An Analytical Study of Technical Efficiency and Total Quality Management of Sugar Industry with special reference to the Ahmednagar District

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Abstract*— Research under the title "A Study of Technical Efficiency and Total Quality Management of Sugar Industry with special reference to Ahmednagar District" was undertaken to explore linkages between TQM and Technical Efficiency in case of sugar industry. Ahmednagar District from Maharashtra was selected for the study. 23 working sugar factories were studied through both primary and secondary data. Objectives of the research included profiling sugar factories in Ahmednagar District, measuring technical efficiency of the sugar factories, assessing TQM practices followed by sugar factories, finding out if TQM practices have an impact on technical efficiency of the sugar factories and suggesting a customized TQM framework for sugar factories. A value chain approach was adopted for assessing technical efficiency breaking the variable in two parts – core activities and auxiliary activities. Similarly the variable TQM was split into two parts – awareness and perception and implementation. A DEA approach was also adopted to measure the technical efficiency of the factories in terms of sugar recovery rate. Findings show that for the variable technical efficiency - a. core operations the disagreement of the sample is 85%. For the variable technical efficiency - b. support and other activities the disagreement of the respondents is 71%. It was found that for the variable TQM - a. Awareness and Perception the disagreement of the sample is 71%. In case of the variable TQM - B. Implementation the disagreement of the respondents is 68%. The correlation between TQM and Technical efficiency is 0.55 and the R2 value is 30% and is statistically significant. There is a significant impact of TQM on Technical Efficiency as far as core activities are concerned that is not the case with Technical Efficiency for auxiliary activities. As per DEA analysis while the 10-year maximum technical efficiency in the form of sugar recovery rate is 11.70, the average rate for all the 23 factories is only 10.59 which is statistically significantly different from the highest rate. The Technical Efficiency of the sugar factories is not at reasonable levels. This was concluded based on both the DEA approach where the average efficiency of the 23 units is quite lower than the highest efficiency and also based on the wide disagreement of the respondents to technical efficiency factors from core and auxiliary activities. TQM practices followed are at a dismal level. This was concluded on the basis of large disagreement responses to both awareness and perception and implementation. A strong positive correlation is seen between TQM practices and Technical Efficiency. Wherever TQM practices have an agreement response same is reflected in the case of Technical Efficiency statements as well. Some practical suggestions were offered. This paper presents a detailed abstract of the entire doctoral thesis.

***Keywords*— Ahmednagar District, Sugar Recovery Rate, Technical Efficiency, Total Quality Management**

I. INTRODUCTION

This study aims at investigating the causal relationship between TQM and technical efficiency in the context of sugar factories. Researcher's main hypothesis is that TQM can positively impact technical efficiency of the sugar factories.

Literature review shows that quite a few authors have associated TQM with Technical Efficiency. Hence this study investigates the cause and effect relationship between TQM and Technical Efficiency in relation to sugar factories.

1.1 Concepts

TQM was initiated by William Deming, a management specialist whose work greatly affected Japanese manufacturing. While TQM shares much in common with the Six Sigma improvement process, it isn't equivalent to Six Sigma. TQM centers around guaranteeing that interior rules and process standards lessen errors, while Six Sigma hopes to eliminate defects.

Technical efficiency can be defined as the effectiveness with which a given set of inputs are used to produce the output. An organization is said to be technically efficient if the organization is producing maximum output from minimum quantity of inputs, such as raw-material, labour, technology and capital. Technical efficiency implies optimum use of resources. Technical efficiency can be expressed in terms of a formula as under –

This study adopts a Value Chain approach to technical efficiency. It is well-recognized that all activities in an organization has some or the other role to play in influencing the technical efficiency.

