Strategy Performance Evaluation of a Port Organisation based on Multi-Criteria Decision Making using Fuzzy Logic Method

M. Ramachandran
Vishal Fegade
P.P. Raichurkar

Abstract

The importance of measurement of strategy performance has long been acknowledged by researchers and industrial experts from various organisations. A better approach would be to focus on the performance measurement system design rather than details of specific measures. Measuring the strategy of an organisation can help in terms of strategy reformulation while implementation pertains to better growth of the organisation. This perspective validates the fundamental approach to organisational control design involving design effort at various levels of the organisation. A multi-criteria decision making analysis using fuzzy logic is an effective tool to measure the industry performance strategy. This measurement system includes both financial and non-financial performance with multi-criteria decision making. This can help improve the organisational set up of the industry and provide the ability to change and adopt. This approach will consider the preferences of port organisations regarding strategic objectives. The main aim of this paper is to design a strategy performance measurement system for port organisations using MATLAB. The result shows that multi-criteria decision making analysis using the fuzzy logic system designed by MATLAB works effectively and the results provided by the analysis are consistent. This design is the best tool to help a port organisation evaluate and revise its strategy and to adopt a modern management approach. This design can be modified for various organisations depending on their strategy performance.

Keywords: *fuzzy logic; Multi-Criteria Decision Making; strategy performance; port organisation; MATLAB*

I. Introduction

Many companies are using new strategies for growth such as value addition in products and services, rather than cost reduction. To assess whether these strategies are working, evaluation of strategy performance is essential. In this paper, we have used the organisation Tuticorin Port as a model for designing a strategy performance measurement system using the MATLAB R2011b software. Normally a port organisation focuses on cost reduction, economy and best services. Using this approach, the port organisation is unable to assess future performance and growth opportunities. Multi-Criteria Decision making (MCDM) analysis is the best measurement system for measuring the strategy performance of various industries or any profitable or non-profitable organisation. Fuzzy analysis uses linguistic variables unlike any other optimization tools which use numerical variables, and provides a unique solution for measuring strategy performance. The MCDM by fuzzy logic analysis can be applied in case of port organisations to increase the financial turnover, customers' satisfaction and growth of the industry. By adopting the MCDM fuzzy methodologies, we can assess the growth opportunities and analyse future performance. The MCDM fuzzy analysis can be the best strategic performance management system for industry, government, and non-profit organisations. The proposed design will be a framework for designing a performance measurement system for various organisations by modification of the performance pointer. This method also helps strategy planners to identify the best performance pointers for their organisations.

II. Fuzzy logic Analysis

For performing fuzzy logic analysis, we need to construct membership functions for all the performance pointers [1, 2]. We are designing seven triangular membership functions for the performance pointers. More the membership functions more accurate the results. Membership functions are (0,0,0.1), (0,0.1,0.3), (0.1,0.3,0.5), (0.3,0.5,0.7), (0.5,0.7,0.9), (0.7,0.9,1) and (0.9,1,1). Figure 1 shows the seven membership functions designed in the MAT LAB software.

