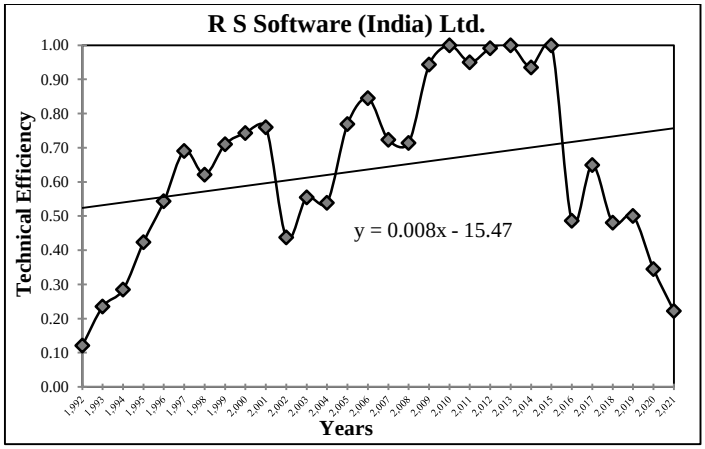


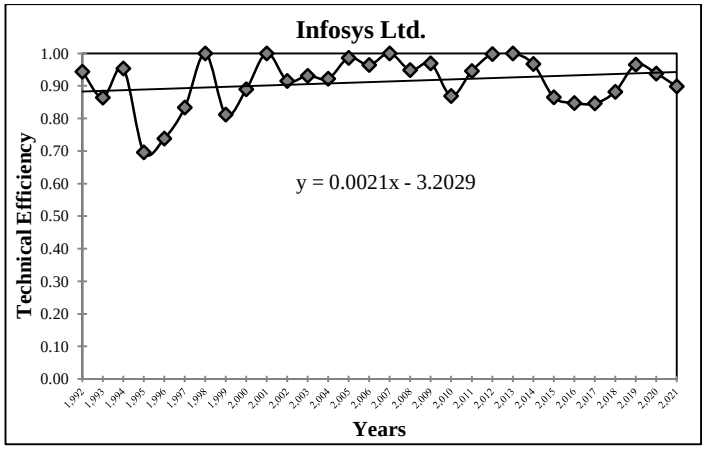
Fig.2. Mean Technical Efficiency of 12 Companies from 2012 to 2021

