

Functional Efficiency Quality of Indian Software Industry: A Computational Approach

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Abstract—Efficiency measures in the software industry are of huge importance as the software sector is a major contributor to the service sectors in India. This study applied a sensitivity function approach to assess the performance of a few selected software companies in India. A measure called Integrated Functional Efficiency Quality (IFEQ) is proposed. With the data from the CMIE database, the IFEQ is assessed and presented. The results revealed that the companies are performing at an average level. The trends of performance of companies are evaluated over a period from 1992 to 2021. The managerial decision-makers may be assisted with policy implementation to attain business efficiency.

Keywords: Performance analysis, Indian software industry, sensitivity function, functional efficiency, quality of efficiency.

INTRODUCTION

India's software industry began to shape in the 1980s and in the following years, the industry grew rapidly, driven by demand from global companies looking to outsource software development work to low-cost destinations. Today, India's software industry is estimated to be worth several billion dollars, with thousands of software development firms operating across the country. Some of India's biggest software firms, such as Tata Consultancy Services, Cognizant Technology Solutions, Infosys Technologies, Wipro, HCL Technologies etc. also have a global presence and are among the largest software companies in the world. Despite the COVID-19 pandemic-induced economic downturn, this sector achieved a real growth rate of 10.4 per cent in the financial year 2021 (Economic Survey 2023-24, Government of India). Hence the assessment of the performance of the software companies appeal its significance.

Efficiency is vital in the Indian software industry for many reasons. It is a must for gaining a competitive edge. Cost Optimization, Time-to-Market, Customer Satisfaction and

Innovation are the other reasons. An efficient software development process helps organizations reduce their costs by streamlining workflows, automating tasks, and minimizing errors. The same also lead to higher customer satisfaction allowing organizations to focus more on innovation and exploring new ideas.

Bhattacharjee (2012) assessed the performance of technical efficiency of Kolkata's Software Technology Park (STP) for IT-ITeS firms considering the Variable Returns to Scale (VRS) assumption. Sahoo(2013) reported that the Mean Pure Technical Efficiency (PTE) score was about 0.6 specifying that companies have 40 per cent pure technical inefficiency. Infrastructure bottlenecks and frequent power cuts lead to unpunctual productivity loss in IT hub, Bengaluru. The percentage of efficient companies in the PTE score follow a cyclical pattern. Sahoo and Nauriyal (2014) applied the Malmquist productivity index to assess the determinants of Total Factor Productivity growth. The study compared the trends in technical efficiency of Indian software companies

during 1999-2008. The efficiency of software firms were analyzed with an input-oriented DEA model under the VRS assumption. Many researchers assessed the performance of software and ITeS companies, i.e., Mathur (2007a, b), Sahoo D (2011), Das and Datta (2017), Das (2017), etc.

DEFINITIONS AND SOME THEORETICAL CONSTRUCTS

FUNCTIONAL EFFICIENCY QUALITY (FEQ) AND QUALITY INTERVAL

To measure the overall quality of efficiency of the companies in the Indian software industry, we have considered the notion of functional efficiency quality. Functional efficiency is defined as the overall efficiency of the company to how it is performing from all aspects including financial, technical, production and employee growth, market share, etc. or in other sense the overall function considering all the variables available in the data set. Functional efficiency quality is a

measure to assess the functional quality of the companies in an industry. The FEQ for all companies is computed for every financial year. This calculation will be data-oriented as all variables in the dataset will contribute to the FEQ. Every input parameter considered for the computation of functional efficiency quality has a recommended value r , or a recommended range ($r_1 \leq x \leq r_2$) within which a minimum l and maximum r permissible limit is presumed. These (l) and (r) are generally referred to as the lower limit and upper limit respectively. The closed interval $[l, u]$ in which the recommended value lies is termed the Quality Interval (QI). There lies an Excellent Quality Interval (EQI) or Excellent Quality Point (EQP) which is the region corresponding to the closed sub-interval $[r_1, r_2]$. The region on the left of EQI is a semi-closed sub-interval $[l, r_1]$ referred to as the Increasing Quality Interval (IQI) and right to the Excellent Quality Interval (EQI) there lies a semi-closed sub-interval $[r_2, u]$ known as Decreasing Quality Region (DQI). All these regions are described in Figure 1 below:

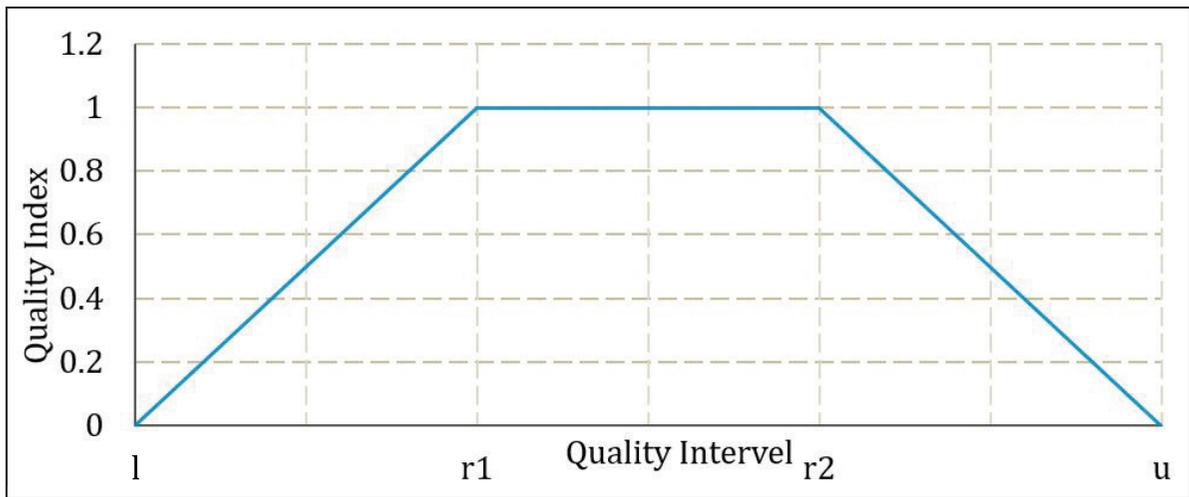


Fig. 1: Quality Map.

The values of the sensitivity function are termed sensitivity numbers which are obtained for all the chosen parameters of the company. These values of sensitivity number can be mapped to real domain R with a mapping $fp : [-1, +1]$.

SENSITIVITY FUNCTION AND SENSITIVITY NUMBER

For accessing the quality index, the following sensitivity function is used (Sundararajan and Loveson, 2002):

$$f_p(x) = \begin{cases} -1 & \text{if } x < l, \\ \frac{x-r_1}{r_1-l} & \text{if } l \leq x < r_1 \\ 0 & \text{if } r_1 \leq x \leq r_2, \\ \frac{x-r_2}{u-r_2} & \text{if } r_2 < x \leq u \\ 1 & \text{if } x > u, \end{cases}$$

where l and u are considered to be the lower limit and the upper limit respectively and p is referred to as the sensitivity number.

INTEGRATED FUNCTIONAL EFFICIENCY QUALITY (IFEQ)

The Integrated Functional Efficiency Quality (IFEQ) for a company is calculated year-wise for each of the companies considered from the dataset. IFEQ integrates the overall quality of efficiency or overall functioning for that company in a particular year. It is an aggregated value of the quality index of the parameters of a company for a particular selected year.

FUNCTIONAL EFFICIENCY ASSESSMENT

The data of the Indian software industry were collected from the CMIE PROWESS database. The datasets are usually unprocessed panel data unbalanced in nature, collected over a long period from 1990 to 2021. The data has a total of thirty variables. For computing the sensitivity number using the sensitivity function, we access the quality index and aggregating the quality index and compute the IFEQ. Twelve companies from the dataset are selected which are namely, Capricorn Systems Global Solutions Ltd., Digispice Technologies Ltd., EIT Services India Pvt. Ltd., Infosys Ltd., Mastek Ltd., NIIT Ltd., R S Software (India) Ltd., Silverline Technologies Ltd., Tata Elxsi Ltd., Tech Mahindra Ltd., Wipro Ltd. and Zensar Technologies Ltd. We used 21 parameters for measuring IFEQ. The input parameters are classified as favourable parameters and non-favourable based on their parameter value. If the value of a particular input variable goes high and the increasing trend of that variable is good for the company, then that variable is marked as favourable. For instance, *Pat* (profit_after_tax), for this variable if the value is increasing, we can conclude it is good for the company, hence *Pat* is marked as a favourable parameter for the company. Similarly, for a variable whose values if it goes high and from simple observation, it can be said that values of that variable if it goes high, is a loss for the company, then that variable is categorized as a non-favourable variable. Like if we consider the *total_liabilities*, and we see that the value of *total_liabilities* goes high that means the company need to pay more compensation to the employees. Such a scenario is not desirable for the company, hence *total_liabilities* is considered a non-favourable variable. To compute the quality index numbers two different formulae are employed for the favourable

and non-favourable parameters. The sensitivity number is then calculated using the sensitivity function defined for the parameter in the interval index. The quality index of each parameter for every company for each year is then estimated from the respective sensitivity number. Finally, the quality index of each parameter is integrated to obtain IFEQ. The algorithm below is formulated to calculate the value of Integrated Functional Efficiency Quality (IFEQ).