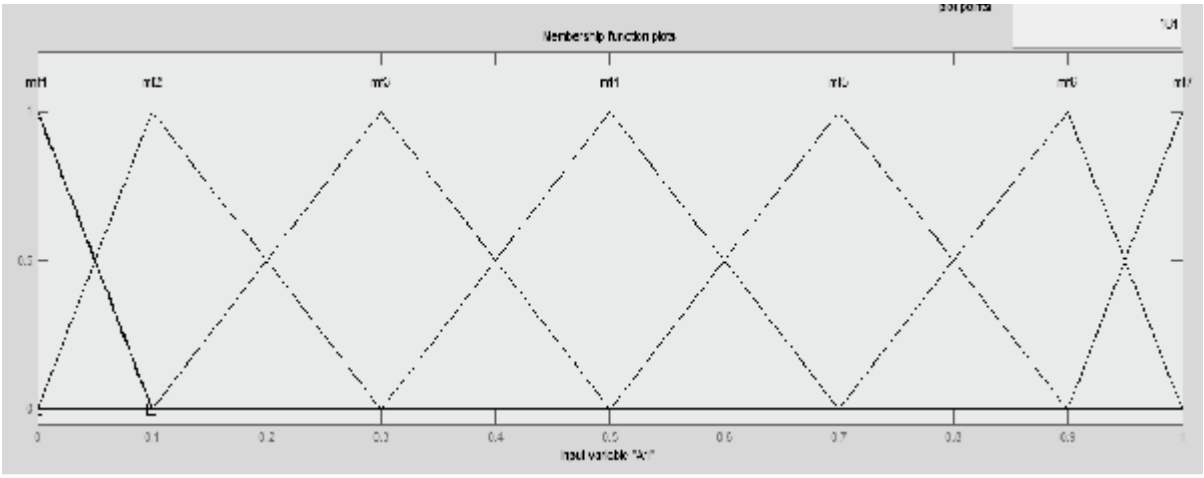

Figure 1: Membership Functions

The data for performing the experiment has been collected from various internet sources and integrity of data is not important to the work. The focus of the work is strategy performance measurement framework design [3, 4]. The first strategic objective - Internal Business Process Assessments - has four variables which are denoted by A1, A2, A3 and A4 respectively. Each variable denotes a performance

pointer of Internal Business Process Assessments. All the performance pointer values of Internal Business Process Assessments are calculated in percentage values. Similarly performance pointers of financial assessment are denoted by B1, B2, B3 and B4 respectively. All the performance pointer values of financial assessment are calculated in ratios. The performance pointers of customer assessment are denoted by C1, C2, C3 and C4 respectively. C1 and C3 performance pointer values of financial assessment are calculated in percentages and C2 and C4 performance pointer values of financial assessment are calculated in time. The performance pointers of learning and growth assessment are denoted by D1, D2, D3 and D4 respectively. All the performance pointer values of learning and growth assessment are calculated in percentage values. For standardizing all the values of the performance pointer, we are providing the fuzzy numbers (0.3, 0.5, 0.7, and 0.9). The lowest values over four years carries 0.3 and the highest value over four years carries 0.9 and 0.5 and 0.7 fuzzy numbers given to the second and third highest respectively [5,6]. The value shows that all the variables follow random distribution making it very difficult to understand the overall improvement of the Internal Business Process Assessments. Table 1, 2, 3 and 4 show the values of all performance pointers of strategic objectives and their fuzzy numbers. The Multi-criteria Decision making fuzzy Analysis is designed in the MATLAB software. The membership functions are designed in the software for all performance pointers of strategic objectives. A simulated model is designed in the MATLAB software with the entire variable to verify the analysis. Figure 2 shows the simulated model of performance measurement system design. The simulated model consists of four components - variable input, mux with four in and one out, fuzzy logic rule solver and display screen. The variable input components are used to provide the variable data to the model. The mux with four in and one out are used to combine the input and provided to the fuzzy logic rule solver. The fuzzy logic rule solver is used to analyze the input parameter and provide the fuzzy score [7, 8]. The fuzzy logic rule solver has 238 rules framed as per the decision maker's decision to analyze the input data. The screen is used to show the final fuzzy score of the analysis. All the variable inputs have inputs from 0 to 1. In the simulated model, the four fuzzy logic rule solvers namely IBPA, FA, CA and LGA are taken for four strategic objectives - Internal Business assessments, Financial assessments, Customer assessments and Learning & Growth assessments respectively. Each fuzzy logic rule solver gets input from the Mux with four in and one out, which is further connected to four input variables. The fuzzy optimization fuzzy logic rule solver takes input from four strategic objectives through Mux and the output is connected to the display.

III. Strategic objectives and constraints

The Multi-Criteria Decision Making analysis suggests that we can assess an organisation from four strategic objectives -Learning & Growth assessments, Internal Business assessments, Customer assessments and Financial assessments [9]. For each strategic objective, four main performance pointers are developed using decision makers [10]. In this measurement system, decision makers play a vital role to assess the organisation's efficiency. The strategic objectives for the analysis are developed for Tuticorin port organisation based on the organisation's strategy. Tuticorin port organisation has focus on its long term financial viability. Since Tuticorin Port organisation is a public sector organisation, profitability and short term financial results are not a major concern for the organisation [11,12]. By keeping in focus the organisation's long term financial viability, we chooseoperating revenues to assets ratio, current ratio, inventory turnover and operating expense to revenue ratio as financial assessment performance pointers. Tuticorin Port organisation's main role is

