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Presenting a Model for Evaluation and Selecting Suppliers Using Interpretive Structure Modeling (ISM)

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ABSTRACT

Efficiency and effectiveness of the organization is the result of management performance and supply chain structure. Today, several factors in supplier selection or the best combination of suppliers have been identified that this issue would increase the complexity of supplier selection. This study investigates the application of Fuzzy Delphi in order to identify the important factors in selecting a supplier in the steel industry. Then, we provide a comprehensive and holistic model of supplier selection to overcome this complexity. In this paper, Interpretive Structural Modeling (ISM), unlike other methods, the holistic ones, deal with supplier selection to prioritize components, surfacing and identifying key components. So, industry leaders will provide a comperhensive map for supplier selection. The results of this study indicate that "technical possiblity", "financial health", and "geographical situation" are the basic components in the selection of suppliers.

1. Introduction

Today, a supply chain plays an important role in production and services, such that the efficiency and effectiveness of the organization is derived from function of the management and structure of the supply chain. A key factor in surviving in today's organizations is identifying customers' needs and a quick response to them; this success will be achieved by improvement in supply chain organization [1].

Increasing level of competition, shortening product life cycles, and rapidly changing tastes of customers made many organizations focus on the supply chain as a means to achieve a long-term competitive advantage. On the other hand, one of the important components of the supply chain management is evaluation, ranking, and supplier selection, that is, a complex issue affecting lots of criteria [2].

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Customer satisfaction, customer needs, and priorities require rapid selection of appropriate suppliers [3]. Since the organizations' dependence on suppliers increases, direct or indirect results of incorrect decisions would be more harmful. In recent years, by increasing importance of the supply chain, researchers, scientists, and managers understand that they can increase competitiveness of the supply chain by means of selecting an appropriate supplier and its management.

The problems of Supplier selection are basically of two types:

1. Supplier selection with no limitation; In other words, each of suppliers, individually, is capable of providing the customer needs (requirements), such as demand amount, quality, delivery time, etc.
2. Supplier selection with some limits in supplier cpability, quality, and so on. In other words, in this case, a supplier is not able to meet customer needs, and the customer is forced to satisfy one part of his request from one supplier and the other parts of his demand from another supplier to compensate for the lack of capacity and poor quality of the first supplier. In the first case, a supplier can meet all of the buyer needs (single sourcing). But, in the second type, none of the suppliers can provide all customer requirements individually. So, in this case, more than one supplier should be selected (multiple sourcing) [4]. The cost of raw materials and components make up a significant portion of the cost of goods or services. On average, 70% of the final value of the companies product or services include the cost of raw materials and services that they receive. Hence, it is extremely important to select the appropriate suppliers. As choosing the proper suppliers is effective in reducing the costs and increasing the competitiveness of company, unproper supplier selection can degrade a company's financial, operational, and competitive position [5].

Efficiency and effectiveness of organization is the result of management performance and supply chain structure. The main goal of the supplier selection process is to choose supplier or the best mix of suppliers to increase profit, reduce cost, risk reduction, increase customer satisfaction and good relationships between buyers and supplier. On the other hand, choosing suppliers means choosing the most suitable suppliers which can provide a qualitative product with proper cost in the right time and in a correct number of the customers. This process is the most important activity in order to promote organization status [6].

In order to evaluate the suppliers, using a model is significant in the organizations which is based on the qualitative and quantitative criteria and simultaneously considering apportunities such as advantages, costs and risks. These will help organizations to choose the best option.

In order to evaluate and choose the best supplier, the first step is to pay attention to the appropriate appendix and criterion [7].

After evaluating different criterion for years, companies choose the most proper criteria fit to their organization. The main assumption of this study is that most of organizations tend to spend so much time on selection of their appropriate suppliers because of strategic importance of this issue. Ellram evaluated choosing the suppliers based on the study on organizations which are involved in relationship between customers and suppliers. He named some other items in addition to quality, cost, and service which organizations must be used for. These items include financial issue, organizational strategy, and culture and technology [8].

