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Developing a structural-interpretive model of factors affecting the establishment of systemic thinking in an organization (Case study: Companies active in the country's sugar industry)

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Abstract

Nowadays, using the most up-to-date and appropriate methods and paradigms in management sciences is necessary for successful management to make the best decisions to guide organizational groups. This study aimed to identify the factors affecting the establishment of systems thinking to develop a structural-interpretive model in companies active in the sugar industry. This study was conducted on 400 managers, officials, and experts of the five studied companies, and 196 samples were selected based on a purposive judgment method according to Morgan's table. The research collection tools were library studies and a researcher-made questionnaire with 57 questions based on the Likert scale technique and a standard ISM method questionnaire. The reliability of the researcher-made questionnaire was checked based on Cronbach's alpha test and composite reliability. The exploratory factor analysis approach was used to identify the desired variables. Based on data analysis in Smart PLS software, ten factors were identified as influential factors in establishing systems thinking based on the Varimax rotation method and explaining 40.8% of the variance of the variables. In the standard steps of the structural-interpretive modeling approach, the variables extracted as model structures were divided into four levels of importance and used in designing strategies and plans for any organization to make the necessary decisions and policies.

Keywords: system, systems thinking, exploratory factor analysis, structural-interpretive modeling
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1 Introduction

The roots of systemic thought lie in the height of human history. Aristotle, Plato, Ibn Khaldun, Rumi, and Hegel are among the scientists who paid attention to the concept of system. In the 19th and early 20th centuries, there was a great need to combine two or more branches of human sciences to solve complex problems, which led to the emergence of interdisciplinary sciences, and various sciences were used in so-called systematic formats to solve complex problems. Systemic thinking is a way of looking at the universe and its phenomena as a process of mental synthesis

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that creates an integrated view of business in the mind through creativity and intuition. The ability of managers to see the future and recognize the dynamics of the environment and the effective presence of the organization implies continuous success over time [9].

Regarding the concept of systems thinking, a person uses his cognitive skills to deal with the complexities of systems, and secondly, thinking about the system to solve the problems that the system is facing [4]. This way of thinking provides a practical methodology for socio-cultural systems in an environment full of chaos and complexity. The basis of the systemic method is the concept of the system, and the behavior of a system does not depend on the individual behavior of its elements but reflects how its components are related. In other words, systems thinking is a conceptual framework for solving problems by focusing on problems during implementation. This method solves issues by finding a pattern to increase organizational understanding and attention to the problem. Systemic thinking includes interdependence between system components, overview, goal search, data conversion into columns, negative entropy, feedback, end-to-end, multi-end, and synergy. Systems thinkers can eliminate mismanagement and system thinking in organizations and contribute to organizational effectiveness. Therefore, systems theory has a positive relationship with organizational effectiveness and is a way to understand and facilitate the obstacles to the effectiveness of organizations [18]. Systemic thinking in strategic thinking is a change in looking at the organization [11, 16]. Society's need for a holistic view of affairs at the micro and macro levels can only be taken for granted, considering the existing inefficiencies and anomalies.