being a service provider for ship trading;customer assessments are a greater focus on the strategic objectives. In this context, the ship satisfaction index, average anchorage time, percentages of cargo operation and average time of cargo operation are taken as performance pointers for customer assessments. For providing better quality services and smooth running of the organisation, internal business process should be well monitored; this is one of the strategic objectives of service sector organisations. By focusing on the objective, we have choosen employee satisfaction index, employee retention index, employee absenteeism index andberth occupied ratio as the performance pointers for internal business process assessment. Last but not the least, growth of the organisation is one of its important strategic objectives. The growth of the organisation directly depends on the workers' ability and utilisation of new technology. By focusing on the above objective, we have choosen a budget allotted for new technology, resource allocation for information technology, workers who have attended training sessions and conferences as performance pointers for learning and growth assessment. In our work, we measured the performance pointers on a yearly basis from 2012 to 2015.

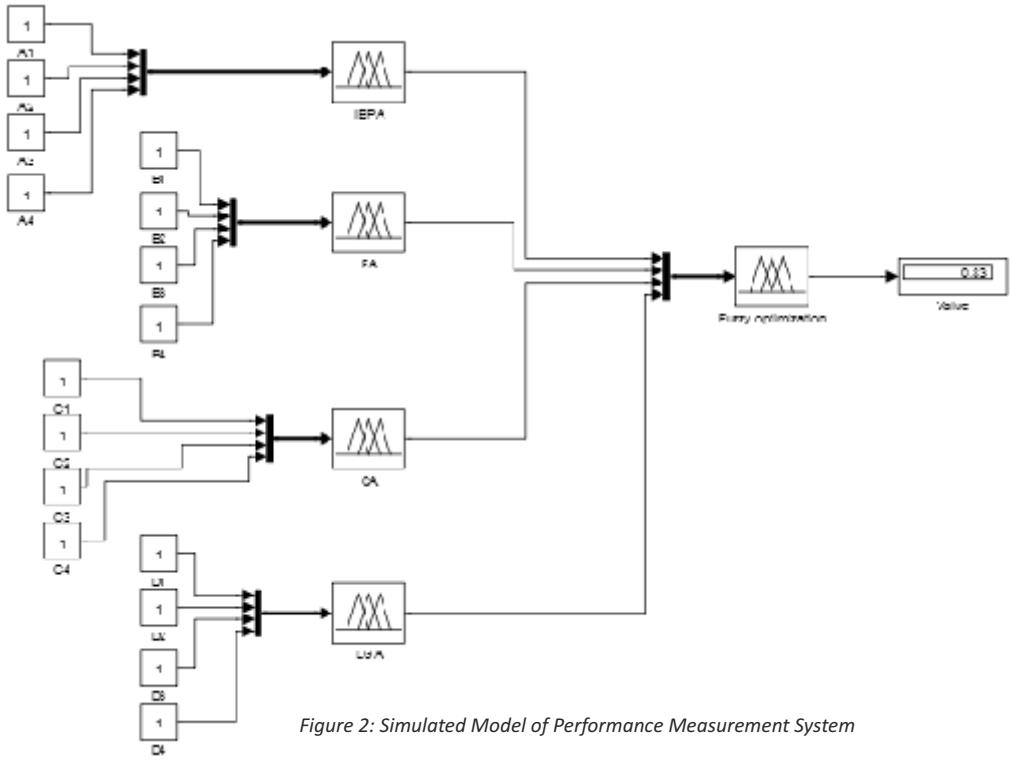

Figure 2: Simulated Model of Performance Measurement System

IV. Case Study- Tuticorin Port Trust

Tuticorin Port is one of the 12 major ports in India. It was declared to be a major port on 11 July 1974. It is the second-largest port in Tamil Nadu and the fourth-largest container terminal in India. It is an artificial port and the third international port in Tamil Nadu; it's the second all-weather port [13, 14]. Tuticorin Port's traffic handling has crossed 10 million tons and is growing at the rate of 12.08 per cent. The inner harbour consists of 14 berths including 2 container and 3 coal and oil jetties [15].

