Petroleum Business Review

Research Article-Oil & Gas Economics & Management

Petroleum Business Review, Vol. 5, No. 4, pp. 82–106, Autumn 2021

Rough Process for Selecting the Most Effective Functions of Supply Chain Flexibility Based on Competitive Value Integration Propositions(Case Study: Petrochemical Industry)

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ARTICLE INFO

Keywords:

Integration of competitive values

Rough analysis process

Supply chain flexibility functions

Received: 29 April 2021
Revised: 14 July 2021
Accepted: 24 August 2021

DOI:10.22050/PBR.2021.283969.1185

ABSTRACT

In a complex and ever-changing environment, competitive values play a crucial role in shaping the supply chain strategies of companies operating in an industry, such as the petrochemical industry. The greater the integration of a company's competitive values against other competitors, the more effective the supply chain flexibility is due to a better understanding of market drivers. The purpose of this study is to evaluate the rough analysis process to select the most effective functions of supply chain flexibility based on the propositions of integration of competitive values in the petrochemical industry. The methodology of this research is hybrid and to perform it from meta-synthesis analysis; Delphi and Rough collection used. The target population in the qualitative sector was similar research and academic experts in the field of industrial management. However, the target population was a small number of 23 managers with experience in petrochemical companies, which is acceptable from the statistical population due to the need to analyze the Rough process. In this study, based on the combined analysis of selected researches, 5 propositions of competitive value integration and 5 components of supply chain flexibility were determined, which entered the Rough collection analysis phase according to the confirmation of theoretical adequacy based on Delphi analysis. The results in this section identify the most effective propositions of integration of competitive values of companies operating in the petrochemical industry, three propositions of demand-based management propositions (P2); creating innovative values (P3) and reducing operating time (P5), which affects the flexibility of the supply chain and causes the flexibility of financing as the most effective component of the flexibility functions in the supply chain in the petrochemical industry.

1. Introduction

In today's competitive world, other traditional supply chain management practices that were less integrated in their procedures do not work because environmental change, social development, technological development, and increasing cultural contradictions have all led to far-reaching changes in this area. (Shafiee et al., 2013). In fact, the need to make the right decision and choose the right option from among the many options in various fields such as choosing the best manufacturer; the best distributor; the best area to attract customers; the best business partners in building integrations and the like are important issues in deciding to create integrated values in supply chain management. These decisions range from minor issues to large and large issues, and in many of these cases, if the decision is incorrect, large costs are imposed on companies operating in a competitive environment (Ghazizadeh et al., 2015). As a result, organizations can no longer achieve competitive advantage and increase their market share as a separate product or service unit, and need a planned and principled partnership with their suppliers and customers. As a result, organizations must partner with each other in the form of integrated supply chains rather than as isolated islands (Cigdem and Anand, 2017). Value integrity in the supply chain is defined as the degree to which the manufacturer engages strategically with its supply chain partners and jointly manages internal and external processes of the organization (Khanuja and Jain, 2019). Because supply chain value integration is a promising yet complex tool that is still considered as a weapon to reach maturity in a competitive environment to enhance the dimensions of business development (Ataseven et al., 2020), the need to pay attention to it can help companies as a competitive advantage to create a level of resilience to be flexible in the face of an ever-changing environment. Therefore, during the past years, many researches have tried to create different paradigms based on sustainability; agility, etc. Based on supply chain flexibility, create a level of value integration for greater competitive advantage. It is important to note that the supply chain needs to be flexible; because its operation has always been subject to various uncertainties, such as customer demand and supplier capacity under turbulent economic conditions (Irfan et al., 2019). In other words, with increasing structural complexity at the level of markets and production processes, customer needs must be met achieved in the shortest possible time by increasing the level of flexibility of the supply chain cycle, because the flexibility of the supply chain reflects the capabilities and capabilities of the system to respond quickly and appropriately to internal and external changes in the system. It is important to note from the perspective of the importance of conducting this research that supply chain flexibility as a whole by reducing cycle time and re-processing, while it can help increase the level of competitive effectiveness, it can also promote value integration in the supply chain. In fact, this study seeks to analyze value integration based on supply chain flexibility in petrochemical companies. In this regard, the importance of this research should be stated, despite the fact that in less than a decade, many researchers such as Cagliano et al. (2006); Kim and Cavusgil (2009); Gimenez et al. (2012); Delic et al. (2019) and many other researchers have provided components and indicators of supply chain flexibility, but less research has examined the level of integrity of supply chain values. The lack of a coherent model and theories related to this field caused the researchers of this research in the direction of today's unbalanced economy, by theoretically screening the components and indicators, based on a Rough Set, provide a coherent model of linking theories with applied facts at the level of petrochemical companies. Therefore, this research, citing the articles of the law of the Fifth Development Plan and focusing on Article 156 of this law, in order to develop the petrochemical industry in order to expand the integrity of the value chain and Article 12 of the Law on Development of Competitiveness of Petrochemical Companies to improve the country's financial system (Office of Energy, Industry and Mining Studies, 2015), on the other hand, reducing production costs and competitive agility in regional and international markets under a resilient economy seeks to develop a level of value integration based on supply chain flexibility.

2. Literature review

2.1. Sustainable supply chain management

The concept of sustainable supply chain management has been extensively studied in the last two decades. Development efforts over the 1960s have focused primarily on the economic aspects of sustainable development (Hutchins and Sutherland, 2008). In the years after the 1960s, the non-economic aspects of development activities were also considered. And in the 1980s, the concept of sustainable development was introduced. Extensive development of this concept,

various dimensions of supply chain sustainability literature in the form of social dimensions; What in terms of economic dimensions; What in the form of cultural dimensions; What was discussed in the form of environmental dimensions, etc., which often included common goals. In an Elkington (2011) classification of research literature, sustainability into three main pillars of economics; Environmental and social divisions. It is noteworthy that prior to 2000, there was no explicit, coherent, independent definition of sustainable supply chain management, but from 2001 onwards, the definitions became more purposeful and broader in scope. In one definition, sustainable supply chain management can be considered as an integration of corporate sustainability into supply chain management in which the main dimensions of corporate sustainability are associated with the characteristics of supply chain management (Ahi and Searcy, 2013). On the other hand, Stivastava (2007) defines sustainable supply chain management from an environmental perspective and states that integrating environmental thinking with green supply chain management, including product design, material sourcing and selection, production processes, final product delivery to end customers. And also the management of products after their useful life. On the other hand, Srivastava (2007) defines sustainable supply chain management from an environmental perspective and states that integrating environmental thinking with green supply chain management, including product design, material sourcing and selection, production processes, final product delivery to end customers. And also the management of products after their useful life. As mentioned, today, the process of defining sustainable chain management definitions revolves around a three-dimensional cycle (3BL) including economics, environment and society, and other interesting aspects of the proposed definitions include external stakeholder pressures and the idea that management Sustainable supply chain goes beyond the traditional business concept but is also related to economic performance (Adesanya et al., 2020). From an operational point of view, sustainable supply chain management is considered as a subset of internal and external processes, emphasizing the role of cooperation between supply chain partners. Strategic integrity, transparency, and the achievement of social goals; Environmental and economic goals of the organization are defined through the systematic coordination of key inter-organizational processes to improve the long-term economic performance of companies and their supply chain (Baliga et al., 2019).