1.2 Objectives

Objectives set for the study were as under –

1. To profile sugar factories in Ahmednagar District
2. To measure technical efficiency of the sugar factories
3. To assess TQM practices followed by sugar factories
4. To find out if TQM practices has an impact on technical efficiency of the sugar factories
5. To suggest a customized TQM framework for sugar factories

1.3 Hypotheses

To translate these objectives into actionable research following hypotheses were set –

Ho1 – Technical efficiency of sugar factories is reasonable.
Ha1 – Technical efficiency of sugar factories is below par.
Ho2 – TQM practices followed by sugar factories are effective
Ha2 – TQM practices followed by sugar factories are not effective
Ho3 - There is no impact of TQM practices on technical efficiency
Ha3 - There is a significant impact of TQM practices on technical efficiency
Ho4 - Suggestions won't be effective
Ha4 - Suggestions would be effective

1.4 Need for the study

Concepts of TQM and Technical Efficiency have been researched exhaustively. Interestingly a study linking the two in the context of sugar factories is not found. This study will explore if there exists a causal relationship between these two variables, that is, TQM and Technical Efficiency. The outcome of the study is expected to make a significant contribution that can be of value for both academicians and professionals from the industry.

1.5 Scope of the study

In terms of concept the key concepts being studied are –

a. Total Quality Management
b. Technical Efficiency
c. Impact of TQM on Technical Efficiency
d. Value Chain

In terms of context the application will be studied for 23 working sugar factories from Ahmednagar district of Maharashtra.

Secondary data including sugar recovery rate of the 23 factories was collected for a period of 10 years from 2009-10 to 2018-19.

II. Literature Review

2.1 Literature on the concept of Technical Efficiency

1) Barasa, L., et.al (2019) stated that countries in Africa have a common goal policy of industrialization that is required to be driven by investing in innovation that yields efficiency. The purpose behind this paper is to investigate the technical efficiency effects emerging from innovation inputs including human capital development (HCD), internal R&D, and foreign technology adoption in manufacturing firms in Africa. This investigation utilizes cross-sectional firm-level survey data from the 2013 World Bank Enterprise Survey & the linked 2013 Innovation Follow-up Survey. A hetero sciatic half-normal stochastic frontier is utilized for examining the technical efficiency impacts of innovation inputs of 418 firms. This investigation reveals that internal R&D and foreign technology have negative effects on technical efficiency. In any case, the combination of foreign technology & internal R&D, and foreign technology & HCD fortify each other's consequences on technical efficiency. This investigation gives evidence that whereas individual innovation inputs may not yield positive efficiency results, the combination of absorptive capacity enhancing inputs involving internal R&D and HCD with foreign technology is vital for improving technical efficiency in manufacturing firms in Africa. This investigation offers significant lessons for managers in manufacturing firms in Africa. This study is basically the first to investigate the relationship between innovation inputs and efficiency in Africa. This study exhibits that investing in foreign technology in isolation from absorptive capacity improving innovation inputs decreases efficiency. HCD and internal R&D are imperative for building absorptive capacity that improves efficiency outcomes emerging from foreign technology.

Duarte, A., et.al (2019) stated that technical efficiency is one of the main performance indicators in a sugar and ethanol mill, and it can be demonstrated by the percentage of cane sugarrecouped and transformed into sugar, ethanol, and other products. In this manner, given the sector's current crisis, to raise competition and enhance the performance, productive units need to improve their efficiency in relation to the utilization of inputs. Therefore, this research aims to propose operating best practices that together increment the technical efficiency of sugar and ethanol mills. The methodological procedures utilized involve a quantitative and qualitative approach, utilizing, initially, data envelopment analysis (DEA), alongside quintile analysis and truncated multi linear regression, permitting a cross-referencing of data from 121 mills through the 2010/2011 to 2014/2015 crushing seasons. Furthermore, a case study was done at a sugar mill in the region of RibeirãoPreto-SP through meetings with specialists in the sugar &ethanol production processes, resulting in a proposal of 35 operating best practices that can cooperatively improve the technical efficiency of sugar & ethanol mills.