The lack of integration destroys the order of work and the organization while equipping with systemic thinking, and its application is considered a fundamental factor for knowledge. Systemic thinking aims to motivate learning and create a common vision for correct and informed decision-making [19]. Knowing this thinking and being equipped with it is necessary to better understand phenomena. The need to have such thinking and insight is felt more in organizations because, in case of a lack of integrity, the organization will not achieve its goals. Therefore, organizations need systemic thinking to strengthen themselves because managers examine structures, patterns, and events in connection. Considering the characteristics of systematic thinking and the expansion of this way of thinking in the scientific realms in recent years, large-scale business and administrative systems should be analyzed with such an attitude. The management of their affairs should also be based on this theory [15]. Management with the expansion of competition among other economic enterprises is impossible by trying to improve all the main components. Management of the company cannot be done without a systematic approach, accurate identification of problems, and an idealistic attitude to improve the situation in the best possible way due to the complexity of the issues, the limitation of financial and economic resources, and the time constraint. The consulting services accepted by managers in the last few decades, such as balanced evaluation models, strategic planning, organizational excellence, and management simulations, have all emerged due to a systemic approach to the activity of a company, indicating a sign of the severe need of the market to implement this approach. A systemic approach is a different way of looking at problems, and one should be able to look at any problem with a systemic view and provide a solution. The system approach Peter Senge considers in his book The Fifth Order is one of the most essential management needs in learning organizations. This book is not intended to answer the macro-level problems of the company, and this attitude should also prevail in examining every small issue of the organization so that the system that creates each issue can be recognized and corrected [10]. [12] studied the different functions of systemic thinking and found that it is possible to analyze different organizational, administrative, and family spheres using system thinking. [5] investigated the impact of systemic thinking and its dimensions, including hierarchy, co-end and multi-end, holistic view, dependence on ambiguous components, and environmental communication on improving organizational performance. Based on this study, systemic thinking and its dimensions significantly impact organizational performance, and the variable of systemic thinking has been able to predict 45% of organizational performance improvement. [8] investigated different definitions of systems thinking in other texts and disciplines to clarify systemic thinking in the modern era and why it is defined differently. [7] concluded that the understanding of system thinking skills by managers and leaders of the organization can contribute to the effectiveness and improvement of organizational performance. [17] analyzed the obstacles to systemic thinking in Iranian organizations using the ISM approach. According to the research results, organizational, cultural, financial, educational, and personality factors were placed in the first level, mental factors in the second level, and information factors in the third level of the model. [13] outlined the fundamental limitations of previous efforts to address and define energy sector interrelationships and emphasized the importance of using systems thinking in addressing energy sector sustainability challenges. [20] examined the impact and the need to use systems thinking to achieve sustainable development goals, to understand the conditions that create and expand sustainability challenges, and to move away from reductionist and human-centered thinking. Bashan [3] presented several key new concepts emphasizing logic and a systems-oriented perspective based on ongoing research. [6] contributed to the engineering field by improving project success rates and team communication while providing a suitable evaluation model. Ahlström [1] analyzed the use and expansion of socio-ecological systemic thinking as a bridging concept in transdisciplinary sustainability research to

improve corporate sustainability practices. [14] discussed the importance of systems thinking when applying ALARP principles to support risk management decision-making. The predominance of the component-oriented attitude and limiting the effect of decisions and actions to the specific subject under investigation is still seen as the dominant view, with a brief look at the state of management of organizations and the decision-making methods of organizational managers. However, the tendency toward managers' thinking and action towards systemic thinking as a theoretical-applied approach is the basis for the growth and elevation of organizational communities and the improvement of effectiveness. Therefore, the influencing factors in establishing system thinking in organizations and the communication and interaction of the factors above should be determined to be effective.

2 Method

This study was conducted on 400 managers, officials, supervisors, and experts of Azar Naqadeh Factory, Urmia Sugar Factory, Khoi Sugar Factory, Piranshahr Sugar Factory, and Miandoab Sugar Factory. A purposive judgmental non-random sampling method was used to select a statistical sample of 196 people based on the Krejcie-Morgan table to distribute the first questionnaire, considering the need for the respondents to be familiar with the topics of systemic thinking and to have sufficient information to analyze the situation and provide appropriate answers. The questionnaire of the structural-interpretive approach was distributed among the sample of research elites to 75 people. The method of library studies and review of reliable sources and the background of previous research was used based on the scientific approaches to increase the appropriateness in designing the questions of measurement tools. The first-stage questionnaire related to the approach (EFA) has 57 questions and is researcher-made and based on a 5-scale Likert spectrum. The standard comparative approach questionnaire (ISM) was used to design the model.

3 The results of exploratory factor analysis (EFA)

The sample size is an influential factor in the accuracy of element clustering to ensure the optimal implementation of the factor analysis approach. In this research, the sample quality index (KMO) was used to check the adequacy of the sample for factor analysis. The value of this statistic is between zero and 1, and the ideal state of this index is numbers above 0.7. In addition, the output of Bartlett's sphericity test was used to calculate the normalized chi-square to ensure the correlation of the variables. The low significance level of Bartlett's test of the probability of type 1 error (0.05) means that the correlation matrix of the variables and the relationship between the variables are not the same. KMO index, Bartlett's chi statistic, and the statistics degree were $0.714, 2491.872$, and 1596, respectively. Also, the significance level of Bartlett's test was 0.000.