Input: A dataset D consist of parameters P_i and l, u .

Output: IFEQ(Integrated Functional Efficiency Quality)

IFEQ_Compute (D, P_i)

Step 1: Start

Step 2: For each, P_i for a company C_i from dataset D

when $P_i_class = favourable$

$$f_p(x) = (P_i - l) / (u - l)$$

$P_i_class = non-favourable$

$$f_p(x) = (u - P_i) / (u - l)$$

Step 3: Calculate quality index, $q_i = 1 - |f_p(x)|$

Step 4: Repeat steps 2 through 3,

$\forall C_i$ in D , until $D = Null$

Step 5: $QI_a = \left(\frac{1}{n} \sum_{i=1}^n q_i\right)$

Step 6: Stop

RESULT AND DISCUSSION

The IFEQ of all selected companies from the period of study is assessed and presented here. In the plotted graph the horizontal axis (x-axis) and vertical axis (y-axis) represent the years and IFEQ respectively. To capture the performance trend of the company the trend line is shown in the graph. The trend equation for every concerned company is shown in the graph. The R^2 values are also obtained for a better understanding of the performance. The slope m , from the plotted equation of the trend line, can be considered to understand the performance.

A positive increasing value of m (towards 1) represents the progress of the company whereas a decreasing value (towards -1) represents the regress (declining trends) of performance for the company for the considered period. The companies can be clustered into different clusters (or classes) based on the observed value of m . The following class may be adopted to classify the companies with some suggested remarks that may be used for better managerial decision-making for enhancing efficiency for the companies.