Weber and his colleagues studied 74 articles about choosing suppliers criteria in the production and sale environment which were published in 1966-1991. They found significant criteria in choosing suppliers. In these studies, they had organized quality, net price, and delivery as the primary and most important criterion and production facilities, geographical location, financial status, and capacity as the secondary criteria [9].

Nydick and Hill suggested four criteria to choose suppliers: quality, cost, delivery, and service. In order to evaluate the factors used to choose the best suppliers, they paid attention to all the quantitative and qualitative factors [10].

Most of the mentioned factors were based on experience of customers in accordance with suppliers. In the following, we mentioned some of the factors which were used in the process of choosing suppliers:

quality, timely delivery, past performance, warranties and assurance policies, commodity, capacity and production facilities, net price, technical capability, financial condition, secure communication system location, and contacts in the industry to deal with utility provide the management and organization of supply, operations management, after-sales services, the

supplier's desire and interest, effect created by personnel of supplier in buyer, the ability to pack, records of working relationship, geographical location volume of transactions in the past, the use of educational assistance, shopping in the future with bilateral agreements [11]. Addressing the issue of selecting supplier in a supply chain is an important issue. The results of the selection of suitable suppliers will lead to maintaining the position of the companies, increasing development and promotion, competetive advantage among other competitors, reducing costs and increasing profitability for organizations. The most important industrial alloys after alluminum and copper are iron and steel. Iron and steel industries are of particular importance. In additon, they are the factors for industrial development of each countries and have an effective role in economy; they can cause the increase of employment [12].

The success of steel company in delivery of their production with competitive costs can improve other company's situation [12].

The aim of this study is to identify key factors in evaluating and selecting suitable suppliers in the steel industry and alloy steel. Because of the importance of steel industry and lack of comprihensive model for managers in choosing the most important criteria for selecting suppliers, the aim of this article is to use ISM model to overcome the difficulties among the items in one group and help managers to choose the best factors for selecting suppliers.

ISM model is an interactive learning process which was introduced by Warfield in 1973 [13]. The model is very suitable when the number of elements and dimensions rises and gets complicated, because it can show the graphic form of the complex issues [14].

This model has the following advantages:

1. Easy understanding of this method for the different members of the interdisciplinary teams.
2. The ability to handle the variables in very much complex system.
3. Presentation of comprehensive attitude of system.
4. A means to integrate different perceptions [15].

ISM tries to identify the correlation between criteria by analysis of criteria in the different levels [16].

As stated, the most important feature of interpretive structural modeling is the power to solve the problems of complexity that will increase due to the large number of factors.

Mandel et al. used ISM to analyze the most important criteria to choose the best seller and the relationship of indices [17]. Identifying the relationship between the variables often depends on the knowledge of the decision-maker's studied case. So, personal judgments about variables can influence the results [18].

Since the important factors for the selection of supplier based on type of industry are different, in this paper, according to alloy steel experts and using Fuzzy Delphi, the most important factors that impact on supplier selection are identified. Then, these factors classified by ISM.

Fuzzy Delphi method was developed in the 1980s by Kaufman and Gupta [19].

The application of this approach is to make decision and consensus on issues whose objectives and parameters are not explicitly specified, and the results are very suitable.

The feature of this method is providing a flexible framework that covers many barriers related to the lack of precision and clarity. Because many of the problems in the decision-making are related to the incomplete or inaccurate information. Furthermore, the decisions adopted by experts in their personal opinion are highly subjective and uncertain.

Since the uncertainty in this situation is of the possibility type, and this type of uncertainty is adapted to the Fuzzy sets, it is better to show the data with fuzzy numbers rather than absolute numbers and use the fuzzy sets for the analysis of experts opinions. Researchers around the world have used fuzzy Delphi in different pieces of research. Karsak used Delphi method with a fuzzy multi-objective decision-making to prioritize design requirements in applying qualitative performance. [20]. Li and Liao used Fuzzy Delphi to assess companies alliance risk [21].