The order of factor analysis was implemented on the research data after ensuring the appropriateness of the statistical sample indicators. The final set of variables was extracted to build the scale after the preliminary variables were created in the factor analysis by rotation (Table 1).

Table 1: Number of confirmed factors and the total explained variance of factors affecting the quality of TMS

	Eigenvalues of extraction factors with rotation				**Eigenvalues of extraction factors with rotation**		
Factors	Total	Percentage of variance	The cumulative percentage	**Factors**	Total	Percentage of variance	The cumulative percentage
C1	3.5	6.2	6.3	**C6**	2.2	3.9	27.7
C2	2.7	4.8	11.1	**C7**	2.0	3.5	31.2
C3	2.5	4.4	15.5	**C8**	1.9	3.3	34.5
C4	2.4	4.2	19.8	**C9**	1.8	3.2	37.7
C5	2.2	3.9	23.7	**C10**	1.7	3.0	40.8

Based on a general rule, eigenvalues with a value of at least one are selected as large eigenvalues and identified factors. In this method, the predicted variance value of the variables is used as a criterion for choosing the number of factors. Therefore, the cumulative variance percentage obtained by the desired factors is used to select the number of factors. A total of 10 factors were identified and extracted from the factors affecting systemic thinking, which explained 40.8% of the variance of factors affecting systemic thinking in the organization.

At this stage, the relationship status of the questionnaire questions (57 questions) was examined to explain the factors identified by the common load of the variables (r^2). Variables with a shared load of less than 0.4 do not have much effect in measuring the primary factors in factor analysis and should be removed from the review process. Based

on the results, the common loadings of the questions ranged from 0.468 to 0.997, and thus, all the questions affected the analysis.

After this stage, the relationship strength of the questions with the factors related to each category was checked based on the measurement of factor loadings. The matrix of components was rotated to interpret the factor loadings optimally. The Varimax rotation method minimizes the complexity of the components by increasing significant loadings and decreasing small loadings within each component (column). In each factor, large loads increase and small loads decrease. Each component is defined in the subset of a factor. Table 2 presents the values of factor loadings and factors related to each question after rotating the matrix of components.

Table 2: Factor load of questions in extracting research factors

Factor	Factor Loud	Ques	Factor	Factor Loud	Ques	Factor	Factor Loud	Ques	Factor	Factor Loud	Ques
C4	0.334	46	C10	0.376	31	C3	0.373	16	C10	0.357	1
C4	0.371	47	C8	0.382	32	C8	0.462	17	C10	0.565	2
C6	0.360	48	C6	0.365	33	C5	0.462	18	C9	0.326	3
C5	0.504	49	C7	0.352	34	C10	0.390	19	C2	0.443	4
C3	0.444	50	C5	0.441	35	C10	0.374	20	C4	0.392	5
C1	0.375	51	C1	0.436	36	C8	0.440	21	C7	0.390	6
C5	0.355	52	C10	0.339	37	C7	0.403	22	C6	0.383	7
C5	0.506	53	C2	0.340	38	C6	0.366	23	C3	0.348	8
C2	0.403	54	C8	0.336	39	C4	0.440	24	C8	0.436	9
C9	0.392	55	C8	0.342	40	C3	0.324	25	C3	0.411	10
C2	0.390	56	C4	0.309	41	C1	0.502	26	C10	0.362	11
C2	0.355	57	C7	0.478	42	C1	0.309	27	C9	0.522	12
			C8	0.371	43	C9	0.457	28	C8	0.349	13
			C1	0.313	44	C10	0.429	29	C4	0.379	14
			C2	0.343	45	C9	0310	30	C7	0.320	15

The size of factor loadings of all questions or items is above 0.3, which indicates the power of proper connection between obvious variables (items) and factors related to each category. Therefore, the categories of questions related to each identified factor can be explained according to Table 3. The labels related to each factor were selected based on the nature of themes extracted from the relevant items.