3. Supply chain flexibility

Today, flexibility has become a common term among managers, researchers and supply chain consultants. But what is the meaning and concept of flexibility? Flexibility refers to the ability of a system to survive, adapt, and grow in the face of change and uncertainty (Soni et al., 2014). In the definition of others, flexibility is the ability of the supply chain to return to the initial state (before disorder) or move to a new situation that is more desirable than before (Fakoor Saghih, 2015). Regarding supply chain flexibility, we can only refer to conceptual studies, which mostly include a review of the literature and definitions, or principled guidelines based only on compelling examples (Singe et al., 2019). Lummus et al. (2003) Supply Chain Flexibility can be defined as the speed of the supply chain in meeting customer demand as well as the degree of adaptation of production volume in response to various market changes. Vickery et al. (1999) present supply chain flexibility in the following form:

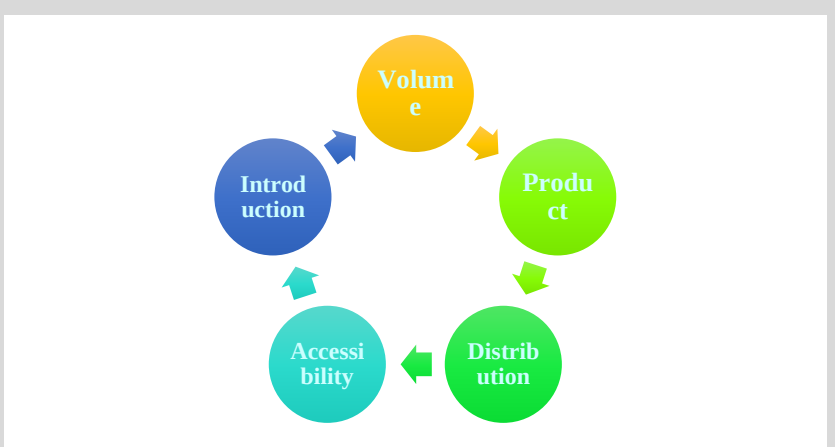

Figure 1: Five-dimensional model of supply chain flexibility (Source: Vickery et al., 1999)

Vickery et al. (1999) believe that from the above five dimensions, there is an interrelationship between the first two components, namely volume flexibility and product flexibility, leading to supply chain flexibility in manufacturing systems and flexibility in distribution and access to market process approaches. And the flexibility to introduce a new product are also linked to research and development (R&D) teams to develop supply chain flexibility functions (Irfan et al., 2019). Sawhney (2006) noted two important aspects of supply chain flexibility, including process flexibility and distribution flexibility. Also, Swafford et al. (2006) in expressing supply chain flexibility into three dimensions of sourcing flexibility; construction flexibility and distribution flexibility were mentioned.

4. Supply chain value integration

Supply chain integration is the degree to which the manufacturer collaborates with supply chain partners and manages processes within and outside the organization as a group to achieve competitive advantage (Flynn et al., 2010). Stevens (1989) first considered value integration to include the following three dimensions:

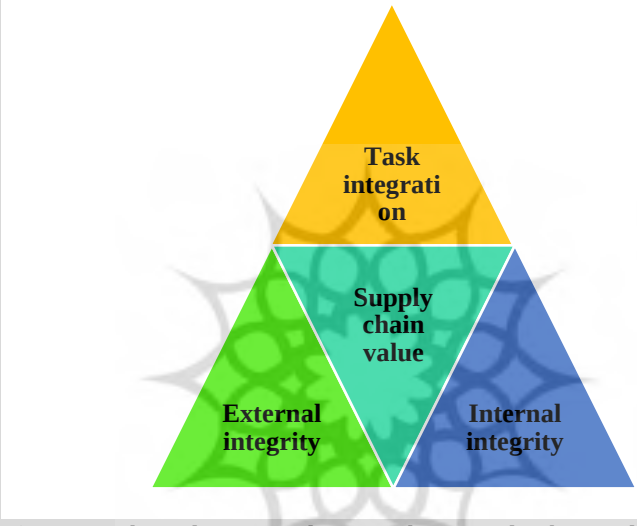

Figure 2: Three-dimensional approach to supply chain value integration (Source: Stevens, 1989)

As can be seen, integration is defined according to Stevens (1989) in three levels of task integration, internal integration and external integration, which includes integration with suppliers and customers, and then researchers identify and introduce other dimensions of integration.

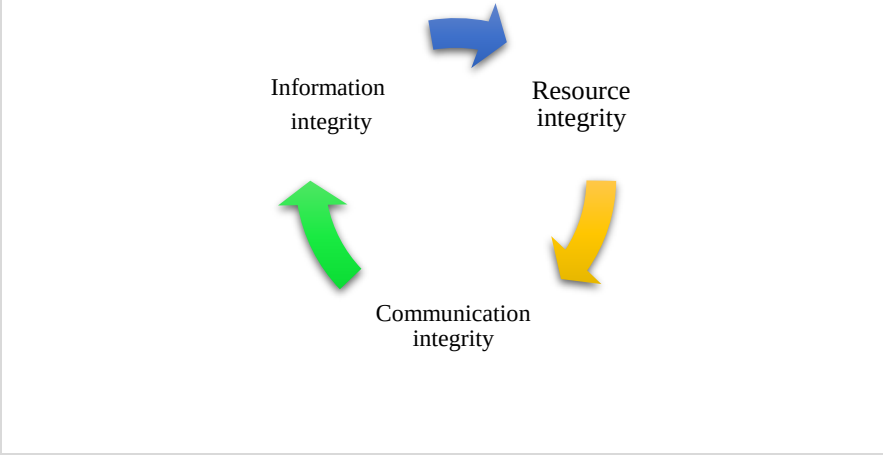

Figure 3: Supply Chain Value Integration According to Lee and Hang (2004)

The researchers introduced supply chain value integration in three dimensions: information integration, coordination and resource sharing, and organizational connectivity and relationships with partners, but emphasized communication integrity given the ever-changing environment. Thus, three dimensions of internal integration, supplier integration and customer integration were introduced as three dimensions of integrated supply chain (Wong et al., 2011; Venpouke et al., 2013). According to various researches, in this research, integration is classified into two dimensions of internal and external integration (Mirhabibi et al., 2018) and external integration includes two dimensions of customer integration and integration with suppliers. Wong et al. (2011) defined internal integration as the process of interaction and collaboration in a group that brings other groups together to create a cohesive organization. According to various researches, in this research, integration is classified into two dimensions of internal and external integration (Mirhabibi et al., 2018) and external integration includes two dimensions of customer integration and integration with suppliers. Wong et al. (2011) defined internal integration as the process of interaction and collaboration in a group that brings other groups together to create a cohesive organization, and there are effective tools to make connections between all tasks. Supplier Integration refers to the process of interaction and collaboration between an organization and its suppliers to ensure effective supply flow. Integration with suppliers increases capacity and, consequently, improves performance indicators such as delivery, quality and cost. Customer integration refers to the cooperation and strategic coordination of a central organization with its customers. Cigdem & Anand (2017) believe that this dimension of integration helps to have a deeper understanding of customer and market expectations and opportunities and leads to a more accurate and faster response to customer needs and requirements by matching supply with demand. Based on the presented theoretical foundations, the research questions are:

1. What are the components of flexibility in the supply chain?

2. What are the integration propositions of competitive values?

3. What are the most effective components of supply chain flexibility based on value integration propositions in petrochemical companies?

5. Research review

Piprani et al. (2021) conducted a study entitled "Prioritizing Economic Sustainability Based on Sustainable Supply Chain: Analytical Hierarchy Process (AHP) in the Textile Industry". This research uses a two-step method. In the first stage, the existing literature was reviewed and based on this, expert panel consultation was conducted to identify flexibility factors at different stages of the supply chain. In the second stage, the Analytic Hierarchy Process (AHP) method was used to rank the elasticity factors required in the Pakistani textile industry. The results show that creating an integrated supply chain ranking requires focusing on the process of economic change, because economic sustainability by adopting appropriate and environmentally friendly policies can contribute to supply chain dynamics. The results also show that companies should focus on the stage of readiness for financing because this stage is classified as the most important stage. Salleh et al. (2020) conducted a study entitled "Development of Large Supply Chain Paradigm for Experimental Study in the Egyptian Shipping Port System". In this study, 4 sustainable supply chains; Green; Lean and agile were analyzed as paradigmatic dimensions of the large supply chain based on theoretical screening. This research, which was a combination, was first developed with the participation of 15 research experts with the aim of developing a large supply chain paradigm. And then, based on the participation of 117 managers in different parts of the Egyptian shipping port system, an attempt was made to explain the dimensions of the model in the target community. The results showed that the development of the large supply chain paradigm helps reduce costs and speed up business interactions in shipping and the most important and in fact the most effective supply chain is the sustainable supply chain, which can clearly be considered as the main driver in the development of interactions between companies. Nath and Agrawal (2020) conducted a study entitled "Analysis of Agile Supply Chain and Lean Supply Chain in Corporate Social Sustainability". The purpose of this study was to investigate the impact of the above two supply chains on the position of companies in the social environment in the form of social responsibilities, maintaining interaction and communication with customers and environmental protection. The statistical population of the study was 311 managers of manufacturing companies in India. Partial least squares (PLS) analysis was used to analyze and fit the model, and exploratory analysis and factor loads were used to reinforce the researcher-made questionnaires. The