Li, H., et.al (2019) stated that considering the interrelationships between periods and the impacts of non-operational factors, a new framework based generalized 3-stage DEA model, grey relational analysis theory & disparity disassembly model is proposed in this paper. Then, the researchers measure the technical efficiency, scale efficiency, & pure technical efficiency of innovation in China's semiconductor industry between 2009 & 2014. In addition, the researchers conducted projection analysis of the inputs to innovation & the disparities analysis in innovation efficiency over the industrial chain and inside each segment. The results of the analyses reveal 4 key findings. The overall innovation efficiency of China's semiconductor industry is expanding; however, each segment of the industrial chain had various trends and various levels of innovation efficiency. All segments show a reliably upward trend except for package testing, which plunged in 2012 due to the time lag between the outputs and inputs associated with major technological advancements. The most efficient innovation is happening in design and package testing,

trailed by manufacturing, materials, and equipment, in that order. Low levels of innovation efficiency were seen as the the most important factor restricting further improvement in the manufacturing, design, and equipment segments of the industrial chain. But the inverse is true for the package testing segment, where pure technical efficiency is the principle factor. A scope of redundancies in input was found across the industrial chain, for the most part in manufacturing and equipment. These 2 segments are capital-intensive and described by a high level of technical complexity combined with a long research cycle. The incongruities in innovation efficiency in and between the segments diminished over the period. Nonetheless, interestingly, the main disparities were found among the enterprises within each segment, which is ascribed to the Chinese government's concerted efforts to help specific companies. Package testing and manufacturing had the most elevated levels of disparity due to relatively high agglomeration of these 2 segments. The materials segment had the lowermost disparity, with equipment & design falling somewhere in-between.

2.2 Literature on concept of TQM

Kaur, M., et.al (2019) stated that the purpose of this paper is 2 fold: first, to introduce a set of critical factors for total quality management (TQM) and supply chain management (SCM) practices through a broad literature review; and, second, to recognize the relationships among them by comparing the identified TQM and SCM practices so as to investigate the concept of supply chain quality management (SCQM). To meet the objectives of this work, a review of published quality research papers was done. For this, the authors recognized papers on TQM and SCM practices and saw how these practices improve the business performance of organizations. Further, based on identified practices, a conceptual model of SCQM was developed. The outcomes introduced a set of 6 critical factors each for TQM and SCM practices. Further, it was discovered that management support and commitment, customer focus, information and supplier partnership are the most well-known practices found in both SCM and TQM practices. The integration of TQM and SCM (SCQM) through the supply chain has the strongest effect on the organizational performance.

Halim, F. A., et.al (2019) stated that Malaysia has set a target to become the first aerospace nation in South East Asia by 2030. In endeavours to ensure industry players are able to accomplish the target, the critical success factors (CSFs) that influencing the successful implementation of total quality management (TQM) in aerospace industry, particularly in Malaysia, need to be recognized and ranked. Ranking CSFs is a sensitive task that requires additional attention. Self-judgment, previous experiences and references by industry experts, comprising the existence of uncertainty in decision making, brings about inaccurate ranking. Along these lines, this study aims to prioritize (identify and rank) the CSFs for fruitful implementation of TQM in Malaysia aerospace industry (manufacturing sector). Through a detailed review of the literature, 11 CSFs were recognized and categorized into 4 main criteria. These criteria were investigated empirically utilizing Fuzzy Analytic Hierarchy Process (FAHP) approach to rank the CSFs built on their relative importance weights. FAHP approach was utilized since the judgments from industry experts have been taken into account as suggested by National Aerospace Industry Coordinating Office (NAICO). The outcomes indicated that the main criterion for successful TQM implementation is people and culture with the highest weight of 0.434, trailed by organizing (0.296), systems and technique (0.151), and measurement & feedback (0.119). Along these lines, the top management and decision makers need to give more consideration on culture and people factors before implementing TQM which incorporate employee involvement and role of quality department. Be that as it may, the relationship between CSFs & the performance of TQM implementation should be analyzed further.

Teta, J., et.al (2019) stated that manufacturing industry in Albania has been grown significantly over the last decades because of expanded public demand, Government's initiatives, and the investors expanded interest in the manufacturing sector. Unfortunately, quality of product is yet a significant issue for the locally produced goods. Just a couple of manufacturers are producing high quality products with greater customer satisfaction. Many of them are holding quality certificates yet a couple has arrived at a stage of product development where they can apply modern quality principles and techniques viably. Research on product quality improvement demonstrates that meeting customer satisfaction, expanding profits and lessening losses to a minimum level can be accomplished through the utilization of modern quality philosophies and principles such as Total Quality Management (TQM). Understanding the tools & techniques of TQM is considered to be significant in order to get valuable outcomes. A better understanding is required to study the current status of TQM implementation. This research article presents a study on current quality control practices within the manufacturing industries in Albania to evaluate the potentiality of implementing TQM technique and principles so as to improve the customer satisfactions and market share.