Table 1: Internal Business Process Assessments

Performance pointer		2012		2013		2014		2015	
		Value	Fuzzy no	Value	Fuzzy no	Value	Fuzzy no	Value	Fuzzy no
A1	Employee satisfaction index	65%	0.5	71%	0.9	70%	0.7	71%	0.9
A2	Employee absenteeism index	3%	0.7	4%	0.5	3%	0.7	7%	0.3
A3	Surplus inventory	5%	0.3	3%	0.7	4%	0.5	3%	0.7
A4	Berth occupied ratio	84%	0.9	80%	0.3	82%	0.5	83%	0.7

Table 2: Financial Assessments

Performance pointer		2012		2013		2014		2015	
		Value	Fuzzy no	Value	Fuzzy no	Value	Fuzzy no	Value	Fuzzy no
B1	Operating revenues to assets ratio	0.62	0.3	0.63	0.5	0.65	0.9	0.64	0.7
B2	Current ratio	0.69	0.7	0.68	0.5	0.66	0.3	0.64	0.9
B3	Inventory turnover	20.	0.9	19.8	0.7	18.8	0.3	19.5	0.5
B4	Operating expense to revenue ratio	0.256	0.7	0.24	0.3	0.251	0.5	0.253	0.9

Table 3: Customer Assessments

Performance pointer		2012		2013		2014		2015	
		Value	Fuzzy no	Value	Fuzzy no	Value	Fuzzy no	Value	Fuzzy no
C1	Ship satisfaction index	55%	0.5	59%	0.7	60%	0.7	65%	0.9
C2	Average anchorage time	2hrs	0.5	2hrs	0.5	1hr	0.9	1.5 hr	0.7
C3	Percentages of cargo operation	5%	0.5	6%	0.7	8%	0.9	8%	0.9
C4	Average time of cargo operation	4day	0.5	5day	0.7	6day	0.9	5day	0.7

Table 4: Learning and Growth Assessments

Performance pointer		2012		2013		2014		2015	
		Value	Fuzzy no	Value	Fuzzy no	Value	Fuzzy no	Value	Fuzzy no
D1	Budget allotted for new technology in %	25%	0.5	25%	0.5	35%	0.9	30%	0.7
D2	Resource allocation for information technology in %	15%	0.7	20%	0.9	12%	0.3	14%	0.5
D3	Workers trained in %	35%	0.7	40%	0.9	32%	0.3	33%	0.5
D4	Workers who have a ttended conferences in %	72%	0.3	84%	0.7	85%	0.7	87%	0.9

Table 5: Final Fuzzy Score

S.No	Year	Fuzzy score
1	2012	0.5000
2	2013	0.8320
3	2014	0.8333
4	2015	0.8329

The values of performance pointers of all the strategic objectives are entered in the variable input for the particular year and the final fuzzy score is taken from the display screen [16, 17]. Similarly for all years, final fuzzy scores' value scores are taken. Table 5 shows the final fuzzy score values for all the years under assessment from 2012 to 2015. The result shows that the strategic performance of the organisation has significantly improved from 2012 to 2014. There is very high improvement from 2012 to 2013; this is because of the organisation focussing on infrastructure development. However, in 2015, there is a slight reduction in the organisation's performance.

V. Conclusions

The proposed strategy performance measurement system using Multi-criteria Decision making fuzzy logic analysisdesign takes into account distinguished characteristicssuch as less competition, social character of organisations, more focus on fulfilling its mission, and to achieve longterm finanicial results, which is the main strategic objective of the public sector. The proposed methodologyis applied in the current work for a port organisation, mainly because the Tuticorin Port Trust has no earlier experience withstrategic performance management tools. Based on presented data, there is significant improvement in Tuticorin Port's strategy performance from 2012 to 2013even though it isslightly lower in the last year, 2015. This proposed strategy performance measurement system can be used for any profitable and non-profitable organisations like schools, colleges, universities and hospitals with slight modifications in the rules and performance pointers. However, the proposed design mainly depends on the decision makers' opinion about the analysis; this can be overcome by having more decision makers.

