Hierarchical structuring of organizational performance using interpretive structural modeling

Asil Nehad Abdel Jawad and Hamdi Bashir
Industrial Engineering and Engineering Management
University of Sharjah
Sharjah, UAE

Abstract

Today's intense competition forces organizations to examine how they can improve performance as they seek to enhance their competitiveness. In order to design and implement an effective program for performance improvement, the interrelations among performance criteria and factors affecting them need to be understood. For this purpose, this study used interpretive structural modeling to represent the interrelationships among seven performance criteria and 19 factors in a simple, hierarchical structure model. The bottom level of this structure contains 12 factors, namely employee selection, employee training , work environment, employee incentives, organizational culture, leadership style, efficiency, size of organization, organizational/commercial resources, product life cycle, internationalization, and employee satisfaction. This mean that any action improving performance must start from these factors. This study's findings will be beneficial for organizations that are planning to enhance their performance.

Key words: Organization; performance criteria; Interpretive Structural Modeling.

I. INTRODUCTION

Performance measurement is an essential management tool that indicates how well an organization is achieving its goals. Despite a lot of studies about measuring organizational performance, no specific definition of this concept has been agreed on universally; it is difficult to connect it to a particular meaning due to its multiple aspects. The classical approach to performance measurement is presented in Sink and Tuttle's model [1], which characterizes organizational performance by seven interrelated criteria: effectiveness, efficiency, quality, quality of work life, innovation, productivity, and profitability.

- Effectiveness: defined as actual output / expected output
- Efficiency: defined as the resource expected to be consumed/resources actually consumed. This is an input-transformation process-question
- Quality: defined as to make things more tangible as its measured using different checkpoints such as: upstream systems, inputs, transformation value adding process, output, downstream.
- Productivity: defined as the ratio of output over the input.
- Quality of work life: which is an essential contribution to a well performing system.
- Innovation: which is essential in sustaining and improving performance
- Financial performance: which is the ultimate goal for any organization as it includes profitability.

The factors affecting these criteria have been investigated in several studies. For instance, Ostroff [2] examined the relationship between employee satisfaction, other job-related attitudes (commitment, adjustment, and psychological stress), and organizational performance and organizational performance in terms of effectiveness. Data were collected from different schools. The study's regression analysis proved the relationship between employee satisfaction and organizational performance. Hoque, et al. [3] examined the relationship between organizational size, product life cycle stage, market position, balanced scorecard (BSC) usage and organizational performance. Based on a survey of 66 Australian manufacturing companies, their article suggested that larger organizations have greater BSC usage, which is associated with improved performance, but this relationship does not depend significantly on organizational size, product life cycle, or market position. Paul, et al. [4] attempted to develop and test a causal model linking human resources management (HRM) with organizational performance through an intervening process. Data were collected from Indian software companies. Their study found that HRM practices such as training, job design, compensation, and incentives directly affect employee retention, employee productivity, product quality, speed of delivery, and operating cost. However, it was found that HRM practices have an indirect causal connection with organizational, operational, and financial performance. Erben, et al. [5] investigated the relationship between paternalistic leadership behaviors, climate regarding ethics, and organizational commitment. Data were obtained from a survey of 142 individuals. Their study's results indicated the effect of paternalistic leadership on the perception of ethical climate and commitment. Moreover, a strong relationship

was found between climate regarding ethics and affective commitment. Finally, the results showed that climate regarding ethics has a mediating effect between benevolent paternalistic leadership and affective commitment. Uzkurt, et al. [6] examined the mediating role of innovation on the relationship between organizational culture and organization performance in a survey of 154 banks in Turkey. Their study's findings revealed that an organization's culture and innovation have direct and positive effects on its financial performance; organizational culture also has a direct impact on innovation. Galende, et al. [7] investigated the determinant factors in the organization of a organization's innovative activities by applying econometric analyses techniques to a sample of 152 Spanish innovative companies. Their study's empirical findings conorganizationed the existence of interesting relationships between internal factors (such as size, debt, commercial resources, organizational resources, and internationalization) and the innovative process. Based on data collected from 31 branches of 13 banks, Hamed, et al. [8] investigated the relationship between office design and productivity. Their study's findings showed that office design is vital in terms of increasing employee productivity. Comfortable and ergonomic office design motivates employees and substantially increases their performance.