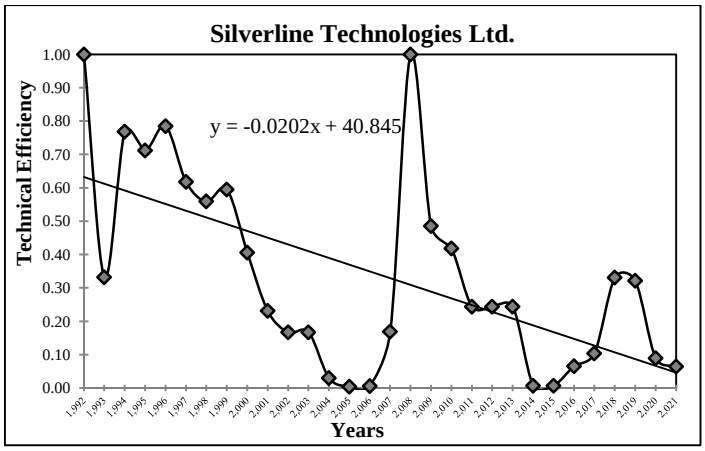


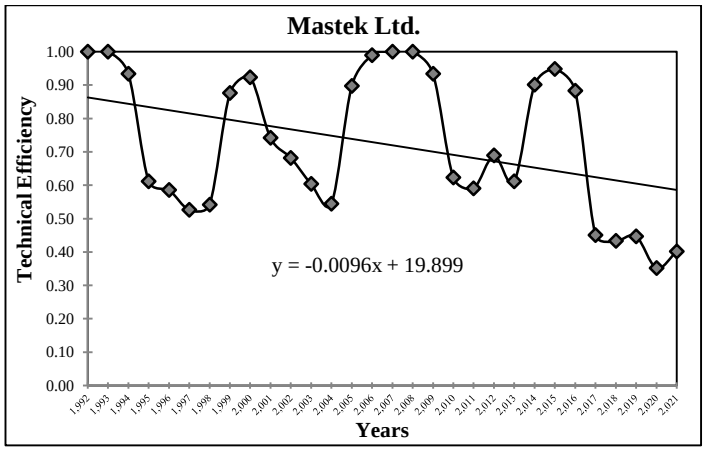


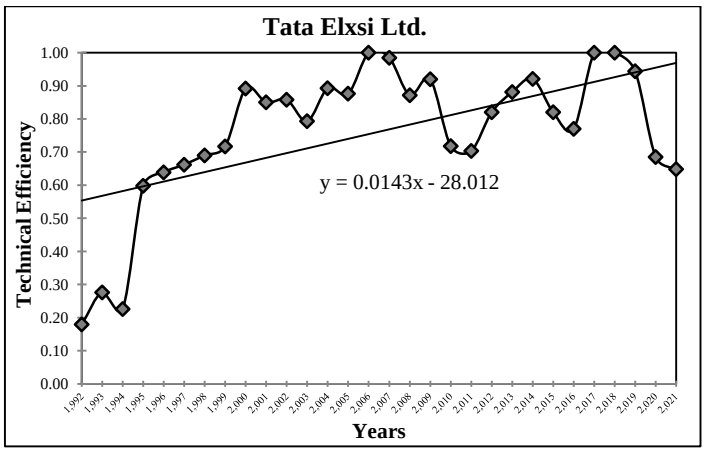

E I T Services India Pvt. Ltd.
Technical Efficiency
y = -0.0046x + 10.016
Years

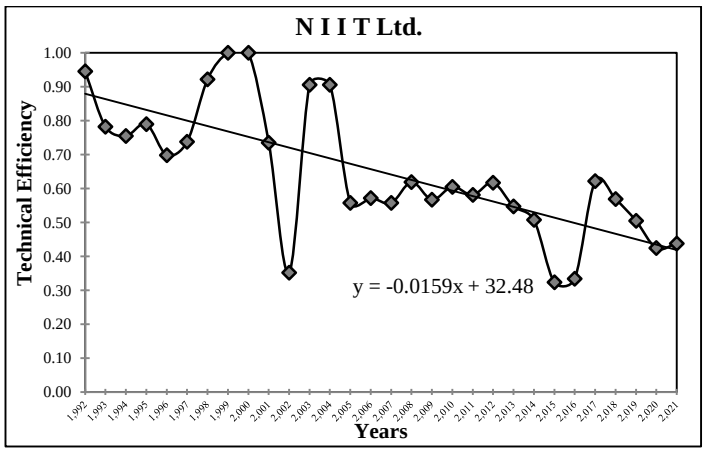

R S Software (India) Ltd.
Technical Efficiency
y = 0.008x - 15.47
Years

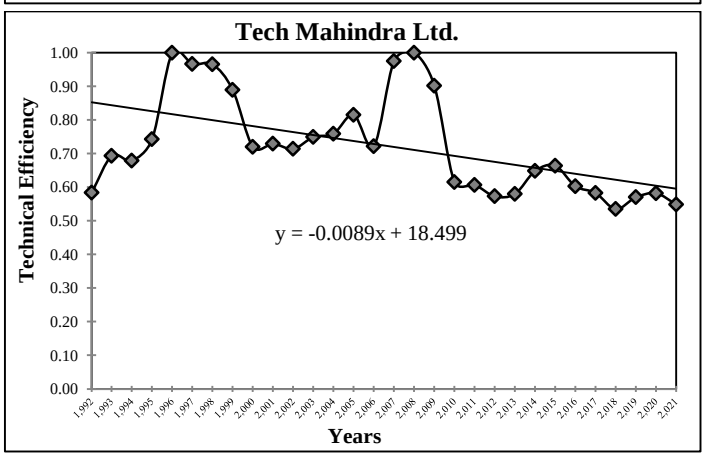

Infosys Ltd.
Technical Efficiency
y = 0.0021x - 3.2029
Years


Silverline Technologies Ltd.
Technical Efficiency
y = -0.0202x + 40.845
Years


Mastek Ltd.
Technical Efficiency
y = -0.0096x + 19.899
Years


Tata Elxsi Ltd.
Technical Efficiency
y = 0.0143x - 28.012
Years


N I I T Ltd.
Technical Efficiency
y = -0.0159x + 32.48
Years


Tech Mahindra Ltd.
Technical Efficiency
y = -0.0089x + 18.499
Years

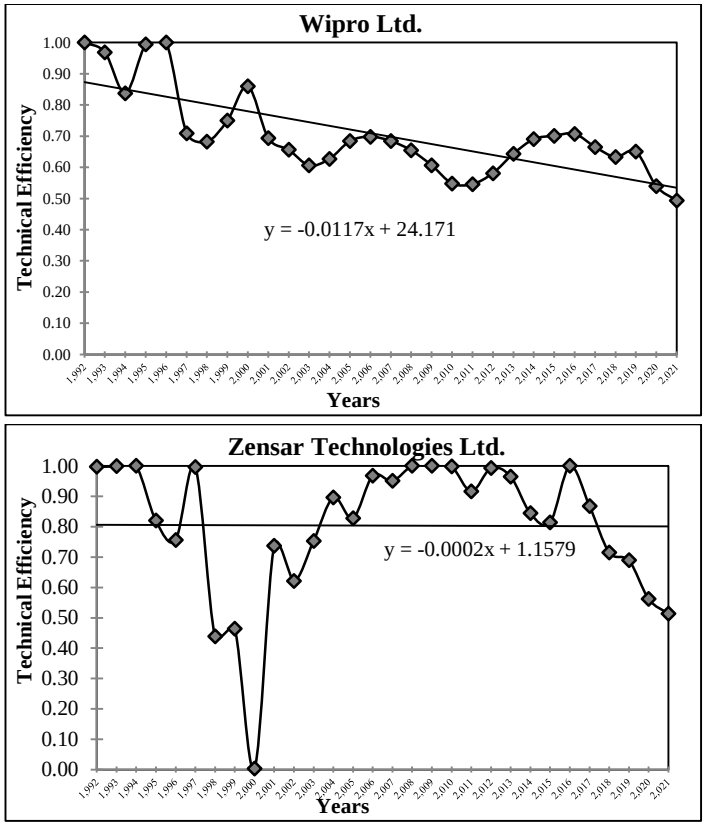


Fig.3. Technical Efficiency of Companies

5. CONCLUSION

The technical efficiency for the twelve selected companies is estimated for the period 1992 to 2021. The Fig.2 shows the mean technical efficiency of each company for the period. The experimental results reveal that Infosys Ltd., Zensar Technologies Ltd., and Tata Elxsi Ltd. are the top three companies in order of technical efficiency. Infosys Ltd. serves as the benchmark, with the highest technical efficiency score of 0.913. Mastek Ltd., Tech Mahindra Ltd., Wipro Ltd., and NIIT Ltd. are the companies that showed an average level of efficiency among the selected companies. RS Software (India) Ltd., Digispice Technologies Ltd., Capricorn Systems Global Solutions Ltd., and Silverline Technologies Ltd. ranked among the bottom four companies. Silverline Technologies is the least efficient company with a technical efficiency score of 0.339. The mean technical efficiency exhibited by the twelve companies over the 30-year period from 1992 to 2021 is 0.641. The study reveals that there is a significant level of inefficiency and the magnitude of inefficiency is 0.358. Business strategies and managerial practices can be adopted from the benchmark and implemented to improve overall efficiency.

REFERENCES

[1] R.D. Banker, A. Charnes and W.W. Cooper, "Some Models for Estimating Technical and Scale Inefficiencies in Data Envelopment Analysis", *Management Science*, Vol. 30, No. 9, pp. 1078-1092, 1984.