results showed that the use and expansion of the two chains of the study, namely agile supply chain and lean supply chain, will strengthen the level of social status of the company, because flexibility in providing resources and improving the level of knowledge in competitive interactions in a pure way promotes the social status of the company. Izadyar et al. (2020) conducted a study entitled "Sustainability Performance Evaluation Model of Large Supply Chain Management Methods in the Automotive Supply Chain Using System Dynamics". In this study, first, by reviewing the literature and interviewing industry experts, large supply chain management methods were identified and prioritized using fuzzy network analysis process, and an integrated approach of large supply chain management methods was presented. Finally, the system dynamics approach has been used to evaluate the dynamics of large supply chain management practices and their impact on sustainable supply chain performance. Findings show that scenarios of improvement in the implementation of total quality management, improvement of timely production execution and improvement of flexible transportation, make the supply chain more stable. The results obtained from the implementation of these scenarios indicate an improvement in supply chain stability. The results show the fact that lean strategy is a very important strategy in achieving stability in the supply chain. The proposed model helps industry managers and decision makers to identify the results obtained from the implementation of large supply chain management practices and, by taking measures, improve the practices that affect supply chain sustainability. Ayoubi Mehrizi and Shahbazi (2020) conducted a study entitled "Assessment of Large Supply Chain Maturity in Saipa Yadak Company Using Fuzzy Inference System (FIS)". The sampling method in this study is judgmental and finally the number of experts in the sample designed to confirm the rules is 7 people. In the present study, a fuzzy expert system is designed to calculate the level of maturity of the large supply chain in organizations. The main dimensions of the system are lean, agile, resilient and green supply chain. The designed system has been tested and validated and the results show the validity and reliability of its performance. Also, this system has been used to calculate the level of maturity of the large supply chain in Saipa Yadak Company.

6. Methodology

Given the existence of three basis results; the purpose and type of data in the methodology of any research should be stated. This research is considered as a developmental research as a result, because the concepts related to the analysis of supply chain flexibility based on value integration are not theoretically coherent and this research seeks to develop the theoretical basis of value chain flexibility, which is considered a development from this perspective. Also, based on the purpose, this research is among the descriptive researches with the aim of explaining the phenomenon in the field of supply chain. Finally, in terms of logic, data collection is inductive-deductive because in the qualitative part, first relying on the inductive approach, it examines the theoretical foundations related to the dimensions of supply chain flexibility and the integration of competitive values and then deduces them based on deductive action. And propositions identified in the target community. In this research, which is a combined research, in the qualitative part, meta-synthesis was used. The meta-synthesis includes steps to arrive at components and propositions that range from recognizing the root cause of the problem in the form of a research question to providing a specific model based on identifying components and propositions from previous research through the participation of panel members. Then, based on Delphi analysis, in order to determine the theoretical adequacy according to the two criteria of average and coefficient of agreement, an attempt is made to analyze the components and propositions back and forth between experts Finally, in the quantitative part, the most effective dimension of supply chain flexibility is selected through the analysis of the total value according to the value integration propositions.

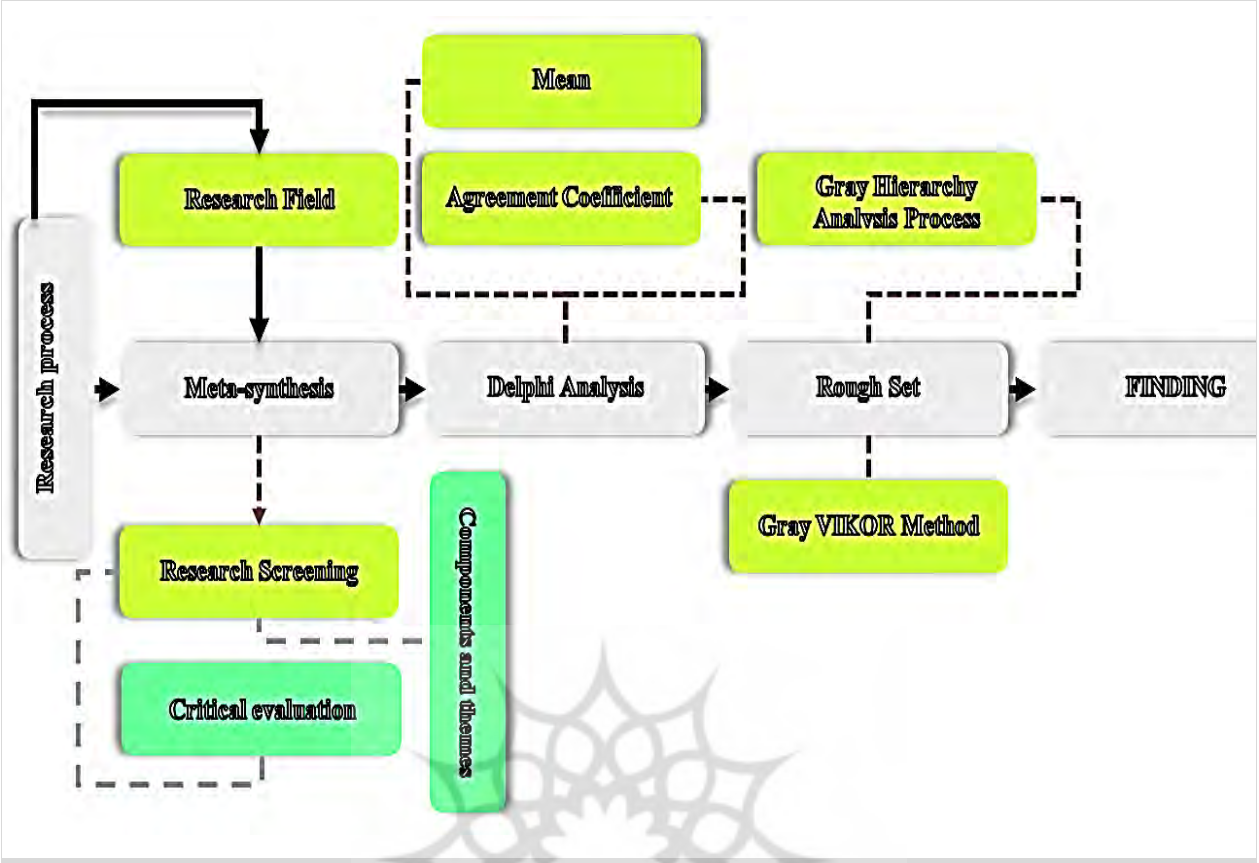

Diagram 1: Methodological diagram

7. Statistical population of the research

The statistical population in the qualitative sector includes 15 specialists and experts in the field of industrial management at the university level, who have a specialized and scientific approach in this regard by conducting scientific research in a similar field. These individuals were selected through homogeneous sampling method, because the goal was for the people who participate in this section to have a theoretical view of the research topic. Also based on meta-synthesis, in this part of the research conducted in sites such as University Jihad (SID) in Iran; Iran Magazine Database (MAGIRAN) Iran; Islamic Computer Science Research Center (NOORSOFR) Iran; International Sciencedirect; Emeraldinsight and OnlineLierary were used to determine components (supply chain flexibility) and research indicators (value integrity). In the second phase, in order to perform the Rough Set, 23 managers with experience in petrochemical companies were asked to as members of the panel, after evaluating the identified components and propositions of the quality section and confirming them, they should respond to the developed matrix questionnaires. In fact, since this method is an analysis based on the analysis of complex systems at certain levels and should be based on a specific criterion such as experience or expertise by participants, which due to the lack of a lot of incomprehensible answers, the cross-matrix questionnaire with participation 15 It takes up to 30 people. Researchers such as Zhang et al. (2016); Shyng et al. (2007) and Pawlak (2005) predicted the optimal sample size selection in the range of 15 to 25 people and based the selection of the sample population on the available sampling method according to the filters in accordance with the nature of the research.