II. Problem Statement

The reviewed studies in the preceding section investigated organizational performance from different perspectives, that is, each study focused on determining the factors affecting certain performance criteria. However, their respective results revealed some common factors influencing different performance criteria. In other words, not only the performance criteria (as ascertained by Sink and Tuttle's model [8]) are interrelated, but also the factors affecting them.

This study's main objective was to use interpretive structural modeling (ISM) to model the interrelationships among performance criteria and factors affecting them in a simple, hierarchical structure model. It should be noted that for simplicity's sake, unless otherwise indicated, the term "factors" is used to mean either "factors" or "performance criteria" in the remaining sections of this paper.

III. Interpretive Structural Modeling

Interpretive structural modeling is an interactive learning process where a set of directly and indirectly related elements are structured into a comprehensive systematic model [9]. First developed by Professor John N. Warfield in 1973, ISM can be used for identifying and summarizing relationships among specific variables, which define a problem or an issue [10], [11], [12]. This model has been extensively used and documented in relevant literature. For instance Hawthorne and Sage [13] applied ISM to program planning in higher education. Saxena and Colleagues [14] employed ISM in an energy conservation project for the Indian cement industry. Mandal and Deshmukh [15] used the model to analyze vendor selection criteria and to demonstrate the interrelationships between these criteria and their levels. Sharma and Colleagues [16] used ISM to develop a hierarchy of actions required to meet the objectives of a waste management project in India. , Farris and Sage [17] used interpretive structural modeling on worth assessment. Furthermore, the ISM tool was employed by Kanungo, et al. [18] To produce a structured model for evaluating information systems' effectiveness. Singh, et al. [19] applied the model to knowledge management to study the complex relationships among the elements of a manufacturing system. Ravi and Shankar [20] analyzed the interactions among barrier elements in reverse logistics. Another study by Bolanos and colleagues [21] adapted ISM in strategic decision-making groups. In a study by Farooquie and Khan [22], ISM was used to develop the structural relationships among the planning factors that contribute to project success. Qureshi and colleagues [23] applied ISM in modeling logistic outsourcing relationship variables to enhance shippers' productivity and competitiveness in the logistics supply chain. Zhang and colleagues [24] used ISM to redesign the governmental purchasing process. Moreover, Kannana, et al. [25] developed a hybrid approach using ISM and fuzzy TOPSIS for the selection of a reverse logistics provider. Bashir [26] adapted the ISM methodology to remove redundant relationships in an activity on node project network. More recently, Raj, et al. [27] employed ISM to model the factor affecting flexibility in flexible manufacturing systems FMS. Attri, et al.[28] applied the ISM approach for identifying and analyzing the barriers in the implementation of total productive maintenance.

IV. Development of an ISM Model for Organizational Performance

Developing an ISM model involves the following steps:

a) The factors are identified and listed.
b) A structural self-interaction matrix (SSIM) of elements is constructed. This matrix indicates the pair-wise relationship among elements, where the associated direction of the relationship between any pair is questioned.
c) The reachability matrix is developed from the SSIM.
d) The reachability matrix obtained in step 3 is partitioned into different levels.
e) A diagraph is drawn to visually present elements and their interdependence by using nodes and lines based on the relationship given in the reachability matrix, as well as to remove indirect links.

A. *Identification of Factors to be Included in the Model*

Based on Sink and Tuttle's model [1] and on the literature review [2], [3], [4], [5], [6], [7], [8], the following 26 factors have been identified as affecting organizational performance:

1. Employee selection

2. Employee training
3. Work environment
4. Employee incentives
5. Competence
6. Teamwork
7. Organizational commitment
8. Customer orientation/satisfaction
9. Employee retention/turnover
10. Productivity
11. Quality (product/process)
12. Speed of delivery
13. Financial performance
14. Operating cost
15. Organizational culture
16. Innovation (process, product, accumulated, incremental)
17. Leadership style
18. Effectiveness
19. Efficiency
20. Climate regarding ethics
21. Size of organization
22. organizational/commercial resources
23. Product life cycle
24. Internationalization
25. Employee satisfaction
26. Implementation of BSC perspectives

B. Construction of Structural Self-Interaction Matrix

Contextual relationships that are identified between factors are represented in the structural self-interaction matrix (SSIM). In ISM terminology, the word "factor" is referred to as an "element." The existence of a relationship between any two factors (i, j) and the associated direction of the relation are questioned. Four symbols are used to denote the direction of the relationship between the factors i and j:

V means that factor i leads to factor j (a forward relationship).