2.3 Literature on relationship between TQM and Technical Efficiency

Liu, H., et.al (2019) stated that to enhance the financial performance of companies by improving the operational capability, the researchers discuss the efficiencies of 10 manufacturing industries by using stochastic frontier analysis (SFA), the results show that there are significant variances in cost efficiency across industries and efficiencies of these industries remain to be consistent throughout the years. The researchers select thirty companies that won Chinese National Quality Award for data envelopment analysis (DEA), and discover that some award winners may not gain their expected advantage that deliberate by efficiencies. The trend of 3 DEA efficiencies shows that companies have encountered going down and going up by years. This paper underlines that companies ought to translate the operational capability into financial and business performance.

Tortorella, G., et.al (2019) stated that the purpose of this paper is to study the intervening impact of learning organization dimensions on the relationship between the implementation of Total Quality Management practices & companies' operational performance improvement. The authors did a cross-sector survey with 135 Brazilian manufacturing companies that have been implementing Total Quality Management as an organizational strategy for at least 5 years. Collected data were examined utilizing multivariate data analysis techniques. The findings give guidelines for manufacturers to increase their learning capability by fortifying the implementation of Total Quality Management practices, whose synergistic effects might be currently neglected. Results show that an enhanced organizational learning capability can considerably impact the improvement level of operational performance through the use of Total Quality Management practices.

Cherng-Yee Jong, et.al (2019) stated that many studies have suggested the adaptation and implementation of Total Quality Management (TQM) is probably going to improve an organization's performance. A considerable amount of literature has analysed the relationship between TQM and other elements like organizational performance, business performance, and marketing performance in various industries. However, little is known about the impact of TQM in project performance with regards to Malaysian construction organizations. The objective of the investigation is to study the relationship between TQM & project performance in Malaysian construction organizations. Data were gathered from

member list of companies from the CIDB (Construction Industry Development Board) Malaysia. A total of 161 valid responses have been returned for data analysis. The findings showed that TQM practices were partially correlated with project performance of Malaysian construction organizations. In particular, operation focus and workforce focus were seen as dominant TQM practices on project performance. This investigation contributes to the knowledge on TQM and project performance by giving empirical evidence on their ability to improve Malaysian construction industry. Moreover, this investigation gives further insight for industrial practitioners to understand the roles of TQM and its capacity in enhancing project performance.

2.4 Literature on studies of Sugar factories

Sarkar, S. (2019) stated that India was the 4th major sugar producing country in the world. India has now emerged as the biggest sugar producing country in the world with 22 per cent share of the world's sugar production .Sugar Industry is the 2nd largest agro-based industry in the country. It ranks 3rd largest industry in terms of its contribution to the net value added by manufacture and employs almost 3 lakh workers, besides making extensive indirect employment for 45 million farmers of sugarcane.

Mohan, N., et.al (2019) stated that India has developed as the biggest sugar producer after Brazil producing 32.2 million tons (MT) sugar which is nearly 20 per cent of global sugar output & is the top most consumer of the sugar in the world. The Indian sugar industry which envelopsaround 180 integrated distilleries, 524 operating sugar mills, and 260 co-generation plants lacks sustainability and has now understood that sugar; molasses and bagasse can never again be viewed as final product or by-products from sugar industry. Hence, value additions, diversifications and transformations are to be energetically researched as possible routes to new market and making sugar industry less reliant on single commodity, i.e., sugar. The eventual fate of the sugar industry, as a whole, lies in development of sugarcane bio-refineries, i.e., bio-ethanol, bio-electricity, bio-manure and chemicals, etc. Sugar industry can be potential source of giving renewable, green and clean bioenergy in the interest of the industry itself by making value addition, energy security for the nation and furthermore to address the environmental issues.