8. Research validity

The Content Validity Ratio (CVR) was used to validate the validity of the constructed questionnaires, based on which ten panel members were asked to fulfill three "important" criteria; to determine "useful but not appropriate" and "unnecessary" claims. To affirm the study's validity, each researcher had to select one of the above three choices. In the end, all the propositions were

determined to be above the set standard (CVR) and were approved.

9. Procedures of the rough set theory

The Rough sets introduced by Pawlak (1982) for the first time, is a valuable mathematical instrument in uncertainty conditions (Pawlak, 1982). After the Rough Set Theory, Zhai et al. (2002) proposed the Rough numbers. A Rough number includes usually "Lower Limit", "Upper limit" and "Rough boundary interval" which depends only on the original data. So there is no need for supplementary data and this can get better understanding of the experts' intended concepts and improve the decision making objectivity (Pawlak, 1982).

Suppose that "U" is a reference set including all members, "Y" is an arbitrary member of U and R sets belonging to "t class". R={G1, G2,…, Gt} which covers all members of U. If these classes are in order as G1< G2<...<Gt, then $\forall Y \in U. G_q \in R. 1 \leq q \leq t$.

The Lower Approximation ($\underline{Apr}(G_q)$), the Upper Approximation ($\overline{Apr}(G_q)$) and the Boundary Area ($Bnd(G_q)$)3 belonging to class Gq are defined as follows:

$$\underline{Apr}(G_q) = \cup\{Y \in U | R(Y) \leq G_q\} \quad E(1)$$

$$\overline{Apr}(G_q) = \cup\{Y \in U | R(Y) \geq G_q\} \quad E(2)$$

$$Bnd(G_q) = \cup\{Y \in U | R(Y) \neq G_q\} \quad E(3)$$

$$= \{Y \in U | R(Y) > G_q\} \cup \{Y \in U | R(Y) < G_q\}$$

Then Gq can be presented using a Rough number RN (Gq)4 in its corresponding lower and upper limits: (Equations 4-6).

$$\underline{Lim}(G_q) = \frac{1}{M_L} \sum R(y) | Y \in \underline{Apr}(G_q) \quad E(4)$$

$$\overline{Lim}(G_q) = \frac{1}{M_U} \sum R(y) | Y \in \overline{Apr}(G_q) \quad E(5)$$

$$RN(G_q) = \left[\underline{Lim}(G_q).\overline{Lim}(G_q)\right] \quad E(6)$$

Where MU and ML are respectively the values of members $\underline{Apr}(G_q)$, $\overline{Apr}(G_q)$

It is clear that the lower and upper limits determine respectively the mean value of the elements related to upper and lower approximations and their difference is defined as "Rough Boundary Interval".

$$IRBnd(G_q) = \overline{Lim}(G_q) - \overline{Lim}(G_q) \quad E(7)$$

The Rough Boundary Interval expresses the ambiguity of "Gq", so that its larger value means more ambiguity, while the smaller value has more accuracy. So the subjective data can be expressed by the Rough numbers.

10. Gray hierarchy analysis process

The gray hierarchy analysis process is one of the most famous and commonly used multiple decision making which is able to measure the level of preferences' consistency and consider the tangible and intangible criteria. The gray relational analysis method is used to select the best choice based on the numbers of criteria. This method, like the TOPSIS technique and the VIKOR technique, starts with a decision matrix but here in addition to distinction between the positive and negative criteria, it also distinguishes between the most desirable values. In this research, because the experts' judgements were subjective and ambiguous, the gray hierarchy analysis process was used. In the following, the gray hierarchy analysis process is presented.

Step 1. Determine the goals, criteria and choices of the research and form the hierarchy structure.

Step 2. Prepare the pairwise comparison questionnaire and collect the experts' opinions.

Step 3. Using the concept of Rough theory to change the experts' preferences to interval numbers and form the interval pairwise comparison matrix like the Equation below:

$$M = \begin{bmatrix} [1.1] & [x_{12}^L . x_{12}^U] & \dots & [x_{1m}^L x_{1m}^U] \\ [x_{21}^L x_{21}^U] & [1.1] & \dots & [x_{2m}^L x_{2m}^U] \\ & & \vdots & \\ [x_{m1}^L x_{2m}^U] & [\dots & \dots & [1.1] \end{bmatrix} \quad E(8)$$

Where, x_{ij}^L, Lower limit; x_{ij}^U, Upper limit. (p.11)

Before computing interval numbers, the inconsistency rate of the pairwise comparison questionnaires should be measured and if this rate is acceptable (below 0.1), we can compute the interval numbers.

Step 4. Calculate the weight of each of the research's criteria using the Equations (9) and (10)

$$w_i = \left[\sqrt[m]{\prod_{j=1}^{m} x_{ij}^L} \cdot \sqrt[m]{\prod_{j=1}^{m} x_{ij}^U} \right] \quad \text{E(9)}$$

$$w_i' = w_i / \max(w_i^u) \quad \text{E(10)}$$

Where, we have: W1' is a normalized form. Finally the weight of the research criteria is obtained (Zhu et al., 2018).

11. Gray yikor method

Step 1: In the VIKOR method, the decision matrix is formed. Since in this research we have used the Gray VIKOR method, the VIKOR questionnaire completed by the experts must be first changed into the interval numbers using the Rough theory concept, then performs calculations using the Gray VIKOR method. In the following the Gray VIKOR method is presented:

Step 1: form the interval decision matrix obtained from the Rough theory,

$$D = \begin{bmatrix} [f_{11}^L f_{11}^U] & [f_{12}^L f_{12}^U] & \dots & [f_{1m}^L f_{1m}^U] \\ [f_{21}^L f_{21}^U] & [f_{22}^L f_{22}^L] & \dots & [f_{2m}^L f_{2m}^U] \\ [f_{n1}^L f_{n2}^U] & [f_{n2}^L f_{n2}^U] & \dots & [f_{nm}^L f_{nm}^U] \end{bmatrix} \quad \text{E(11)}$$

Step 2: determine the best (the most desirable) value fj* and the worst value fj- in each criterion of matrix D

For positive criterion (with the profit nature), the largest number shows the best value and the smallest value shows the worst value:

$$f_j^* = \text{Max}_i f_{ij}^U \cdot f_{ij}^- = \text{Min}_i f_{ij}^L \quad \text{E(12)}$$

It is vice versa for negative criterion (with the expense nature):

$$f_j^* = \text{Min}_i f_{ij}^U \cdot f_{ij}^- = \text{Max}_i f_{ij}^L \quad \text{E(13)}$$

In general, the best and the worst values are obtained as follows:

$$f_j^* = \{(\text{Max}_i f_{ij}^U | j \in B) \text{or} (\text{Min}_i f_{ij}^L | j \in C)\} \quad \text{E(14)}$$

$$f_j^- = \{(\text{Min}_i f_{ij}^L | j \in B) \text{or} (\text{Max}_i f_{ij}^U | j \in C)\} \quad \text{E(15)}$$

B is a set of positive criteria and C is a set of negative criteria.

Step 3: Calculate values of $[S_i^L S_i^U]$ و $[R_i^L R_i^U]$

$$S_i^L = \sum_{j \in B} W_j^L \left(\frac{f_j^* - f_{ij}^U}{f_j^* - f_j^-} \right) + \sum_{j \in B} W_j^L \left(\frac{f_{ij}^L - f_j^*}{f_j^- - f_j^*} \right) \quad \text{E(16)}$$

$$S_i^U = \sum_{j \in B} W_j^U \left(\frac{f_j^* - f_{ij}^L}{f_j^* - f_j^-} \right) + \sum_{j \in B} W_j^U \left(\frac{f_{ij}^U - f_j^*}{f_j^- - f_j^*} \right) \quad \text{E(17)}$$

$$R_i^L = \max_j \begin{cases} W_j^L \left| \frac{f_j^* - f_{ij}^U}{f_j^* - f_j^-} \right| j \in B \\ W_j^L \left| \frac{f_{ij}^L - f_j^*}{f_j^- - f_j^*} \right| j \in C \end{cases} \quad \text{E(18)}$$

$$R_i^U = max_j \begin{cases} W_j^U \left| \frac{f_j^* - f_{ij}^L}{f_j^* - f_j^-} \right| j \in B \\ W_j^U \left| \frac{f_{ij}^U - f_j^*}{f_j^- - f_j^*} \right| j \in C \end{cases} \quad \text{E(19)}$$

Where WjL is lower limit and WjU is upper limit of each criterion's weight.