2. Litruature Review

Various studies have been conducted on the evaluation and selection of supplier, some of which are mentioned in the following: the first research on supplier selection was done by Dixon in 1996. For this research, a questionnaire of 23 criteria was sent to 273 managers and customers in America and Canada and asked them to classify these specified criteria on a scale of zero to four[11]. In a comprehensive review on 74 articles in 1991, Waber and his colleagues found that some of them had chosen only one criterion

(cost) and others had chosen criteria (cost and quality); others had mentioned several criteria. This method by Waber was based on dixson classification method[8]. In another research, Ghoudsypour and O'Brien developed a linear programming model combined with AHP which could help managers to recognize quantitative and qualitative factors in purchasing and logistic activities in a systematic way [4]. Zaim and his colleages proposed fuzzy AHP in order to solve the problem of multi-criteria decision-making for supplier selection. Their case of study was television suppliers in Turkey. In this method, FAHP was compared to non-fuzzy, and the results showed that this method is a more appropriate method for evaluating and selecting suppliers [22]. Franklin and Hai, in their paper, suggested a new method which is called voting analytic hierarchy process for supplier selection. This method is a new weighting method, instead of AHP paired comparisons for supplier selection, which is more simple than the AHP method; it is a systematic approach to modereate the weights used in the scoring function and it will not lose its suppliers [23]. Timuri paid attention to the study entitled "Development of a distributed model for supplier selection and supply chain management approach". In this study, a set of mathematical models is presented in order to optimize the supply chain management. The researchers looked at two key activities in the supply chain management and the mathematical model to optimize the existing research gaps. These activities include electing and developing suppliers in the supply chain and distributing as part of a central repository of item in the sub-cellar. In this research, a set of mathematical models was presented to select the preferred suppliers and upgrade them if necessary [24]. Hoshi Maher, in a study entitled "Mathematical Model for Supplier Selection Using Decision-making Multi-variate Case Study: Chainstores' payment", used an integrated approach to select supplier and demand ration provided between them. In this study, they used the analytic network process (ANP) and the multi-objective integer linear programming to select the best suppliers [25]. Ling Tasi and his colleagues had conducted some pieces of research about selecting suppliers based on meta-heuristic method of ant colony algorithm. By expert's consideration, they identified the most important supplier selection criteria, then they evaluated them; after that, using ant colony algorithm to find appropriate suppliers [26]. Ghodsipoor and O'Brien found DSS that could decrease the number of suppliers. They used Analytical Hierarchy Process (AHP) and mixed integer programming in their decision support systems [4]. To evaluate the best implements of war's tools, Cheng, Ching and Lin used the Delphi method with group decision-making, a fuzzy multi-criteria, ranking fuzzy numbers [27]. In another research, Karsak used Delphi fuzzy multiple-objective decision-making with fuzzy logic to prioritize design requirements in using quality function deployment [20].

ISM model has been used in a number of different studies that have been shown in Table (1).

Tab. 1. Using ISM model various management fields

Aouther/Year	Field of study
[17]	Analysis of the whole salers selection criteria
[14]	IT enablers
[18]	Developing balanced score card
[28]	Business Process Model
[29]	Agility design in a new product development process
[30]	Formulation of strategy map
[31]	Design model for selecting and ranking of agile supplier
[32]	Six sigma enabelers model
[33]	Interpretive structural modeling of supply chain risks
[34]	Providing a model for achieving agility through IT

3. Methodology

Methdology of this research, according to research strategy, is survey and its goal is descriptive. In order to collect suitable informations for this research, we used two kinds of questionnaire in this method. The first questionnaire was about the most important criteria of experts in steel industry about

choosing suppliers. In these questionaries, we had two kinds of question: close questions which were based on studying in the library; open questions which were used by experts to express their ideas. After examining these questionaries based on fuzzy Delphi method, we found that among 34 criteria, only 15 of them were chosen as the most important by experts. We transfered these 15 criteria to the second questionnaire, which was based on explanation model, and once again, we asked experts to evaluate each criterion; the results were recorded at the end. We should pay attention that in this paper, the case studies are those experts who are familiar with steel industry, among which 11 of them were used in this method.