Table 3: Extracted factors affecting the systemic thinking establishment

Factor	Factor Label	Factor	Factor Label
C1	Establishment of optimal information systems	C6	Changing and reforming organizational culture
C2	Long-term change Modeling	C7	Strengthening the attitude of purposive causation
C3	Systematic thinking education	C8	Comprehensiveness in the analysis of phenomena
C4	Promotion and application of holistic thinking	C9	Deconstructing assumptions
C5	Defining evaluation indicators based on systemic thinking	C10	A comprehensive view of phenomena

4 Developing a structural-interpretive model (ISM)

Warfield introduced and developed ISM as one of the systems design methods, especially in economic and social systems. In this method, the order and direction of the complex relationships between system elements are checked, and the complexity between the elements is overcome by analyzing the effect of one element on other elements. Different elements are structured in the form of a comprehensive systematic model. This method is a technique that enables checking the complexity of the system and structures the system in a way that is easily understood [2].

This scientific approach was performed with the necessary calculations to achieve the research model based on standard procedures. A survey was conducted from the research elite group of 75 people (15 people from each studied company) based on comparing the identified variables in the following order.

5 Formation of Structural Self-Interaction Matrix (SSIM)

The opinions of the elite research group regarding the pairwise measurement of the factors were obtained based on the following relationships after the design of the Standard Approach Questionnaire (ISM) based on the extracted factors.

V	A	X	O
The effect of variable i on variable j	The effect of variable j on variable i	Bilateral relationship	No relationship

The frequency method (Mode) was used to summarize the opinions after examining the bilateral relationship based on the rules of the structural-interpretive modeling approach.

The primary access matrix was used according to the rules of the scientific approach to form the primary access matrix from the following relationships:

$(i,j)=1$	$(i,j)=1$	X	$(i,j)=0$	$(j,i)=1$	V
$(i,j)=0$	$(i,j)=0$	O	$(i,j)=1$	$(j,i)=0$	A

6 Formation of the final access matrix

The final access matrix was formed based on entering transferability and multiplicative relationships between factors. If component a leads to component b and component b leads to component k, then it can be concluded that component a will also lead to component k. Finally, a value is achieved based on examining mutual relations and applying the transferability of relations with the definition of new relations.

7 Determining the level of research factors

Each factor's output and input sets are determined, with the number one in the row of each factor forming the output set. In addition, the input numbers in each factor's column are checked to determine the set. Then, the common set of members of the two input and output sets should be determined, and the equality of the members of the output and common sets related to each factor in each iteration of the calculation should indicate the corresponding level of that factor in the model. According to the ISM approach principles, each model level's determined factors should be removed from the review process in the next iterations of calculations (Table 4).

Table 4: Levels of extracted factors in the research model

Repetition	Factor	Output set	Input set	Common collection	level
First	C1	1, 4, 7	1, 3, 5, 6, 9	1	
	C2	2, 4, 7, 8, 10	2, 3, 6, 9	2	
	C3	1, 2, 3, 4, 6, 7, 8, 10	3, 6, 9	3, 6	
	C4	4, 7, 8, 10	1, 2, 3, 4, 6, 7, 8, 9, 10	4, 7, 8, 10	1
	C5	1, 5, 7	5, 9	5	
	C6	1, 2, 3, 4, 6, 7, 8, 10	3, 6, 9	3, 6	
	C7	4, 7, 8, 10	1, 2, 3, 4, 5, 6, 7, 8, 9, 10	4, 7, 8, 10	1
	C8	4, 7, 8, 10	2, 3, 4, 6, 7, 8, 9, 10	4, 7, 8, 10	1
	C9	1, 2, 3, 4, 5, 6, 7, 8, 9, 10	9	9	
	C10	4, 7, 8, 10	2, 3, 4, 6, 7, 8, 9, 10	4, 7, 8, 10	1
Second	C1	1	1, 3, 5, 6, 9	1	2
	C2	2	2, 3, 6, 9	2	2
Third	C3	3, 6	3, 6, 9	3, 6	3
	C5	5	5, 9	5	3
	C6	3, 6	3, 6, 9	3, 6	3
Fourth	C9	9	9	9	4

7.1 Model design based on ISM

The research model was formed in four levels, which significantly impacted higher-level factors based on the principles of approach (ISM) with factors of lower levels. Therefore, the final diagram of the research is designed based on the levels of each extracted variable according to Figure 1 in the following order.