Step 4: Calculate values of $[Q_i^L Q_i^U]$

$$Q_i^L = v \left(\frac{S_i^L - S^*}{S^- - S^*} \right) + (1 - v) \left(\frac{R_i^L - R^*}{R^- - R^*} \right) \quad \text{E(20)}$$

$$Q_i^U = v \left(\frac{S_i^U - S^*}{S^- - S^*} \right) + (1 - v) \left(\frac{R_i^U - R^*}{R^- - R^*} \right) \quad \text{E(21)}$$

$S^* = \text{Min}_i S_i^L$ ، $S^- = \text{Max} S_i^U$ ، $R^* = \text{Min}_i R_i^L$ ، $R^* = \text{Max}_i R_i^U$

Q is a cumulative index. in addition, v indicates the weight of the maximum criterion policy and is shown a

Shown as $v \in [0.1]$: usually $v = \frac{0}{5}$

Step 5: Ranking choices according to S, R and Q.

Since the Gray VIKOR method suggests the interval weights for the choices of the research, the weight of the choices, similar to VIKOR method, cannot be easily ranked according to Q index. In order to rank the interval weights, there are several ways that are described below.

$$A = [a_1 . a_2]; B[b_1 . b_2] \quad \text{E(22)}$$

$$C = [c_1 . c_2] = A - B = [a_1 - b_2 . a_2 - b_1] \quad \text{E(23)}$$

$$\text{IF} \frac{|c_1|}{c_2 - c_1} < \frac{|c_2|}{c_2 - c_1} \rightarrow \text{Then } A > B \quad \text{E(24)}$$

$$\text{IF}\ \frac{|c_1|}{c_2 - c_1} < \frac{|c_2|}{c_2 - c_1} \rightarrow \text{Then A} \leq \text{B} \qquad \text{E(25)}$$

12. Findings

In order to link the consequential components of flexibility in the supply chain and competitive value integration propositions, meta-synthesis is used to enter the phase of Rough analysis by formulating the identified components and propositions in the form of research matrix checklists in the quantitative part.

13. Meta-Synthesis findings

The method of meta-synthesis through theoretical and research screening seeks to identify components and propositions related to the research topic. The period for analyzing similar research has been 2017 to 2020. In other words, in order to find similar articles and researches and using international and domestic research databases and references, researches related to the research goal were identified.

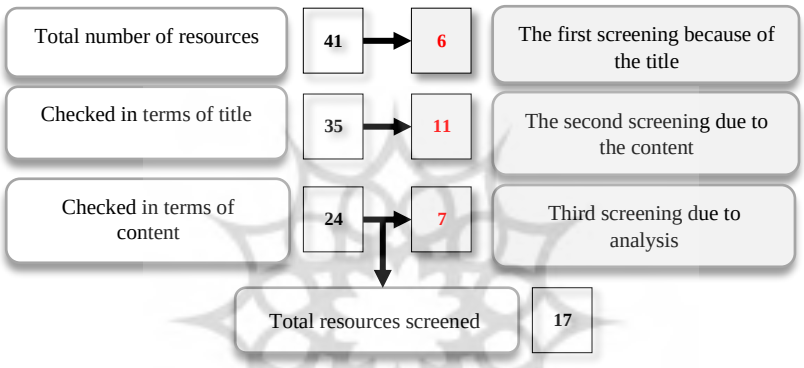

Figure 4: Screening of initial research

(**Source**: Research Findings)

As shown in Figure (4), all of the primary sources identified are 41, which after several stages of the screening process in terms of content, title and analysis, finally, 17 research relevant to the content, title and analytical processes of this research were chosen. At this stage, concepts should be broken down into components and propositions based on the Atttride-Sterling (2001) method, to determine value integration based on supply chain flexibility in the form of scorecards. In fact, through the criterion of economic evaluation based on 10 criteria of research objectives, logic of research method, research design, sampling, data collection, reflectivity, accuracy of analysis, theoretical and transparent expression of findings and research value in part A) to determine the components of supply chain flexibility and in part B) to determine Integrating the values resulting from flexibility in the supply chain.

A) Identify components of supply chain flexibility (T)

In this section, according to the explanations given, the components of supply chain flexibility are identified with the symbol (T). Table (1) evaluates how to evaluate components and indicators based on a 50-point index in the form of scores from 1 to 5 based on the 10 criteria described.

Table 1: Vital Analysis Process of Screened Research.

Researches Status	Critical evaluation criteria / Researches	Research purposes	The logic of the research method	Research plan	Sampling	Collecting data	Reflexivity	Ethical considerations	Accuracy of analysis	Theoretical and clear expression of findings	The value of research	Total
International Researches	Singh et al. (2020)	3	5	4	3	3	3	4	5	4	4	38
	Liao (2020)	4	4	4	4	4	4	4	3	4	4	39
	Irfan et al. (2019)	3	3	3	3	3	4	3	3	3	5	33
	Singh & Kumar (2019)	3	4	4	4	3	4	4	4	3	4	37
	Novais et al. (2019)	4	4	3	4	2	3	4	4	4	4	36
	Goyal et al. (2018)	4	3	3	4	3	3	3	4	4	4	31
	Rojo et al. (2018)	2	2	3	4	3	3	3	3	3	4	***21***
	Manders et al. (2017)	4	5	5	3	4	3	3	3	4	4	38
	Obayi et al. (2017)	3	4	5	4	3	3	2	3	3	4	30
Internal Researches	Akbarzade et al. (2019)	2	3	3	3	4	3	3	3	4	4	32
	Sahebi & Gilani (2019)	3	2	3	2	3	3	3	2	3	4	***26***
	Meftahi et al. (2019)	4	5	4	4	3	4	4	3	5	4	39
	Aghaeipour et al. (2019)	2	3	2	1	1	3	1	2	1	4	***18***
	Abbasi Bastami et al. (2017)	3	3	3	3	4	4	3	3	4	4	34
	Aghaei & Aghaei (2018)	2	2	2	1	2	2	2	3	3	3	***23***

(Source: Research Findings)

The scores presented based on the fashion index showed four researches of Rojo et al. (2018); Sahebi and Gilani (2019); Aghaeipour et al. (2019) and Aghaei and Aghaei (2018) considering that they received less than 30 out of 50 points according to the guidelines for the adequacy of the score of this analysis, the studies that have a score of 30 or higher are approved, were eliminated, and therefore were excluded from the review. Then, using the trade-sterling method (2001), the components of supply chain flexibility are extracted. Accordingly, the following scoring method is used to determine the components of supply chain flexibility. Based on this method, all sub-criteria extracted from the text of approved articles are written in the table column. Then, in the row of each table, the names of the approved researchers are given. Based on each researcher's use of the sub-criteria written in the table column, the symbol "☑" is inserted, then the scores of each ☑ are added together in the sub-criteria column and the scores above the average of the researches are selected as research components.

Table 2: The process of determining the main components of research.