Steps of the research are as follows:

Step 1: identifing the factors affecting supplier selection. To achieve this objective by means of an extensive library studies, 34 factors were identified that are shown in Table 2. Also, in addition to these 34 factors, in order to identify other influencing factors, Fuzzy Delphi questionnaire and asking open questions have been used, which are described in step 2.

Tab. 2. Supplier selection criteria

Supplier selection criteria	
Quality	Services after saling
Delivery time	How to deal with the seller
Past performance	Image created by the buyer's labor supply
Warranty and Guarantee Policy Shipping	The ability to package
Facilities and Production Capacity	Experience working relationships
Price	Location
Financial status	Volume of transactions in the past
Admission procedures and guidelines for the buyer Supplier	Training
The technical	Bilateral agreements
Communication System Supplier	Flexibility
Reputation and position in industry	The use of environmentally friendly materials
Willingness to deal with the supplier	Accept compensation in transportation
Management and organizing	Long-term relationships with suppliers
Operational control	Product Warranty
Innovation	Financial health
Acceptance of new technology by supplier	Complete the process of transportation
Continuous improvement programs	Department of Product Design

Step 2: Using the fuzzy Delphi technique:

Implementation of fuzzy Delphi method is as follows:

A: Selecting the experts and the problem of description for them

B: Preparing a questionnaire and sending it to the experts: The importance of 34 factors identified in step1 by linguistic variable slow, medium, and high were questioned. Also, open questions were added to the questionnaire to identify other influencing factors.

C: Get experts opinions and their analyses:

After collecting the completed questionnaires by experts based on linguistic variables, analysis of questionnaires was done.

It should be noted that for determining the importance of the supplier selection criteria, linguistic variables are in accordance with those in Table 3.

Tab. 3. Linguistic variables for determining the importance of the criteria

Trapezoidalfuzzy number	Linguistic variables
(10,10,6,8)	High
(3,4,6,7)	Middle
(0,0,2,4)	Low

For data analysis, the mean of expert panel and differences between it and each expert opinion was calcualated. Then, to get new ideas, this information is sent to experts again.

Fuzzy average is calculated by Equations 1 and 2. Also, the difference is calculated by Equation 3 [19].

$$A^i = (a_1^{(i)}, a_2^{(i)}, a_3^{(i)}, a_4^{(i)}), \quad i = 1,2,3,\ldots,n \tag{1}$$

$$A_{ave} = (m_1, m_2, m_3, m_4) = \left(\frac{1}{n}\sum_{i=1}^{n} a_1^{(i)}, \frac{1}{n}\sum_{i=1}^{n} a_2^{(i)}, \frac{1}{n}\sum_{i=1}^{n} a_3^{(i)}, \frac{1}{n}\sum_{i=1}^{n} a_4^{(i)}\right) \tag{2}$$

$$\begin{aligned}&(a_{m1} - a_1^i, a_{m2} - a_2^i, a_{m3} - a_3^i, a_{m4} - a_4^i)\\ &= (1/n\sum a_1^i - a_1^i, 1/n\sum a_2^i - a_2^i, 1/n\sum a_3^i - a_3^i, 1/n\sum a_4^i - a_4^i)\end{aligned} \tag{3}$$

$$s(A_{m2}, A_{m1}) = \left|\frac{1}{4}\left[(a_{m21}+a_{m22}+a_{m23}+a_{m24}) - (a_{m11}+a_{m12}+a_{m13}+a_{m14})\right]\right| \tag{4}$$

Step 3: Using the ISM model

The various steps involved in ISM technique are as follows:

(1) Selection of relevant elements to the problem: the starting point is the identification of relevant elements to the problem. This step is based on using Fuzzy Delphi in the previous step.