A means that factor j leads to factor i (a backward relationship).

X means that factor i leads to factor j and factor j leads to factor i (a mutual relationship).

0 means that factor i and factor j are unrelated (no relationship).

Based on the review of previously published papers [2], [3], [4], [5], [6], [7], [8] all the identified contextual relationships are presented in Table I.

TABLE I. STRUCTURAL SELF-INTERACTION MATRIX (SSIM)

FACTORS	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**v**	0	0	0	
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**v**	0	0	0	0	**v**	0	0		
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**v**	0	**v**	**v**	**v**	**v**	0			
4	0	0	0	0	0	0	0	0	0	0	0	0	**v**	0	**v**	**v**	**v**	**v**	0	0	**v**	**v**				
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**v**	0	0	0	0	0					
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**v**	0	0						
7	0	0	0	0	0	**A**	**A**	0	0	**A**	0	0	0	0	0	0	**v**	**v**	0							
8	**A**	0	0	0	0	0	0	0	0	0	0	0	**v**	0	**v**	**v**	**v**	0								
9	0	**A**	0	0	0	0	0	0	0	0	0	0	0	**v**	0	0	0									
10	0	0	0	0	0	0	0	**A**	**A**	0	**A**	0	0	**v**	0	**A**										
11	**A**	0	0	0	0	0	0	0	0	0	0	0	0	**v**	0											
12	0	0	0	0	0	0	0	0	0	0	0	0	0	**v**												
13	**A**	0	0	0	0	0	0	0	0	0	**X**	**A**	**A**													
14	0	0	0	0	0	0	0	0	0	0	0	0														
15	0	0	0	0	0	0	0	0	0	0	**v**															
16	0	0	**A**	A	**A**	**A**	0	0	0	0																
17	0	0	0	0	0	0	**v**	0	0																	
18	0	**A**	0	0	0	0	0	0																		
19	0	0	0	0	0	0	0																			
20	0	0	0	0	0	0																				
21	**v**	0	0	0	0																					
22	0	0	0	0																						
23	0	0	0																							
24	0	0																								
25	0																									
26																										

C. *Development of the Reachability Matrix*

The initial "reachability" matrix is developed from the SSIM by substituting the four symbols (V, A, X, or 0) with 1s and 0s, as detailed below. The rules for the substitution are as follows:

a) If the (i, j) entry in the SSIM is V, then the (i, j) entry in the reachability matrix becomes 1 and the (j, i) entry becomes 0.

b) If the (i, j) entry in the SSIM is A, then the (i, j) entry in the reachability matrix becomes 0 and the (j, i) entry becomes 1.

c) If the (i, j) entry in the SSIM is X, then the (i, j) entry in the reachability matrix becomes 1 and the (j, i) entry becomes 1.

d) If the (i, j) entry in the SSIM is 0, then the (i, j) entry in the reachability matrix becomes 0 and the (j, i) entry becomes 0.

According to these rules, the development of the initial reachability matrix for these factors is shown in Table II.

TABLE II. REACHABILITY MATRIX

Factors	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	1	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	1	0	1	1	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	1	1	1	0	0	1	1	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	1	0	1	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
20	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
21	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0
24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0
25	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0
26	0	0	0	0	0	0	0	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1

D. Partitioning of the Reachability Matrix

Reachability set R_i and antecedent set P_i are defined for each element S_i .The final reachability matrix is partitioned by finding the reachability R_i and antecedent P_i sets for each element. The reachability set contains the element itself and other elements that it may cause, whereas the antecedent set contains the element and other elements that may impact it.

Next, the intersection of the two sets is derived for all factors and levels. The Reachability set R_i , the antecedent set P_i, and their intersection $R_i \cap P_i$ are shown in Table III.

Factors S_i for which $P_i = R_i \cap P_i$ are not reachable from any of the remaining elements are denoted, as the bottom level (L_0) factors.

As shown in Table III, Factor 1 (employee selection), Factor 2 (employee training), Factor 3 (work environment), Factor 4 (employee incentives), Factor 15 (organizational culture) , Factor 17 (leadership style), Factor 19 (efficiency), Factor 21 (size of organization), Factor 22 (organizational/commercial resources), Factor 23 (Product life cycle), Factor 24 (internationalization), Factor 25 (employee satisfaction), are found at level 0. Therefore, it is placed at the bottom level of the hierarchy in the ISM model. These factors are the root elements (factors) affecting organizational performance.