References

- Pulkit Purohit, M. Ramachandran, Selection of Flywheel Material using Multicriteria Decision Making Fuzzy Topsis, Indian Journal of Science and Technology 2015; 8(33): 1-5.
- Salkind, A. J., Fennie, C., Singh, P., Atwater, T., & Reisner, D. E. (1999). Determination of state-of-charge and state-of-health of batteries by fuzzy logic methodology. Journal of Power Sources, 80(1), 293-300.
- R. Kaplan, R., D. Norton, D. The Balanced Scorecard: measures that drive performance, Harvard Business Review, pp.71 – 79, 1992.
- Wu, Shwu-Ing, and Jr-Ming Hung. "The performance measurement of cause-related marketing by balance scorecard." Total Quality Management & Business Excellence 18, no. 7 (2007): 771-791.
- Kumar S, Ramachandran M. A novel approach for the vendor selection in the refrigeration industry. International Journal of Applied Engineering Research 2015; 10(11):10119–22.
- Okumus, Fevzi. "A framework to implement strategies in organizations." Management Decision 41, no. 9 (2003): 871-882.
- Jain M, Ramachandran M. Buy/Make decision making framework for pump product development with multi criteria decision making. International Journal of Applied Engineering Research 2015; 10(11):10486–9.
- Huang, Hao-Chen. "Designing a knowledge-based system for strategic planning: A balanced scorecard perspective." Expert Systems with Applications36, no. 1 (2009): 209-218.
- Gautreau, Andrew, and Brian H. Kleiner. "Recent trends in performance measurement systems-the balanced scorecard approach." Management Research News 24, no. 3/4 (2001): 153-156.
- Patil Chetan Vitthal, Chaudhary Saurabh Sanjay, Bhavna R Sharma, M. Ramachandran, Need of Biomedical Waste Management in Rural Hospitals in India. Int. J. Pharm. Sci. Rev. Res. 2015; 35(1): 175-179.
- Haralambides, h.e., and r. Behrens. “Port restructuring in a global economy: an Indian perspective.” International Journal of Transport Economics / Rivista Internazionale Di Economia Dei Trasporti, vol. 27, no. 1, 2000, pp. 19–39.
- Sheth, A., Sanyal, S., Jaiswal, A., & Gandhi, P. (2006). Effects of the December 2004 Indian Ocean tsunami on the Indian mainland. Earthquake spectra, 22(S3), 435-473.
- Nagarajan, B., Suresh, I., Sundar, D., Sharma, R., Lal, A. K., Neetu, S., & Shankar, D. (2006). The Great Tsunami of 26 December 2004: A description based on tide-gauge data from the Indian subcontinent and surrounding areas. Earth, planets and space, 58(2), 211-215.
- Natesan, M., Venkatachari, G., & Palaniswamy, N. (2005). Corrosivity and durability maps of India. Corrosion Prevention and Control, 52(2), 43-55.
- Thomas, B. J. (1995). Manpower and employment issues. Maritime Policy and Management, 22(3), 239-253.
- Carlucci, Daniela, Bernard Marr, and Gianni Schiuma. "The knowledge value chain: how intellectual capital impacts on business performance." International Journal of Technology Management 27, no. 6-7 (2004): 575-590.
- Lodha S, Ramachandran M. Need of multi criteria decision making in vendor selection for the automobile industry. International Journal of Applied Engineering Research 2015; 10 (11):10301–4.

M. Ramachandran *is an Assistant Professor at Mukesh Patel School of Technology Management and Engineering, NMIMS, Shirpur Campus. He has published more than 50 research papers and articles in reputed national and international publications. He is pursuing his doctorate from Nirma University, Ahmedabad. He is the Executive Editor for International Journal on the Textile Engineering and Processes which is Published by NMIMS. He is a recipient of the Sentinels of Science Award. He is also a reviewer for various journals like Indian Journal of Engineering & Materials Sciences (NISCAIR Journal), Society of Automotive Engineers and Cogent OA (Taylor & Francis Journal). He is a life member at prestigious bodies such as IEI, ISTE and MRSI. He can be reached at manickam.ramachandran@nmims.edu*

Vishal Fegade *is an Associate Professor at Mukesh Patel School of Technology Management and Engineering, NMIMS, Shirpur Campus. He has published a number of research papers and articles in international and national publications. He is pursuing his doctorate from R.T.M Nagpur University. He is a recipient of the Best Faculty Award from NMIMS. He is the Executive Editor for REST Journal on Emerging trends in Modelling and Manufacturing. He can be reached at vishal.fegade@nmims.edu*

P.P. Raichurkar, *Ph.D., is the Associate Dean of Centre for Textile Functions at Mukesh Patel School of Technology Management and Engineering, NMIMS, Shirpur Campus. He has published 60 research papers and articles in international and national publications. He has a judicious blend of industrial and academic experience spanning over 32 years. He is the Editor In Chief for the International Journal on Textile Engineering and Processes, which is published by NMIMS. He is Technical Expert for ITTAMA, ITME India and TMMA Association. He is a life member of bodies like ISTE, JTA and MRSI. He can be reached at pp.raichurkar@nmims.edu*