(2) Establishing contextual relation type: the contextual relation must be cogently stated as a possible statement of relationship among the elements. Relations may be of several types like comparative, influential, neutral, or temporal relations [35].

(3) Construction of structural self-interaction matrix (SSIM) by pairwise comparison: Phase (3) of ISM is the most tedious and demanding. During this phase, the participants must decide upon the pairwise relationship between the elements. Keeping in mind the contextual relationship for each element, the existence of a relation between any two sub-elements (i and j) and the associated direction of the relation is questioned. Four symbols are used to denote the direction of the relationship between the elements i and j:

V – for the relation from i to j, but not in both directions;

A – for the relation from j to i, but not in both directions;

X – For both direction relations from i to j and j to i;

O – If the relation between the elements does not appear to be valid.

(4) Developing a reachability matrix from the SSIM and checking for transitivity: Phase (4) is concerned with the construction of the reachability matrix M. It is a binary matrix since the entries V, A, X, and O of the SSIM are converted into 1 and 0 as per the following rules:

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

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

If the (i, j) entry in the SSIM is X, then both (i, j) and (j, i) entries of the reachability matrix become 1.

If (i, j) entry of the SSIM is O, then both (i, j) and (j, i) entries of the Reachability matrix become 0.

Transitivity is a basic assumption in ISM that leads to the final reachability matrix. It states that if element A is related to B and B is related to C, it may be inferred that A is related to C. If element (i, j) of the final reachability matrix is zero, there will not be any direct as well as indirect relationships from element i to element j. The initial reachability matrix may not have this characteristic, because when there is only an indirect relationship from element i to j, entry (i, j) is also zero, that is, until the steady-state condition is reached, such that $M^{n-1} < M^n = M^{n+1}$

(5) Level partitioning of reachability matrix: the fifth phase involves extraction of a hierarchical ordering from the reachability matrix by level partitioning [35]. The purpose of this phase is to facilitate the construction of the digraph from the reachability matrix. The level partition makes use of sets associated with each element sj in s. The reachability set R (si) consists of the element itself and other elements which are reachable from si. Similarly, there may be some elements which can reach the element si constituting the antecedent set A (si). Thereafter, an intersection of the reachability set and antecedent set (R (si) ∩ A(si)), i.e., the common elements in both sets, is derived for each element. The element for which R (si) = R(si) ∩ A(si) is the top-level element in the ISM hierarchy. The top-level element has no relation to any other elements above their own level. Once top-level elements are identified, they are separated out from the other elements. Then, the same process undergoes iterations till the level of all elements is achieved. These identified levels help in building the digraph and final ISM model.

(6) Drawing of digraph with removed transitivity links: An initial digraph, including transitivity links, is obtained from the conical form of the reachability matrix. The conical matrix is achieved from the partitioned reachability matrix

by rearranging the elements according to their level, which means that all the elements having the same level are pooled, i.e., with most zero (0) elements in the upper diagonal half of the matrix and most unitary (1) elements in the lower half. For the sake of simplicity, transitivity links are removed to obtain the final digraph. If there is a relationship between elements i and j, this is shown by an arrow which points from i to j.

(7) MICMAC analysis: identification and classification of the various supplier selection criteria are essential to develop the ISM under study. Comparing the hierarchy of these criteria in the various classifications (direct, indirect, potential) leads to rich source of information. MICMAC is an indirect classification method to critically analyze the scope of each element. The objective of the MICMAC analysis is to assess the driving power and dependence of supplier selection criteria [17], [19]. Based on the driving power and dependence of supplier selection criteria, all elements are divided into four groups of risks (autonomous, dependent, linkage, and independent). Group I includes autonomous elements that have weak driver power and weak dependence. Group II consists of dependent elements that have weak driver power and strong dependence. The third group includes linkage elements that have both strong driving and dependence power. In group IV, all independent elements are clustered that have strong driving power except poor dependence power.