Now, Factors 1, 2, 3, 4,15,17,19, 21, 22, 23, 24, and 25 should be discarded from Table III. The same process is repeated to find the factors at the next bottom level. Iterations are continued until each factor is placed at its level After that , the top level factors in the ISM hierarchy are found which will not lead to other factors above them. Levels are identified as follows: $L_1 =$ (5,6,18,20,26), $L_2 =$ (7, 8), $L_3 =$ (9, 11,12,14), $L_4 =$ (16), $L_5 =$ (10), and $L_6 =$ (13)

E. Formation of the Diagraph and ISM Model

The diagraph is drawn to visually present elements and their interdependence by using nodes and lines based on the relationship given in the reachability matrix, after removing the indirect links between the factors to obtain the ISM-based model. The levels of all elements so determined are positioned at their respective levels in the ISM-based model. For example, customer orientation/satisfaction is positioned at the third level from the bottom in the ISM hierarchy because it belongs to level L_2, as calculated from iteration 3. When the hierarchy organized, an arrow is needed to depict the direction of the action. If factor *i* at a certain level leads to factor j at the level above, an arrow pointing from factor *i* to factor *j* is drawn.

Based on the ISM methodology, the transitivity links between these elements need to be removed in order to gain an anticipated diagraph (ISM model). In other words if a factor *i* is related to *j* and *j* is related to *k*, then *i* is necessarily related to *k*, therefore there is no need for a direct link from *i* to *k*.

By following the above steps and removing the transitivity, the diagraph of the hierarchical structure is presented in Fig. 1. As shown in this figure, the structure arranged in 7 different levels. The bottom level consists of 12 factors: 1, 2, 3,4,15,17,19, 21, 22, 23, 24, and 25 which are: employee selection, employee training, work environment, employee incentives, organizational culture, leadership style, efficiency, size of organization, organizational/commercial resources, product life cycle, internationalization and employee satisfaction. This implies that any corrective actions taken to improve organization performance must start from these factors.

TABLE III THE REACHABILITY SET R_i, THE ANTECEDENT SET P_i AND THEIR INTERSECTION $R_i \cap P_i$

Element S_i	**Reachability set R_i**	**Antecedent set P_i**	**$R_i \cap P_i$**	**Level**
1	1,5	1	1	L_0
2	2,5,10	2	2	L_0
3	3,5,6,7,8,10	3	3	L_0
4	4,5,6,9,10,11,12,14	4	4	L_0
5	5,11	1,2,3,4,5	5	
6	6,9	3,4,6	6	
7	7,9,10	3,7,17,20,21	7	
8	8,10,11,12,14	8,3,26	8	
9	9,13	4,6,7,9,25	9	
10	10,13	2,3,4,7,8,10,11,16,18,19	10	
11	10,11,13	4,5,8,11,26	11	
12	12,13	4,8,12	12	
13	13,16	9,10,11,12,13,14,15,16,26	13	
14	13,14	4,8,14	14	
15	13,15,16	15	15	L_0
16	10,13,16	13,15,16,21,22,2	16	
17	7,17,20	17	17	L_0
18	10,18	18,25	18	
19	10,19	19	19	L_0
20	7,20	17,20	20	
21	7,16,21,26	21	21	L_0
22	16,22	22	22	L_0
23	16,23	23	23	L_0
24	16,24	24	24	L_0
25	9,18,25	25	25	L_0
26	8,11,13,26	21,26	26	