2.5 Research Gap

Despite a number of studies on both TQM and Technical Efficiency there is no research in the form of investigating a causal relationship between the two in the context of sugar factories. This is a very clear gap and strong motivation for this study. There is also adequate research on sugar factories in India. But surprisingly one hardly comes across a study that has attempted to marry TQM with Technical Efficiency of a sugar factory. Technical Efficiency is an important performance metric for a sugar factory. Popularly known as sugar recovery rate, it is widely recognized as a major indicator of the Technical Efficiency of a sugar factory. But not much of research is seen by way of an application of TQM to improve Technical Efficiency of a sugar factory.

III. Research Methodology

3.1 Research Model

The model used for the study is shown below –

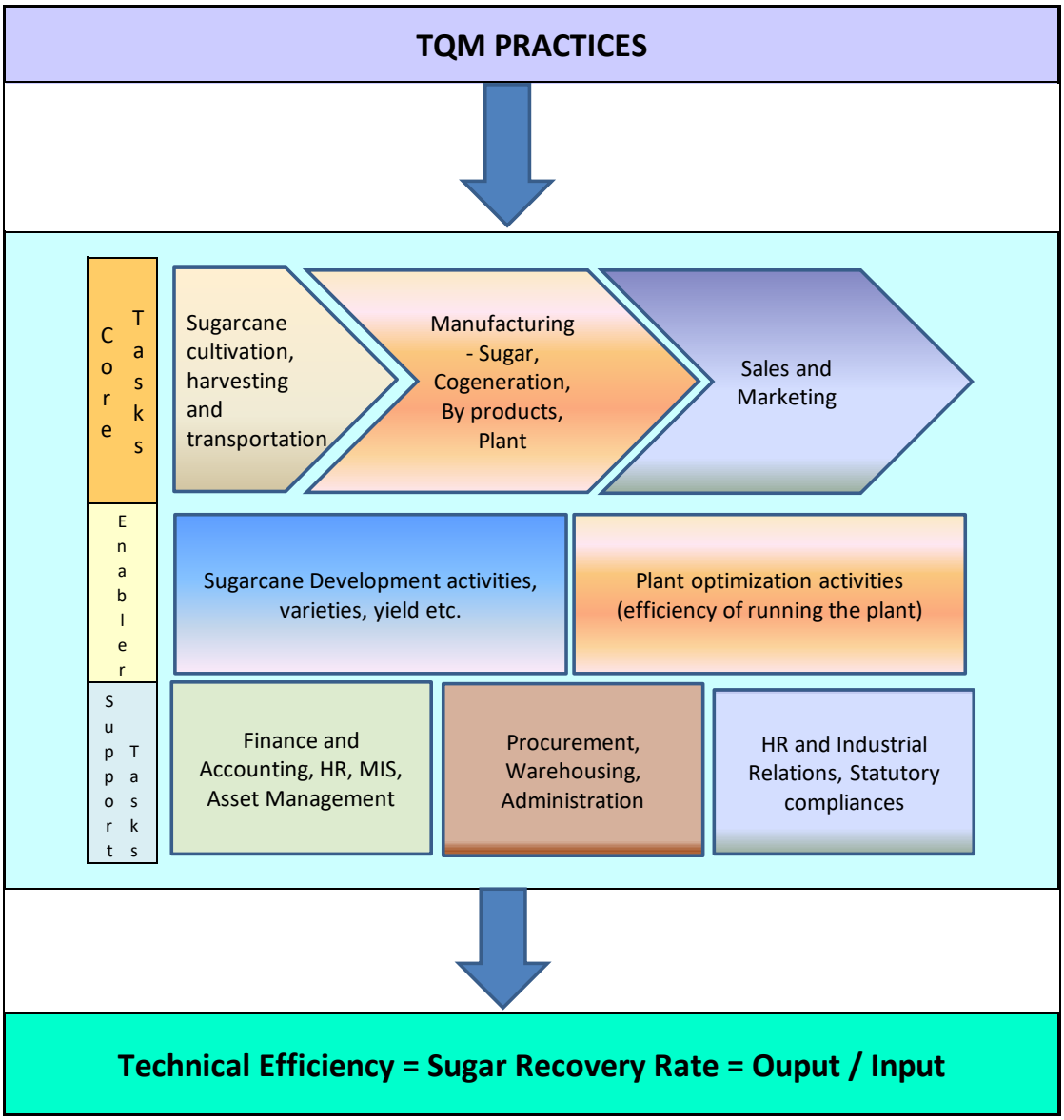

Figure 3.1 Value chain approach model for the study

3.2 Research Variables

Independent Variables - TQM Practices, Suggestions
Dependent Variables – Technical Efficiency

3.3 Outline of Scheme for Testing of Hypotheses

- Technical efficiency was measured on the basis of secondary data using Data Envelopment Analysis (DEA) technique. (Brief explanation of the technique is given immediately after this outline.)
- It was measured in terms of average sugar recovery rate for last ten years.
- The primary data questionnaire will have the 1st response option as “No Response” in line with suggestion by Menold N and Bogner K (2016) in their article on designing of questionnaire. The 1st response option of “No Response” caters to the requirement of providing a Don’t Know (DK) filter.
- The 1st hypotheses was tested in two ways –
  - The average efficiency of all the working factories was compared with the highest efficiency amongst the group of the working factories and a t-test was applied to find out if

the average differs from the highest level significantly or not. If the average was statistically significantly below the highest rate, the null hypotheses technical efficiency of sugar factories is reasonable was to be rejected.

- As a corroborative evidence for the 1st hypothesis, responses to the 10 questions each from Section I (A & B) on assessment of technical efficiency were averaged and the average agreement/disagreement was compared with a level of 50% agreement/disagreement taken as hypothesized mean of the population. If the disagreement percentage to the efficiency statements is significantly above 50% level then null was to get rejected implying that the average percentage is statistically significant and not by chance (50%).