It should be noted that in order to collect information based on 11 experts opinion, the frequency response has been considered [28].

4. Data Analysis

As stated in steps 1 and 2, the objective of the first questionnaire is to collect alloy steel based on experts' opinion by Fuzzy Delphi about their agreement degree with the supplier selection criteria, extracted from literature review. So, experts stated their degrees of agreement based on linguistic variables. Fuzzy Delphi steps in three phases determined 15 main factors that affect supplier selection.

Tab. 4. Final supplier selection criteria

No	Supplier selection criteria	The importance of each factorafter D-Fuzzy prcess
1	Quality	8.13
2	Delivery time	8.44
3	Price	8.44
4	Admission procedures and guidelines for the buyer Supplier	7.82
5	The technical	7.19
6	Services after saling	8.13
7	Location	8.13
8	Volume of transactions in the past	7.51
9	Bilateral agreements	7.82
10	Flexibility	7.51
11	Accept compensation in transportation	7.82
12	Product Warranty	8.13
13	Innovation	7.51
14	Financial health	8.44
15	Complete the process of transportation	7.82

15 important criteria were revealed from alloy steel industry experts, and ISM questionnaire was created and sent to the experts.

The initial reachability matrix was created by the collected questionnaires. Table 5 shows the final reachability matrix.

Tab. 5. Final reachability matrix

Dimensions	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	1	1	1	0	1	0	1	1	1	1	1	0	0	1	1
2	1	1	1	0	1	0	1	1	1	1	1	1	0	1	1

3	0	1	1	0	0	0	1	1	1	1	1	0	0	1	1
4	1	1	1	1	1	0	1	1	1	1	1	1	0	0	0
5	1	1	1	0	1	0	0	1	1	1	1	1	0	0	0
6	1	1	1	0	1	1	1	1	1	1	1	1	0	1	1
7	1	1	1	0	1	0	1	1	1	1	1	1	0	1	1
8	1	1	1	0	1	0	1	1	1	1	1	1	0	1	1
9	1	1	1	1	1	0	1	1	1	1	1	1	0	1	1
10	0	1	1	0	0	0	1	1	1	1	1	0	0	1	1
11	1	1	1	1	1	1	1	1	1	1	1	0	0	1	1
12	1	1	1	1	1	0	0	1	1	1	0	1	0	0	0
13	0	1	1	0	0	0	1	1	1	1	1	0	1	1	1
14	0	1	1	0	0	0	1	1	1	1	0	0	0	1	1
15	1	1	1	0	0	0	1	1	1	1	1	0	0	1	1

As mentioned in methodology section, the latter stage is level partitioning. In order to get this aim, we need reachability set, antecedent set, and intersection set which are shown in Table 6.