Functional Efficiency Quality of Indian Software Industry

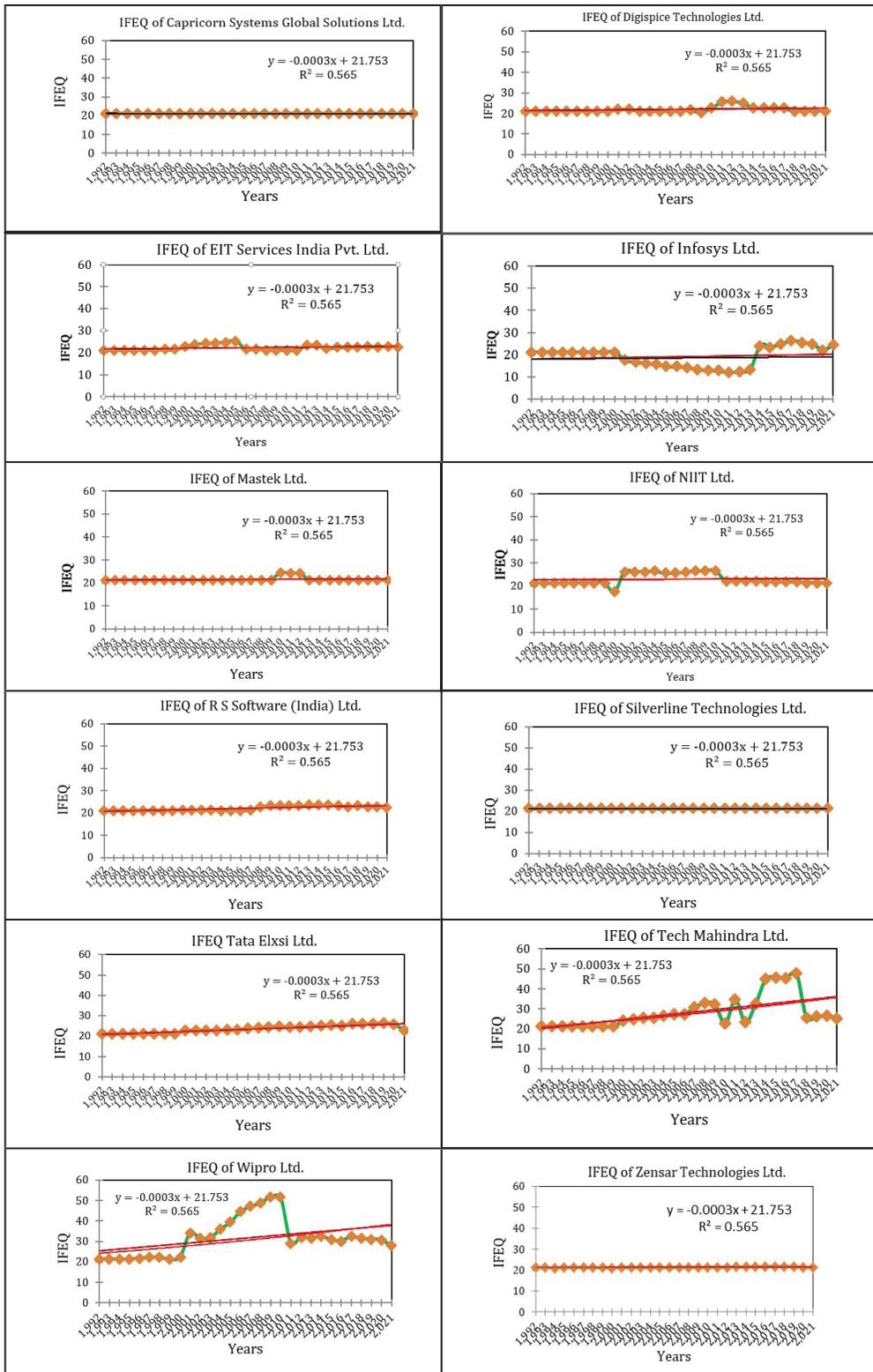


Fig. 2: IFEQ of Companies.

Table 3: Class and Remarks for the Companies.

Class	<i>m</i> (Slope)	Remarks	Class	<i>m</i> (Slope)	Remarks
C1	0.9 – 1	Outstandingly Progressive	C6	0.4 < 0.5	Satisfactory in Progress
C2	0.8 < 0.9	Excellently Progressive	C7	0.1 < 0.4	Poorly Progressive
C3	0.7 < 0.8	Very good in Progress	C8	0.0	Constant
C4	0.6 < 0.7	Good in Progress	C9	< 0.0	Regress
C5	0.5 < 0.6	Fair in Progress			

CONCLUSION

The IFEQ for the Wipro Ltd. is seen to be performing best, while Infosys Ltd. came out to be the least performing company. An almost similar pattern is depicted from the trend equation in the graph. Most of the companies fall into the Poorly Progressive class. For the considered period of study based on mean IFEQ Wipro Ltd., Tech Mahindra Ltd. and NIIT Ltd. came up as the top three companies among the 12 companies. Infosys Ltd., Zensar Technologies Ltd. and Mastek Ltd. are the bottom three companies respectively. R S Software (India) Ltd., Digispice Technologies Ltd. and Capricorn Systems Global Solutions Ltd. are the average-performing companies. From the performance trends analysis, it was observed that only Tech Mahindra Ltd. with a value of $m=0.5513$ is in class C5 with the remark ‘Fair in Progress’ and Wipro Ltd. with a $m=0.4332$ in class C6 with the remark of ‘Satisfactory in Progress’.

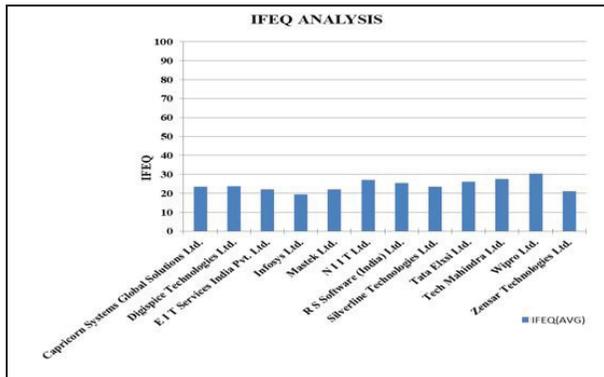


Fig. 3: Average IFEQ.

The rest of the companies are in class C7 with slope in the range of 0.1 to 0.4 and have remarks as Poorly Progressive. Capricorn Systems Global Solutions Ltd. is in the remark ‘Regress’ with a negative slope of its trend equation and it is classified as class C9. Only Silverline Technologies Ltd. is found to be with a remark ‘constant’ with its slope near zero. From this analysis, it is observed that the performances of

the companies yet need to be more efficient. IFEQ can assist managerial decision-making with identifying the trends of performance. Better resource allocation and managerial effort may be needed to improve the overall IFEQ of the companies to gain efficiency.

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