- The 2nd hypothesis was tested in the following manner –
  - Responses to the 10 questions each from Sections II (A & B) on TQM practices were averaged and the average agreement/disagreement was compared with a level of 50% agreement/disagreement taken as hypothesized mean of the population. If the disagreement percentage to the TQM practice statements is significantly above 50% level then null was to get rejected implying that the average percentage is statistically significant and not by chance (50%).
- The 3rd hypothesis was tested as under –
  - Regression and correlation analysis was used to correlate the technical efficiency as inferred from the primary data with the average responses to the TQM practices section. The value of R^2as per regression analysis was used to assess the dependability of technical efficiency on TQM practices. Based on the R^2 value read along with the correlation coefficient and resulting p-value, the null hypothesis was to be tested for rejection or non-rejection.
- The 4th hypothesis was tested as under –
  - Responses to the 10 questions each from Sections III on effectiveness of suggestions were averaged and the average agreement/disagreement was compared with a level of 50% agreement/disagreement taken as hypothesized mean of the population. If the agreement percentage to the effectiveness of suggested solutions statements is significantly above 50% level then null was to get rejected implying that the average percentage is statistically significant and not by chance (50%).
- A questionnaire was designed to collect primary data in order to test the hypothesis as stated earlier.
- The structure of the questionnaire was kept simple by framing statements/ factors as questions and responses were sought by way of rating of the various factors on a 5-point Likert Scale
- For each of the strong element of the response – completely agree/disagree, completely effective/ineffective a weight of 2 was used to separate the responses from the other two moderate responses
- Scores for each of the questions were aggregated and bifurcated into agree/disagree.
- If the p-values were less than 0.05, the null hypotheses were rejected in favour of the alternate.
- T-test was employed given the fact that the SD of the population was unknown.

Other statistical functions like standard deviation were also planned for use. MS Excel formulae like t-dist were also deployed.