MICMAC analysis: Variables are divided according to the values of two indicators of the power of influence and the degree of dependence in the four areas of the diagram with the titles of autonomous, dependent, linked, and influence. Two indicators indicating the type of interrelationships of the elements are determined based on the degree of influence and effectiveness towards each other based on the number of numbers one in the row and column of each factor in the final access matrix. Therefore, the results of arranging the variables of the research model in the areas of the MICMAC diagram are as follows:

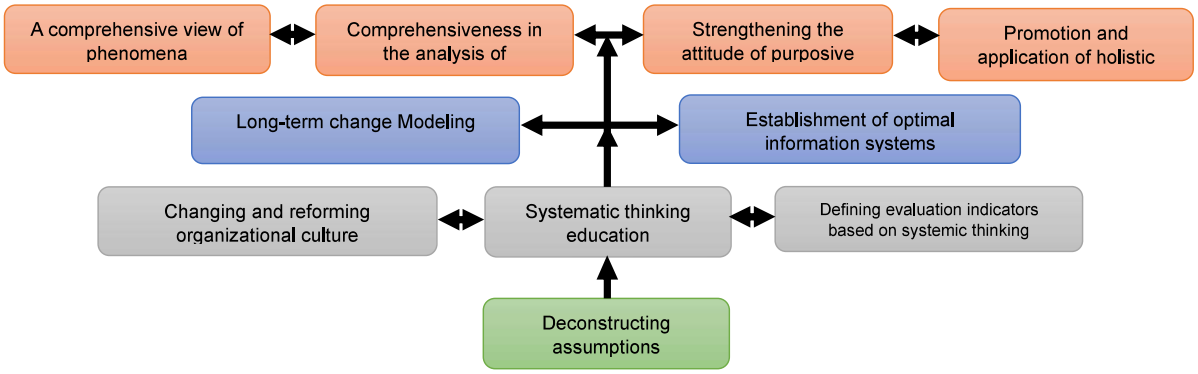

Figure 1: Variables affecting the establishment of systemic thinking

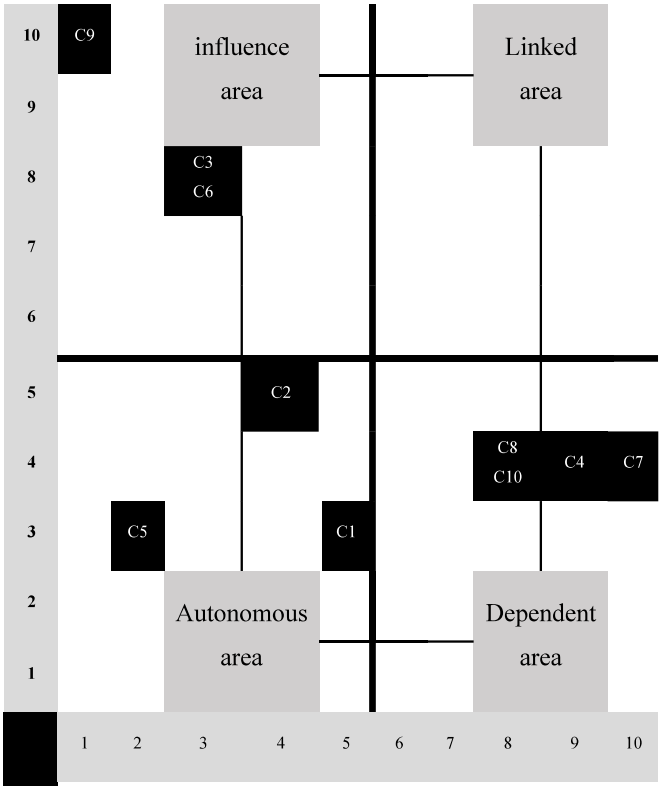

Figure 2: MICMAC diagram of extracted research variables

8 Goodness of fit

The structural equation approach is used since the model's validity guarantees the certainty of correct and stable identification of the factors used. Hence, the relationships between the hidden variables or the factors identified with each other and the measurement items of each hidden variable can be examined with the relevant variable. The strength of the relationship between factors and items is measured based on factor loadings. Based on the results, all observable variables' t-statistics and factor loadings were above acceptable levels. In addition, the diagnostic validity of the constructs was measured with average variance extracted (AVE), and the values obtained for all factors were higher than 0.5. Therefore, the diagnostic validity of the model structures was confirmed.

The reliability of the research measurement tool was also checked by calculating Cronbach's alpha and composite reliability coefficients (CR). T-statistic values measure the significance of the relationship between the establishment

of systems thinking and research variables. The path coefficient or the beta coefficient of standardized regression is between 1 and -1. Positive values of this coefficient indicate a direct relationship between variables (Table 5).

Table 5: Validity parameters of the research model

Factor	CR	α. Cbach	Path coefficient	T statistic
C1	0.92	0.88	0.92	55.50
C2	0.92	0.89	0.85	35.24
C3	0.91	0.87	0.92	57.66
C4	0.96	0.95	0.93	71.67
C5	0.67	0.75	0.83	93.27
C6	0.77	0.71	0.80	62.21
C7	0.85	0.75	0.91	65.53
C8	0.93	0.91	0.91	99.47
C9	0.91	0.88	0.93	94.71
C10	0.94	0.93	0.96	76.11

The t-statistics of all paths related to the outcome of the establishment of systemic thinking regarding the factors extracted from the research indicate that the relationship is significant. On the other hand, the path coefficient of these relationships is positive and more significant than 0.7, which suggests that the relationships examined in the research model can be considered directly and at a high level.

9 Conclusion and Recommendations