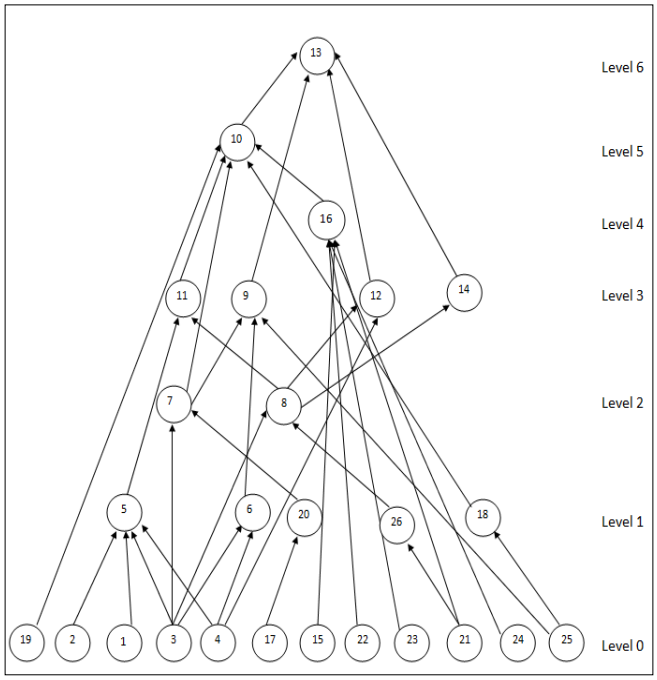

FIG.1 . ISM MODEL

IV. CONCLUSIONS

Several studies have been conducted to investigate the factors affecting various organizational performance criteria. The main objective of this research was to integrate the results of these studies into a single model. This aim was achieved by applying the ISM methodology to seven performance criteria and 19 factors.

The methodology arranged these factors and criteria in a simple hierarchical structure model consisting of seven levels. Since it forms the base of the hierarchy, employee selection, employee training, work environment, employee incentives, organizational culture, leadership style, efficiency, size of organization, organizational/commercial resources, product life cycle, internationalization, and employee satisfaction are considered as fundamental for improving organizational performance.

The results of this study proves that improving organizational performance is not a solitary effect rather it is a net result of many action occurring in sequence or parallel. Therefore, for any enhancement desired in organizational performance, a comprehensive program need to be implemented.

Last, but not least, it is worth mentioning that this study's preliminary model is being reviewed and refined by an in-depth investigation into verified empirical studies that have proven the relationship among certain factors affecting organizational performance—in order to refine and validate the developed model and obtain further results.

REFERENCES

[1] D. S. Sink and T. C. Tuttle, Planning and Measurement in your Organisation of the Future, Norcross: Industrial Engineering and Management Press, 1989, pp. 170-84.

[2] C. Ostroff, "The relationship between satisfaction, attitudes, and performance: An organizational level analysis.," *J. Appl. Psychol*., vol. 77, no. 6, pp. 963-974, 1992.

[3] Z. Hoque and W. James, "Linking Balanced Scorecard Measures to Size and Market Factors: Impact on Organizational Performance," *J. Manag. Account. Res*., vol. 12, no. 1, pp. 1-17, Dec 2000

[4] A. Paul and R. Anantharaman, "Impact of people management practices on organizational performance: analysis of a causal model," *Int. J. Hum. Resource. Manag*., vol. 14, no. 7, pp. 1246-1266, Nov 2003.

[5] G. S. Erben and A. B. Güneşer, "The Relationship Between Paternalistic Leadership and Organizational Commitment: Investigating the Role of Climate Regarding Ethics," *J. Bus. Ethics*, vol. 82, no. 4, pp. 955-968, Nov 2008.

[6] C. Uzkurt, R. Kumar, H. S. Kimzan and G. Eminoglu, "Role of innovation in the relationship between organizational culture and organization performance," *Eur. J. Innovat. Manag*., vol. 16, no. 1, pp. 92-117, 2013.

[7] J. Galendea and J. M. de la Fuenteb, "Internal factors determining a organization's innovative behaviour," *Res. Pol*., vol. 32, no. 5, p. 715–736, May 2003.

[8] A. Hameed and S. Amjad, "Impact of Office Design on Employees' Productivity: A Case study of Banking Organizations of Abbottabad, Pakistan," *J. Publ. Aff. Admin. and Manag*., vol. 3, no. 1, 2009.

[9] R. Attri, A. Dev and V. Sharma, "Interpretive Structural Modelling (ISM) approach: An Overview," *Res. J. Management Sci*, vol. 2, no. 2, pp. 3-8, Feb 2013.

[10] A. p. sage, Interpretive structural modeling: Methodology for large scale systems, New York: McGraw-Hill, 1977, pp. 91-164.

[11] D. W. Malone, "An introduction to the application of interpretative structural modeling," *Proc. IEEE*, vol. 63, no. 3, pp. 397-404, 1975.

[12] W. J. Warfield, "Developing interconnected matrices in structural modelling," *IEEE Trans. Syst. Man Cybern*. , vol. 4, no. 1, pp. 51-81, 1974.