3.4 Population and sample selection

3.4.1 **Population** – There are 30 sugar factories in Ahmednagar district. 7 out of these 30 were not in working condition when data was collected. Hence effectively the population was considered as 23 factories. As per The Hindu Business Line (2019) there are around 1.65 lakh employees working in

sugar factories in Maharashtra. Mahasugarfed.com (2020), states that there are 337 sugar factories in Maharashtra. This gives an average employment of (1.65 lakh / 337) = 489 or approximately 500 employees per sugar factory. At this rate the population of Ahmednagar district sugar factory employees for the 23 working factories comes to 23 x 500 = 11,500.

3.4.2 **Sample Size** – For a population of 11,500, sample size at 95% confidence level and 5% confidence interval was worked out as under –

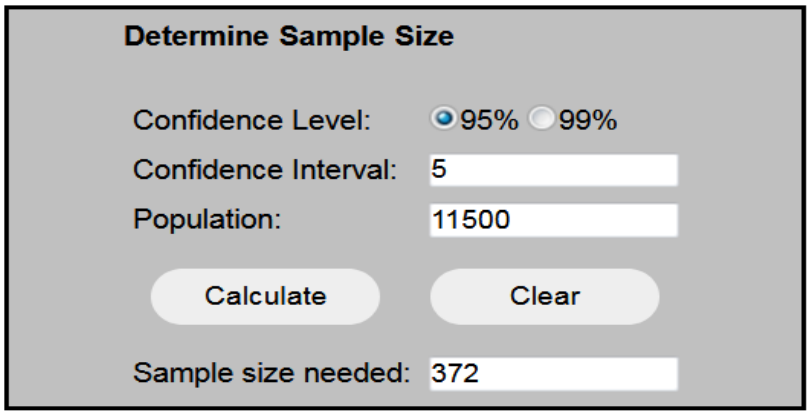

Figure 3.2 Sample size calculation
(Source : www.surveysystem.com)

The size of 372 was rounded off to 400 to take care of possible errors with sampling. Assuming a response rate of 80%, the questionnaires were distributed to 500 sugar factory employees from the district.

3.5 Others

The questionnaire was tested for validity and reliability.

IV. Data Analysis and Interpretation

4.1 Scheme formulated for data analysis

The scheme formulated was as under –

Table 4.1 Data Analysis and Interpretation Scheme Explained

Sr. No.	Data Analysis	Expected Outcome	Interpretation
1	Data Envelopment Analysis of the Technical Efficiency in terms of sugar recovery rate	Comparative measure of efficiency of the 23 sugar factories	If the average efficiency of 23 factories was statistically significantly below the highest rate, the null hypotheses technical efficiency of sugar factories is reasonable was to be rejected.
2	Assessment of Technical Efficiency by way of Value Chain approach covering Core and auxiliary activities	Disagreement percentages on various efficiency indicating statements and the resultant p-value	If the disagreement percentage to the efficiency statements is significantly above 50% level then null was to get rejected implying that the average percentage is statistically significant and not by chance (50%).

3	TQM practices (Awareness and Perception and Implementation)	Disagreement percentages on various TQM effectiveness indicating statements and the resultant p-value	If the disagreement percentage to the TQM practice statements is significantly above 50% level then null was to get rejected implying that the average percentage is statistically significant and not by chance (50%).
4	Impact of TQM on Technical efficiency	Correlation between average of effectiveness of TQM practices and average of Technical efficiency and the resultant p-value and R^2 value	Based on the R^2 value read along with the correlation coefficient and resulting p-value, the null hypothesis was to be tested for rejection or non-rejection.
5	Effectiveness of suggestions	Agreement percentages on various suggestion statements and the resultant p-value	If the agreement percentage to the effectiveness of suggested solutions statements is significantly above 50% level then null was to get rejected implying that the average percentage is statistically significant and not by chance (50%).