Researches Status	Researchers	Flexibility of financial resources	Information systems flexibility	Strategic flexibility	Operational flexibility	Structural flexibility	Environmental flexibility	Knowledge management flexibility	Marketing flexibility
International Researches	Singh et al. (2020)	-	✓	-	-	-	-	✓	-
	Liao et al. (2020)	✓		✓	✓	-	✓	-	-
	Irfan et al. (2019)	✓	✓	-	-	✓	-	✓	-
	Singh & Kumar (2019)	✓		-	✓	-	-	✓	✓
	Novais et al. (2019)	-	✓	✓	-	✓	-	✓	✓
	Goyal et al. (2018)	✓		-	✓	-	-	-	✓
	Manders et al. (2017)	✓		-	-	✓	-	✓	-
	Obayi et al. (2017)	-	✓	✓	✓	-	-	-	✓
Internal Researches	Akbarzadeh et al. (2019)	✓		-	✓	-	-	✓	✓
	Meftahi et al. (2019)	✓	✓	-	✓	-	✓	-	✓
	Abbasi Bastami et al. (2017)	✓	✓	-	✓	-	-	-	✓
Total		**8**	***6***	**3**	**7**	**3**	***2***	**6**	**7**

(**Source**: Research Findings)

Based on this analysis, seven components of knowledge management flexibility were identified; Marketing flexibility; flexibility of operation processes; the flexibility of financing and the flexibility of the effectiveness of information systems are the most common and therefore in this study are examined as the main criteria of the supply chain. In this section, after analyzing the theoretical foundations of the approved researches, each of the identified components has been defined according to Table (3).

Table 3: Supply Chain Flexibility Components

Components	Definitions
Knowledge management flexibility	This level of flexibility refers to knowledge-based processes in the development of production process functions to distribution and sales. As management systems seek to develop creativity and innovation by improving methods of doing work and acquiring and utilizing knowledge, the level of flexibility in knowledge management in the supply chain is strengthened and increases the competitive advantage for the company (Novais et al., 2019).
Marketing flexibility	In this approach, the level of capabilities and capacities of the company from the marketing perspective to deliver products to potential customers is considered, so that there is a good balance between the level of order with the volume of production and the presence of demanding or demanding customers. This level of flexibility also includes the

	level of ability of the company to effectively and efficiently manage warehouses, loading capacity, its distributors and other distribution facilities in response to emerging market conditions (Obayi et al., 2017).
Flexibility of operation processes	The more agile the process of operations, the more capable it will be to produce better quality products at a lower cost in exchange for greater benefits. In fact, in defining the flexibility of production processes in the supply chain, the technological level and the ability to use available resources to produce quality products with characteristics, combinations and volumes in accordance with the characteristics of different customers, to meet the demands of different markets (Liao, 2020) .
Flexibility of financing	Another important dimension of the supply chain is access to financial resources to pursue future investment plans and projects. As long as a company has the capacity to access liquidity to invest in projects with a positive net present value, it can pursue the development of production infrastructure or the creation of a new single line or new market, regardless of financial constraints, and to a reasonable level. Achieve more attention to competitive advantage (Irfan et al., 2019).
Flexibility of information systems effectiveness	At this level of flexibility, information flow and feedback infrastructures and the timely use of analyzed data for decision making are considered. Information systems seek to provide managers with a level of effectiveness of decision-making processes by creating a reference database to maximize the efficiency of stakeholders. The ability of the organization's information system to adapt to changing conditions, especially during unforeseen events is one of the most important components of flexibility in the supply chain (Abbasi Bastami et al., 2017).

(**Source**: Research Findings)

B) Identify value integration propositions (P)

As in the above steps and following the critical evaluation method in this section, the integration of values resulting from supply chain flexibility is determined. In this section, according to the explanations given, the integration of values resulting from supply chain flexibility with the symbol (P) is identified. Table (4) evaluates how to evaluate the contents of a proposition based on an index of 50 points in the form of scores from 1 to 5 based on the 10 criteria described.

Table 4: The process of critical analysis of screened research.

Research Status	Critical evaluation criteria / Researches	Research purposes	The logic of method	Research plan	Collecting data	Collecting data	Reflexivity	Ethical considerations	Accuracy of analysis	Theoretical and clear	The value of research	Total
Researches International	Huang et al. (2020)	2	3	2	3	3	4	3	3	3	3	**26**
	Liu et al. (2020)	3	4	3	2	2	3	3	3	3	3	**29**
	Oleghe (2019)	4	4	4	4	4	3	4	4	4	4	36
	Abdelkafi and Pero (2018)	3	4	4	4	3	4	4	4	3	4	37
	Zhu et al. (2018)	4	4	3	4	2	3	3	4	4	4	36
	Prasad et al. (2017)	3	5	4	3	3	3	4	5	4	4	38
	Gawankar et al. (2017)	3	4	5	4	3	3	2	3	3	4	30
Internal Researches	Ebrahimi et al. (2020)	3	4	4	4	4	5	4	4	4	4	40
	Manoochehri et al. (2019)	3	3	3	4	5	٤	٤	4	4	4	36
	Khakbazan et al. (2018)	3	4	4	4	4	4	3	4	5	5	40
	Khatami Firoozabadi et al. (2018)	3	2	2	2	2	3	4	3	3	3	**27**
	Rashidi et al. (2017)	2	3	3	3	2	3	3	2	3	3	**26**

(**Source**: Research Findings)

The scores presented on the basis of the fashion index showed that out of a total of 12 initial studies, four studies by Hang et al. (2020); Lee et al. (2020); Khatami Firoozabadi et al. (2018) and Rashidi et al. (2017) considering that they received less than 30 out of 50 points in accordance with the guidelines for the adequacy of the scores of this analysis, the studies that have a score of 30 or higher are approved, were eliminated and were therefore excluded from the review. Accordingly, the following scoring method is used to determine the components of supply chain flexibility. Based on this method, all sub-criteria extracted from the text of the approved articles are written in the column of the table and then in the row of each table, the names of the approved research researchers are given. Based on each researcher's use of the sub-criteria written in the table column, the symbol "☑" is inserted, then the scores of each ☑ are added together in the sub-criteria column and the scores above the average of the researches are selected as research components.

Table 5: The process of determining the main components of research.

Status	Researchers	Customer interaction dynamics	Reduce waiting time and on-time delivery	Creating innovative values	Dynamics of relationship with suppliers	Reduce market and process conflicts	Demand-based management	Dynamics of warehousing management	Reduce startup time	Effectiveness of investment decisions
International Researches	Oleghe (2019)	-	-	-	✓	-	-	-	✓	✓
	Abdelkafi and Pero (2018)	-	✓	✓	✓	✓	✓	✓	-	✓
	Zhu et al. (2018)	-	✓	✓	-	✓	-	✓	-	✓
	Prasad et al. (2017)	-	-	✓	-	✓	-	✓	-	✓
	Gawankar et al. (2017)	-	✓	✓	✓	-	-	✓	-	-
Internal	Ebrahimi et al. (2020)	✓	-	✓	✓	-	-	-	-	-
	Manoochehri et al. (2019)	-	✓	-	✓	✓	✓	-	-	✓
	Khakbazan et al. (2018)	-	✓	-	✓	-	-	-	✓	✓
Total		**1**	**5**	**6**	**6**	**4**	2	**4**	**2**	***5***

(**Source**: Research Findings)

Based on this analysis, it was also identified that there are five statements of reduction of waiting time and timely delivery; Demand-based management; Creating innovative values; Dynamics of relationship with suppliers and reduction of driving time are most frequent. In this section, after analyzing the theoretical foundations of approved research, each of the identified propositions is defined according to Table (6).

Table 6: Proposals for value integration.

Value integration propositions	Symbols	Definitions
Reduce waiting time and on-time delivery	P1	Timely delivery in compliance with the time specified in the delivery of the product, while satisfying the demands of customers, acts as a stimulus to motivate the next interaction with the company. Shortening the waiting time shows the company's commitment to respecting the rights of customers to satisfy their demands (Abdelkafi and Pero, 2018).
Demand-based management	P2	Leading the market in terms of demand is one of the most important strategies for integrating the value of leading companies in the competitive market, because by balancing demand with supply, it can prevent the existence of bubbles and market fluctuations that cause stagnation (Gawankar et al., 2017).
Creating innovative values	P3	Customer value will increase when their tastes and expectations are met, and even beyond that, in order to inspire innovative needs by using up-to-date knowledge, the necessary planning is done by the company in a competitive environment (Prasad et al., 2017).
Dynamics of relationship with suppliers	P4	Supply of raw materials for production is one of the most strategic processes in the supply chain, which requires interactions and effective presence of the company in communication channels with suppliers of raw materials. The greater the capacity to communicate with suppliers, the less pressure the company faces in the absence of raw materials in times of crisis, and this does not mean that the production line is stopped on the basis of losses (Abdelkafi and Pero, 2018).
Reduce startup time	P5	Another of the most strategic functions of value integration is the short time required to produce a product or to set up a production line in general. Existence of this value can be decisive in gaining more company share of the market (Manoochehri et al., 2019).