Tab. 6. Criteria level partitioning

Criteria	Reachability set	Antecedent set	Intersection set	Level
1	1,2,3,5,7,8,9,10,11,14,15	1,2,4,5,6,7,8,9,11,12,15	1,2,5,7,8,9,11,15	2
2	1,2,3,5,7,8,9,10,11,12,14,15	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15	1,2,3,5,7,8,9,10,11,12,14,15	1
3	2,3,7,8,9,10,11,14,15	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15	2,3,7,8,9,10,11,14,15	1
4	1,2,3,4,5,7,8,9,10,11,12	4,9,11,12	4,9,11,12	5
5	1,2,3,5,8,9,10,11,12	1,2,4,5,6,7,8,9,12	1,2,5,8,9,12	3
6	1,2,3,5,6,7,8,9,10,11,12,14,15	6,11	6,11	5
7	1,2,3,5,7,8,9,10,11,12,14,15	1,2,3,4,6,7,8,9,10,11,13,14,15	1,2,3,7,8,9,10,11,15	4
8	1,2,3,5,7,8,9,10,11,12,14,15	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15	1,2,3,5,7,8,9,10,11,12,14,15	1
9	1,2,3,4,5,7,8,9,10,11,12,14,15	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15	1,2,3,4,5,7,8,9,10,11,12,14,15	1
10	2,3,7,8,9,10,11,14,15	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15	2,3,7,8,9,10,11,14,15	1
11	1,2,3,4,5,6,7,8,9,10,11,14,15	1,2,3,4,5,6,7,8,9,10,11,13,15	1,2,3,4,5,6,7,8,9,10,11,15	2
12	1,2,3,4,5,8,9,10,12	2,4,5,6,7,8,9,12	2,4,5,8,9,12	3
13	2,3,7,8,9,10,11,13,14,15	13	13	5
14	2,3,7,8,9,10,14	1,2,3,6,7,8,9,10,11,13,14,15	2,3,7,8,9,10,14	1
15	1,2,3,7,8,9,10,11,14,15	1,2,3,6,7,8,9,10,11,13,15	1,2,3,7,8,9,10,11,15	2

Based on Tables 5 and 6, supplier selection interpretive structural model has been designed like Figure 1. As Figure 1 shows, all criteria are located in level 5.

Also, in order to draw Driving Power-Dependency diagram, driving power and dependency values are used based on Table 6. Figure 2 shows this diagram.