[13] R. W. Hawthorne and A. P. Sage, "On applications of interpretive structural modeling to higher education program planning," *Socio-Econ. Plan. Sci*., vol. 9, no. 1, pp. 31-43, 1975.

[14] J. P. Saxena, Sushil and P. Vrat , "The impact of indirect relationships in classification of variables: A MICMAC analysis for energy conservation," Syst. Res., vol. 7, no. 4, pp. 245-253, 1990.

[15] A. Mandal and S. G. Deshmukh , "Vendor selection using interpretive structural modeling (ISM)," *Int. J. Oper. Prod. Manag*., vol. 14, no. 6, pp. 52-59, 1994.

[16] H. D. Sharma, A. D. Gupta and Sushil, "The objectives of waste management in India: a future inquiry," *Technol. Forecast. Soc. Change*, vol. 48, pp. 285-309, 1995.

[17] D. R. Farris and A. P. Sage, "On the use of interpretive structural modeling for worth assessment," Comput. Electr. Eng., vol. 2, p. 149–174, 1975

[18] S. Kanungo, S. Duda and Y. Srinivas, "A structured model for evaluating information systems effectiveness," *Syst. Res. Behav. Sci*., vol. 16, pp. 495-518, 1999.

[19] M. D. Singh , R. Shankar , A. Agarwal and R. Narain, "An interpretive structural modeling of knowledge management in engineeing industries," *J. Adv. in Manag. Res*., vol. 1, no. 1, pp. 28-40, 2003.

[20] V. Ravi , R. Shankar and M. K. Tiwari, "Productivity improvement of a computer hardware supply chain," *Int. J. Prod. Perform. Manag*., vol. 54, no. 4, pp. 239–255, 2005.

[21] R. Bolanos, E. Fontela, A. Nenclares and Pasto, "Using interpretative structural modeling in strategic decision-making groups," *Manage. Decis.*, vol. 43, no. 6, pp. 877-895, 2005.

[22] P. Farooquie and J. Khan, "An interpretive structural model for project planning and success," in *Proc., the IEEE international conference on Industrial Engineering and Engineering management*, Singapore, 2007.

[23] M. N. Qureshi, D. Kumar and P. Kumar , "Modeling the logistics outsourcing relationships variables to enhance shippers productivity and competitiveness in logistics supply chain," *Int. J. Prod. Perform. Manag*., vol. 56, no. 8, pp. 689-714, 2007.

[24] L. Zhang , "The Application of ISM to Re-designing of Government's Purchasing Process," in Software Engineering, 2009. WCSE '09. *WRI World Congress*, Xiamen, 2009.

[25] G. Kannana, S. Pokharelb and P. S. Kumarc, "A hybrid approach using ISM and fuzzy TOPSIS for the selection of reverse logistics provider," *Resour. Conservat. Recycl*., vol. 54, no. 1, pp. 28-36, 2009.

[26] H. A. Bashir, ""Removal of redundant relationships in an AON project network," *J.constr.Eng.Manage*, vol. 136, no. 7, pp. 787-793, 2010.

[27] T. Raj , R. Attri and V. Jain , "Modelling the factor affecting flexibility in FMS," *Int. J. Ind. Syst. Eng.*, vol. 11, no. 4, pp. 350-374, 2012.

[28] R. Attri , S. Grover and D. Kumar, "analysis of barriers of Total Productive Maintenance (TPM)," *Int. J. Syst. Assur. Eng. Manag*., 2012.

BIOGRAPHIES

Asil Nehad Abdel Jawad graduated with a First Class B.Eng. (Honors) in Civil and Environmental Engineering from the University of Sharjah, United Arab Emirates in 2013. She is currently a Master's Student and Teaching Assistant in the Department of Industrial Engineering and Engineering Management at the University of Sharjah. Organizational performance and project management are her areas of research interest.

Hamdi Bashir received his Ph.D. degree from McGill University, Montreal, Canada. He is currently an associate professor in the Department of Industrial Engineering and Engineering Management, University of Sharjah, UAE. Prior to that, Dr. Bashir held faculty positions at Concordia University, University of Alberta, and Sultan Qaboos University. His current research interests are in the areas of project management, health care operations management, quality management, logistics, and cellular manufacturing systems. Dr. Bashir is a senior member of the Institute of Industrial Engineers (IIE).

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