[2] S.K. Mathur, "Indian IT and ICT Industry: A Performance Analysis using Data Envelopment Analysis and Malmquist Index", *Global Economy Journal*, Vol. 7, No. 2, pp. 1-11, 2007.

[3] S.K. Mathur, "A Performance Analysis and a Model for Possible Adoption", *Munich Personal Repec Archive*, No. 2368, pp. 1-7, 2007.

[4] S. Bhattacharjee, "Efficiency Dynamics and Sustainability of the Indian IT-ITeS Industry: An Empirical Investigation using DEA", *IIMB Management Review*, Vol. 24, No. 4, pp. 203-214, 2012.

[5] D. Sahoo, "Efficiency of the Information and Technology Sector of India and its Relevance to Indian Economic Growth", *Journal of Infrastructure Development*, Vol. 4, No. 1, pp. 41-58. 2012.

[6] X. Chen, X. Wang, D.D. Wu and Z. Zhang, "Analysing Firm Performance in Chinese IT Industry: DEA Malmquist Productivity Measure", *International Journal of Information Technology and Management*, Vol. 10, No. 1, pp. 3-23, 2011.

[7] B.K. Sahoo, "Total Factor Productivity of the Software Industry in India", *IEG Working Paper*, Vol. 8, No. 3, pp. 1-7, 2013.

[8] B.K. Sahoo and D.K. Nauriyal, "Trends in and Determinants of Technical Efficiency of Software Companies in India", *Journal of Policy Modeling*, Vol. 36, No. 3, pp. 539-561, 2014.

[9] P. Das, "An Assessment of Performance of Indian Software Industry during 2000-01 to 2014-15 using Data Envelopment Analysis", *International Journal of Engineering, Applied and Management Sciences Paradigms*, Vol. 44, No. 1, pp. 7-21, 2017.

[10] P. Das and A. Datta, "Performance Evaluation of Indian Information Technology-Enabled Services (ITeS) Industry: An Application of Two-Stage Data Envelopment Analysis", *International Journal of Advances in Management and Economics*, Vol. 6 No. 2, pp. 52-70, 2017.

[11] Prosenjit Das, "An Evaluation of the Determinants of Total Factor Productivity Growth in Indian Information Technology Industry: An Application of DEA-based Malmquist Index", *The Central European Review of Economics and Management*, Vol. 1, No. 4, pp. 175-224, 2017.

[12] N.K. Jain, S. Celo and V. Kumar, "Internationalization Speed, Resources and Performance: Evidence from Indian Software Industry", *Journal of Business Research*, Vol. 95, pp. 26-37, 2019.

[13] 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, 2020.