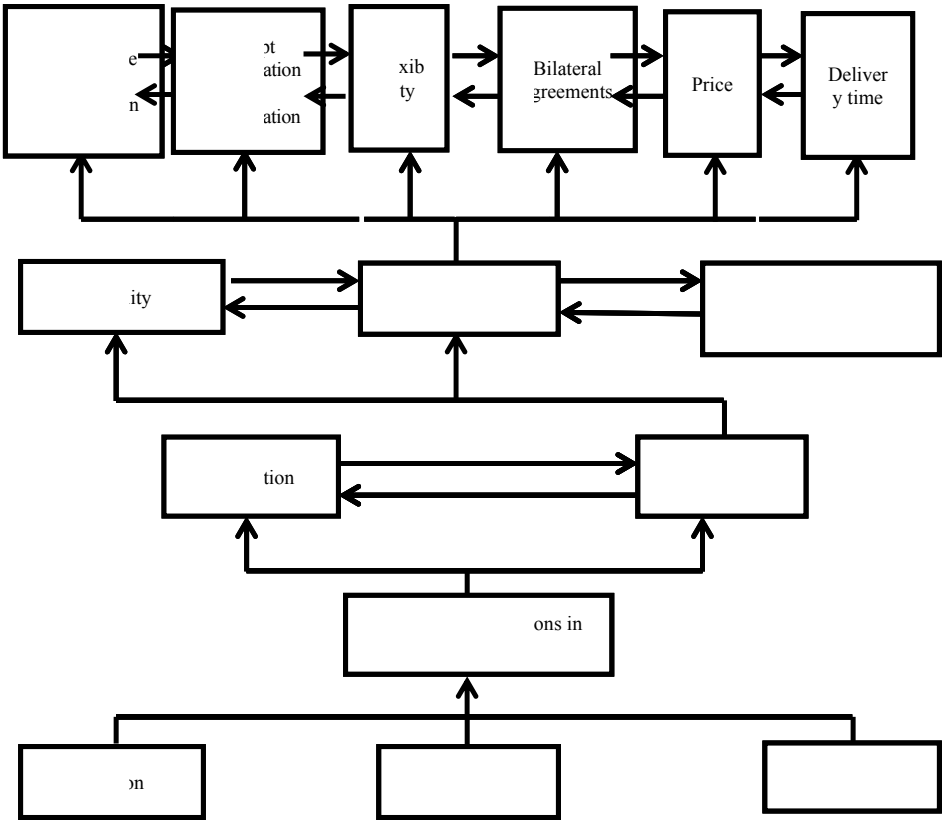

Fig. 1. Interpretive structural model

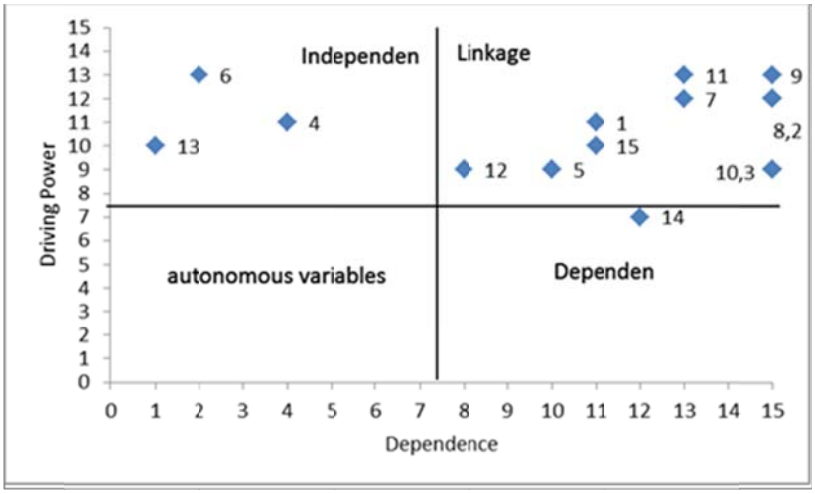

Fig. 2. Driving power-dependency diagram

5. Conclusion

Iron and steel industries are the two most important industries in any country. The steel production and consumption in each country is the indicator of economic development and progress. This industry is also one of the key industries for many supply chains, especially down stream factories. Steel companies' success in providing appropriate products with competitive price would improve the status of many other industries. One of the most significant production factors in the steel industry is supplying of raw materials. To select suitable suppliers, a first step is to identify and evaluate the measures of supplier selection. Given the importance of suppliers to gain a competitive advantage and increase profitability of organizations, in this paper, the factors which

affect supplier selection in the steel industry have been identified.

Therefore, various sources were examined and 34 factors were identified. Then, by using Fuzzy Delphi method and after 3-time sending and receiving of the questionnaires, 15 criterias got finalized. According to the plethora of factors that affect the supplier selection and lack of comperhensive model to supplier selection in steel industry, in this paper, ISM was used to overcome the complexity of relationships between the criteria. Using Driving Power-Dependency diagram by which components can be divided into four categories as follows:

Quadrant 1 shows the first cluster of the "autonomous criteria" with weak driver and dependence power. These criteria will be separated from the model, because they have weak links with the model. In this paper, this kinds of criteria do not exist, which show the strong relationship between criteria in the supplier selection model.

Quadrant 2 shows the second cluster, which is known as the "dependent criteria". These criteria have weak driver-power but strong dependence. In this research, "Financial health" criterion is located in this area. Generally, these criteria are the results of supplier selection model. To create these factors, many factors were involved and these factors have less effect on the other criteria.

Variables in the linkage area that involved variables with strong driver-power and dependence are not stable; any changes would be made on them and their own time, and other variables would also affect them. The results of this study show that quality, delivery time, technology, location, volume of transactions in the past, bilateral agreements, flexibility, product warranty, financial health, completition of the process of transportation and completition of the process of transportation criteria are located in this area.

The criteria in independent area have strong driver-power but weak dependence. These variables along with linkage variables are the key factors that form the basis of the model. Also, to begin the operation in the first place, we should pay attention to them. In this paper, admission procedures and guidelines for the buyer-supplier, services after saling, and innovation were located in this area. For future studies, researchers can use statistical methods to confirm the proposed model.

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