(**Source**: Research Findings)

Now, in order to determine the reliability and generalizability of competitive value integration propositions as a set and designated components of supply chain flexibility as a reference (according to the relationships defined in Ruff method), Delphi analysis was used to reach the theoretical saturation point. For this purpose, these statements and components were provided to experts in the form of a checklist of 7 options for the survey, which table (7) shows the results of Delphi analysis.

Table 7: Delphi analysis process.

Identified components	The first round of Delphi			Second round of Delphi			Result
	Average	Coefficient of agreement	Standard deviation	Average	Coefficient of agreement	Standard deviation	
Knowledge management flexibility	5.30	0.64	0.45	5.50	0.80	0.94	**Confirm**
Marketing flexibility	5.10	0.55	0.63	5.20	0.60	0.72	**Confirm**
Flexibility of operation processes	6	0.80	0.55	6.20	0.85	0.63	**Confirm**
Flexibility of financing	5.20	0.60	0.56	5.50	0.75	0.66	**Confirm**
Flexibility of information systems effectiveness	5.10	0.55	0.78	5.10	0.58	0.82	**Confirm**
	The first round of Delphi			**Second round of Delphi**			**Result**

Identified propositions	Average	Coefficient of agreement	Standard deviation	Average	Coefficient of agreement	Standard deviation	
Reduce waiting time and on-time delivery	5.50	0.78	0.84	6.10	0.82	1.002	**Confirm**
Demand-based management	5.30	0.64	0.45	5.50	0.80	0.94	**Confirm**
Creating innovative values	6	0.80	0.55	6.20	0.85	0.63	**Confirm**
Dynamics of relationship with suppliers	5	0.50	0.96	5.10	0.55	0.80	**Confirm**
Reduce startup time	5.20	0.60	0.67	5.30	0.65	0.69	**Confirm**

(**Source**: Research Findings)

As it is known, all components and propositions in line with the nature of analysis and concept due to the participation of research experts in the form of panel members, have the necessary theoretical adequacy, because both in terms of scores obtained from the average and in terms of scores obtained from the agreement coefficient is approved by all of them.

14.Rough analysis

In this step, in order to determine the weight of the criteria according to the separation of reference variables from member variables and in order to better understand and deduce more noticeable coding is used.

Table 8: Coding of components and propositions for Rough analysis.

Purpose	Elements	Research component codes
Supply chain flexibility components	Knowledge management flexibility	T1
	Marketing flexibility	T2
	Flexibility of operation processes	T3
	Flexibility of financing	T4
	Flexibility of information systems effectiveness	T5
Competitive value integration propositions	Reduce waiting time and on-time delivery	P1
	Demand-based management	P2
	Creating innovative values	P3
	Dynamics of relationship with suppliers	P4
	Reduce operating time	P5

(**Source**: Research Findings)

After forming the propositions and components of the research, it is time to calculate the weight of the research criteria using the gray hierarchical analysis process. For this purpose, after forming the pairwise comparison matrix of the problem, the opinions of experts were collected. In the next step, the degree of incompatibility of each pairwise comparison matrix was determined. If the incompatibility of the pairwise comparison questionnaires is standard (less than 0.1), the next step can be started, otherwise the pairwise comparison questionnaires will be returned to the experts for review. After confirming the compatibility of the pairwise comparison questionnaires using Rough theory (Equations 1 to 6), the experts' opinion was converted to distance numbers. Finally, the criteria were obtained using equations of 8 to 10 weights. Table (9) shows the results obtained from the calculations of the gray hierarchical analysis process.

Table 9: Results of Gray hierarchical analysis process.

Purposes	Weight of criteria		Elements	Weight of elements		The final weight of the elements	
	Low limit (L)	Upper limit (U)		Low limit (L)	Upper limit (U)	Low limit (L)	Upper limit (U)
Components	0.49	0.76	Knowledge management flexibility	0.301	0.354	0.287	0.354
			Marketing flexibility	0.222	0.268	0.195	0.268
			Flexibility of operation processes	0.129	0.211	0.108	0.211
			Flexibility of financing	0.463	0.517	0.421	0.517
			Flexibility of information systems effectiveness	0.230	0.282	0.185	0.282
Propositions	0.64	0.81	Reduce waiting time and on-time delivery	0.155	0.237	0.131	0.235
			Demand-based management	0.414	0.535	0.398	0.535
			Creating innovative values	0.606	0.689	0.576	0.684
			Dynamics of relationship with suppliers	0.311	0.453	0.243	0.453
			Reduce startup time	0.262	0.293	0.241	0.264

(**Source**: Research Findings)

According to the final weight of each component and proposition, it is determined that the incompatibility values are below 0.1, based on which the second step of the rough analysis can be entered. The next step after calculating the weight of the research criteria is to form a problem decision matrix. To form the distance decision matrix, experts' opinions on the status of each option in each of the criteria were first collected using the VIKOR questionnaire, the results of which are presented in Table (10).

Table 10: Expert opinion on each of the options based on each criterion.

The first participant					
	(P1)	**(P2)**	**(P3)**	**(P4)**	**(P5)**
T1	2	4	3	6	4
T2	3	5	5	6	4
T3	3	4	4	5	2
T4	2	1	4	6	2
T5	3	2	5	3	2
* Note: Due to the limited pages of the article only, the answer of a contributor is provided.					

(**Source**: Research Findings)

After distributing and analyzing the opinions of experts about the status of each option in each of the propositions, a decision matrix is formed to analyze the problem. To form a problem-solving table, the analysis of the views of 23 managers with experience in petrochemical companies as members of the target community in the quantitative sector must first be converted into distance numbers. Equations 1 to 6 are used to convert score analyzes to distance numbers. Table (11) shows the decision matrix of the distances obtained from the rough method:

Table 11: Decision analysis distance analysis matrix.

	(P1)		(P2)		(P3)		(P4)		(P5)	
	Low limit (L)	Upper limit (U)	Low limit (L)	Upper limit (U)	Low limit (L)	Upper limit (U)	Low limit (L)	Upper limit (U)	Low limit (L)	Upper limit (U)
T1	10.28	12.44	20.84	22.17	18.74	20.32	14.35	16.07	17.66	19.23
T2	9.89	11.52	18.11	20.10	18.61	20.21	13.75	15.55	16.50	18.29
T3	13.86	15.77	19.04	21.66	20.16	21.95	16.05	17.82	17.15	18.96
T4	11.24	13.45	17.74	19.19	16.78	18.24	14.37	16.11	18.36	20.15
T5	9.67	11.41	19.56	21.89	19.01	21.52	15.70	17.30	17.91	19.53

(**Source**: Research Findings)

Based on the result of the distance decision matrix, the demand-based management propositions (P2) were identified; creating innovative values (P3) and reducing start-up time (P5) are considered as the most effective propositions of integration of competitive values of companies operating in the petrochemical industry. Then, in order to analyze Gray VIKOR, research options are reviewed and evaluated. The first step in the Gray Vicker method after the formation of the decision matrix is to identify the values of positive ideal (f_j^*) and negative ideal (f_j^-) in each of the criteria of the decision matrix. Table (12) shows the results obtained:

Table 12: Determining positive and negative ideals.

	(P1)	(P2)	(P3)	(P4)	(P5)
Positive ideal (f_j^*)	12.76	22.46	20.22	16.63	20.08
Negative ideal (f_j^-)	10.03	20.34	18.15	15.14	17.98

(**Source**: Research Findings)

As can be seen, none of the propositions has a higher negative ideal than the positive ideal, and this reflects the effectiveness of all propositions in terms of supply chain flexibility. But based on the results, it was again confirmed that the three demand-based governance propositions (P2); Creating innovative values (P3) and reducing start-up time (P5) as the most effective propositions of the integration of competitive values of companies operating in the petrochemical industry, have a higher degree of desirability than other propositions. But to recognize the most influential dimension of supply chain flexibility in the petrochemical industry based on the existence of competitive value propositions of companies operating in the petrochemical industry, one must rely on the Gray VIKOR method as the last step. That is, based on relations (16) to (19), first the propositions S_i^U , S_i^L , R_i^U, R_i^L are calculated, then by specifying the propositions, the main proposition of Vicky Gray, ie Q, is determined from equations (20) and (21) are used. Table (13) shows the results of the calculations.