This study aimed to identify factors affecting the establishment of systems thinking in companies active in the sugar industry northwest of the country. The desired variables were extracted to design an interactive model and determine the level of importance of each one to help make necessary policies and plans to create corrections and improvements in management methods. Based on the results of the exploratory factor analysis approach, ten factors were extracted based on the technique of predicted variance of the variables. The titles of the identified components were determined based on examining the structure of the questions for each element and psychological principles about the existing concepts in the design of the questions. The research model was designed based on the structural-interpretive modeling approach, and the influential factors related to the establishment of the systems thinking approach were placed in the four levels of importance of the model. The validity of the research model was verified based on the structural equation approach and the desired parameters. Based on the principles of the ISM approach, the impact of factors has an inverse relationship with the reduction of their level height in the model. The research model indicated that the deconstruction of presuppositions is the most critical identified component affecting other variables and establishing systemic thinking in the organization. Therefore, the traditional thinking methods mainly caused by almost fixed beliefs and principles based on dominant paradigms about organization management should be changed, which was placed on the highest level of influence area in the MICMAC diagram. Therefore, managers and policymakers of companies should pay special attention to designing practical solutions to break, adjust, and change outdated mental assumptions in the relations and management of respective organizations. Cooperation with scientific and educational centers to design educational workshops to create changes in people's ways of thinking and inject the paradigm of systemic thinking in the organizational space of the studied companies can be considered a solution. In addition, the general pathology of the corporate culture of companies is necessary to identify the cultural parameters that need to be modified to adapt as much as possible to the characteristics of the organizational culture with the principles of systemic thinking. The formation of specialized working groups to carefully examine the organization's events with the principles of systemic thinking to accurately analyze the leading causes of the events, if continued, can effectively deposit the culture of systemic thinking in the organization as much as possible. The presented model can be considered in adapting to the conditions of the studied companies and other organizations interested in applying systems thinking. According to the conditions of each organization, the implementation and follow-up of each identified variable with different quantitative and qualitative degrees can change the ways of thinking and decision-making in the organization.

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