4.2 Summary of data analyses of responses & overall interpretation

The following table summarizes data analysis and overall interpretation –

TABLE 4.2 SUMMARY OF DATA ANALYSES OF RESPONSES & OVERALL INTERPRETATION

Sr. No.	Parameter	Parameters measured	Interpretation
1	Technical Efficiency	Average sugar recovery rate for 10 years – Maximum rate 11.70. Average rate (23 factories) 10.59. p-value <0.0001 Disagreement to technical efficiency statements as per Section I part A 85% and part B 71%. P-values <0.0001	As the p-values are <0.0001, the null hypotheses that technical efficiency is reasonable, as per both methods stands rejected.
2	TQM	Disagreement to TQM statements as per Section II part A 71% and part B 68%. P-values <0.0001	Since the disagreement percentage is significantly different from 50%, the null hypothesis that TQM

			practices followed by sugar factories are effective stands rejected.
3	Impact of TQM on Technical Efficiency	Correlation between TQM and Technical efficiency 0.55 R^2 30% p-value <0.0001	As the correlation and R^2 values are significantly higher the null hypothesis that there is no is no impact of TQM practices on technical efficiencystands rejected.
4	Effectiveness of suggestions	Agreement percentage to suggestions 72% p-value <0.0001	Since the agreement percentage is significantly different from 50%, the null hypothesis that suggestions won't be effective stands rejected.

4.3 Technical efficiency as per DEA approach

TABLE 4.3 TECHNICAL EFFICIENCY AS PER DEA APPROACH

Factory No.	Technical Efficiency	Efficiency as per DEA #	Rank
1	11.41	98%	3
2	10.74	92%	11
3	11.18	96%	5
4	11.47	98%	2
5	10.54	90%	15
6	10.61	91%	13
7	10.33	88%	19
8	11.29	97%	4
9	9.54	82%	22
10	10.57	90%	14
11	10.84	93%	9
12	10.72	92%	12
13	8.84	76%	23
14	10.50	90%	16
15	10.76	92%	10
16	9.76	83%	20
17	10.45	89%	18
18	10.88	93%	7
19	11.70	100%	1
20	10.49	90%	17
21	9.57	82%	21
22	10.86	93%	8
23	10.90	93%	6

Factory 1 = Sugar recovery rate of factory 1 / Maximum sugar recovery rate of 11.70 = 11.41/11.70 = 98%.

V. FINDINGS

1. Findings show that for the variable technical efficiency - a. core operations the disagreement of the sample is 85%. For the variable technical efficiency - b. support and other activities the disagreement of the respondents is 71%.
2. It was found that for the variable TQM - a. Awareness and Perception the disagreement of the sample is 71%. In case of the variable TQM - B. Implementation the disagreement of the respondents is 68%.
3. The correlation between TQM and Technical efficiency is 0.55 and the R^2 value is 30% and is statistically significant.
4. There is a significant impact of TQM on Technical Efficiency as far as core activities are concerned that is not the case with Technical Efficiency for auxiliary activities.
5. For the variable effectiveness of suggested solutions the agreement of the sample is 72%.
6. As per DEA analysis while the 10-year maximum technical efficiency in the form of sugar recovery rate is 11.70, the average rate for all the 23 factories is only 10.59 which is statistically significantly different from the highest rate.

VI. CONCLUSIONS

The Technical Efficiency of the sugar factories is not at reasonable levels. This was concluded based on both the DEA approach where the average efficiency of the 23 units is quite lower than the highest efficiency and also based on the wide disagreement of the respondents to technical efficiency factors from core and auxiliary activities. TQM practices followed are at a dismal level. This was concluded on the basis of large disagreement responses to both awareness and perception and implementation. A strong positive correlation is seen between TQM practices and Technical Efficiency. Wherever TQM practices have an agreement response same is reflected in the case of Technical Efficiency statements as well.

VII. SUGGESTIONS

Ten suggestions were offered as under –

TABLE 5.1 SUGGESTION FRAMEWORK

Sr. No.	Suggestion
1	Value-chain approach should be adopted for implementing TQM
2	Thrust should be given on training of sugarcane cultivators
3	Research and Development activities should be strengthened
4	TQM experts should be hired on a regular basis
5	Apex bodies like VSI should be made to TQM as a focus area
6	IT developments like Big Data, AI etc. should be leveraged
7	Quality initiatives should be strongly rewarded
8	Participation and involvement of workmen should be improved
9	Service activities like Finance, HR, etc., should be brought under the

	ambit of TQM
10	Feedback systems should be improved

All the suggestions were agreed to by the respondents on a large scale. They were validated by the respondents for their effectiveness.

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