Table 13: Analysis of Gray VIKOR Method propositions.

Supply chain flexibility components	Code	S_i^U	S_i^L	R_i^U	R_i^L	Q_i^U	Q_i^L	Rank
Knowledge management flexibility	P1	0.527361	1.261317	0.213896	0.404428	0.287366	0.450030	Third
Marketing flexibility	P2	0.554720	1.284763	0.243887	0.421605	0.301628	0.523588	Forth
Flexibility of operation processes	P3	1.10263	1.906635	0.352651	0.571672	0.440372	0.702763	Fifth
Flexibility of financing	P4	0.414443	1.12379	0.182651	0.325502	0.183193	0.332694	First

Flexibility of information systems effectiveness	P5	0.493055	0.234539	0.188745	0.330564	0.216721	0.419085	Second
Assessment criteria	Propositions			S^*	S^-	R^*	R^-	
	The value of propositions			0.652410	3.40561	0.503451	1	

(**Source**: Research Findings)

Since the proposition Q represents the most important law in rough analysis, ie the most important feature for modifying or improving the components, in this study it was determined based on Table (14), Q is related to the flexibility of operations processes (P3) is the highest among research components. However, since according to the Ruff Analysis Guidelines, the lowest Q value determines the center component, which is called the inverse of Rough analysis, it was determined that the lowest component, financing flexibility (P4), is the most important component of supply chain flexibility. It becomes. Also in second place is the effectiveness of information systems (P5). In fact, this result shows that the most effective component of supply chain flexibility is the financing functions, which has the highest level of priority in the dimensions of supply chain flexibility. , Which under the influence of the propositions of integration of competitive values of companies operating in the petrochemical industry experience the greatest strengthening.

15.Conclusion

Value integration based on supply chain flexibility is pursued today as one of the most important strategic considerations at the top levels of corporate governance in a competitive market environment, so that if not considered, it will affect all corporate activities according to market needs. Therefore, this study tried to identify the components of flexibility and the propositions of integration of competitive values, using Ruff set analysis, to examine the degree of flexibility of the chain under the propositions of integration of competitive values of companies operating in the petrochemical industry. It can help the effective competitive functions of companies active in this field. Based on this, first, by using meta-synthesis analysis and theoretical screening in the content of similar researches, an attempt was made to identify the components and propositions of the research and then based on Delphi analysis, an attempt was made to evaluate the theoretical adequacy of components and propositions. Then, based on the approved components and propositions, the research entered the Rough collection phase, in order to determine the most effective propositions of integration of competitive values of companies operating in the petrochemical industry, as well as the most influential components of supply chain flexibility. In analyzing the obtained results, the results can be interpreted in several sections. First, based on determining the most effective integration value propositions of companies operating in the petrochemical industry, it should be stated that the two demand-based management propositions and the creation of innovative values were identified as the most effective reference in integration values. This result means that competitive values with the development of innovation and creativity in product production to help increase the level of demand management in the market and enable the company as a market leader to control volatility and align with customer needs in environmental conditions. The turbulent will provide the best answer so that it can gain a more significant competitive advantage. Finally, it was found that among the components related to flexibility in the sustainable supply chain, two components of financing flexibility (P4) and information systems flexibility (P5) are allocated the most effective in competitive conditions for supply chain flexibility of companies operating in the petrochemical industry. The flexibility of financing in the supply chain helps companies operating in the petrochemical industry to have the necessary plans for the future advancement of their investment plans and projects, regardless of any financial constraints, so that it can launch its plans to launch a new production line in the shortest possible time or pursue new products. Having this flexibility as a competitive basis in the supply chain will allow the company to open its hands to the path of sustainable economic development. And by developing investment in its infrastructure to provide a level of efficient production processes to marketing in various international regions and access to new markets. On the other hand, the flexibility of information systems helps companies active in the competitive field of petrochemicals to reduce their need for raw materials by recognizing new markets and obtaining more accurate information from the market and adapting it to production processes while under inflation and sanctions. At the same time, it can respond to the ever-changing needs of the market by providing timely

information to production teams and various parts of the company. By creating a reference database and collecting data on operations and performance processes,

from improving product quality to achieving include new markets and even macroeconomic dimensions. Results obtained from the perspective of analytical and conceptual processes with the research of Singh et al. (2020); Singh et al. (2019); Abbasi et al. (2017); Tachizawa and Gimenez (2009) and Naser Sadrabady et al. (2014) correspond. Based on the obtained results, it is suggested that companies active in the field of petrochemicals, according to the needs of customers and the existence of opportunities and market threats, try to create new production lines in order to improve production processes and improve the quality of their products. Have ergonomic order both in terms of space occupation and resources, accordingly, the effectiveness of supply chain production processes can lead to greater profitability for the company by reducing costs. On the other hand, try to make financial resources more accessible to invest in your future plans and projects. By timely disclosure of financial information and improving the quality of financial reporting, to gain the trust and confidence of banks and financial institutions and even foreign investors to pursue investment projects more effectively. These companies should also strive to develop infrastructure investments to collect data through cross-border teams and research and develop (R&D) teams, in line with the information needs they need to meet in today's competitive market environment. And by dynamizing their analytical processes, which require interactions and the effectiveness of communication channels within the company, to try to develop the level of flexibility of information systems, and thus to their competitive goals in terms of customer recognition; what about recognizing new markets; what about recognizing production with newer methods and so on. Regarding the limitations of this research, it should be noted that since the research combines the content and theoretical part with the real perceptions of the managers of petrochemical companies, while a significant level of connection between theories and practical facts can be pointed out. At the same time, she acknowledged the lack of coverage of all aspects of supply chain flexibility, as there may be numerous strategic and operational insights in the face of competitive realities that play a role in creating value for companies' competitive advantages. Also, another limitation of this research is related to its general nature and should be examined in different case situations and according to the structural characteristics of a particular company and its results should be compared with other similar companies in this field. However, as a suggestion for future research, the analysis method presented in this study can be done for a specific case analysis to evaluate the flexibility in the direct value chain based only on statistical data, so by referring to the functions of analytical processes, the level of cost differences in dimensions can be determine the various supply chains, based on that, through the formulation of codified strategies to control costs, implemented appropriate actions. It may also be used to rank flexibility strategies along the indirect value chain for the dimensions of sustainable corporate development. Finally, it should be noted that this study opens the way for future research in two areas: one, conducting practical case analyzes and extracting unique propositions, and the second, further refining the process method of supply chain operations and developing a decision support system at the process level what makes it possible at the operational level.

these information systems provide managers with a level of effectiveness of decision-making processes to maximize returns to stakeholders, a return that may range

Appendix

A) Delphi analysis questionnaire

Elements	Code	Likert scale						
		1	2	3	4	5	6	7
Knowledge management flexibility	T1							
Marketing flexibility	T2							
Flexibility of operation processes	T3							
Flexibility of financing	T4							
Flexibility of information systems effectiveness	T5							
Reduce waiting time and on-time delivery	P1							
Demand-based management	P2							
Creating innovative values	P3							

Dynamics of relationship with suppliers	P4							
Reduce operating time	P5							

B) Rough Set Questionnaire

Elements		T1	T2	T3	T4	T5	P1	P2	P3	P4	P5
Knowledge management flexibility	T1										
Marketing flexibility	T2										
Flexibility of operation processes	T3										
Flexibility of financing	T4										
Flexibility of information systems effectiveness	T5										
Reduce waiting time and on-time delivery	P1										
Demand-based management	P2										
Creating innovative values	P3										
Dynamics of relationship with suppliers	P4										
Reduce operating time	P5										

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