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RESEARCH PAPER

Providing a Model for Supply Chain Agility of Ground-Based Military Products and Its Impact on Supply Chain Performance

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ABSTRACT
The most important goal of manufacturing military products in Iran is self-reliance and defensive deterrence against threats. These two goals have led to international competition of Iranian military industries with pioneer countries in this field. The rapid manufacturing of diverse and new military products by advanced countries enforced Iran's military industries supply chain to produce diverse products rapidly. Manufacturing military products by such features needs an agile supply chain, which can produce diverse military products rapidly and meet different volumes of demand. Military products are categorized into three groups: ground-based, air-based, and sea-based. Although air-based and sea-based military products are known as strategic military products in the world, ultimate success has not yet been achieved in any global military event without the help of ground-based military products. This paper aims to provide a model that shows the relations between supply chain agility practices for ground-based military products and their impact on chain performance. To this end, first, we identified the most important supply chain agility practices by expert's questionnaire. Then, using factor analysis, practices are categorized. Finally, the final model is represented by using interpretative structure model (ISM). Research findings indicate that there are 41 effective practices in the agility of military products supply chain within 8 groups including supplier's relationship, workshop level management, improving organizational structure, improving human resources, product design, process integration and improvement, IT utilization, and customer's relation. The final model of this research indicates that using such practices in the format of hierarchical relations will lead to the proper responsiveness of the military products supply chain to its customers.

KEYWORDS: *supply chain, agility, ISM, military products, performance improvement.*

1. Introduction

Countries are always encountering various types of threats by their enemies, and this has made national security a key element for them. Providing national security against threats usually occurs in two ways. One is a country's recourse to unity and coalition with big powers against threats, and another one is to rely upon national resources and defensive self- reliance. Considering the universal message of the Islamic Republic of Iran and its revolutionary ideology, no strategic coalition is possible between Iran and big powers. Thus, the only way to generate national security is self-reliance and defensive deterrence. Iranian military products can yield defensive deterrence if they can compete against advanced countries military products in terms of diversity, production speed, and proper performance. Thus, manufacturing military products with such features is necessary, and Iranian military industries should use their full power to produce such products. Similar to other products, military products should be manufactured in a supply chain format through competition among organizations; thus, new supply chain approaches, including agility, are taken into consideration by supply chain

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managers [11]. The proper management of supply chain has the ability to increase customer service, reduce operating costs, increase product quality, and increase the speed of delivery and innovation [24]. Supply chain agility is an approach based on the introduction of new products into turbulent and volatile markets in terms of diverse and varied demands for different volumes of products, facilitating the production of diverse products of high quality and high speed [26]. Considering the military attendance of superpowers (which enjoy the state-of-the-art military equipment) in the region on the one hand and unstable conditions in the neighboring countries of Iran that have become nests to groom terrorist groups on the other hand, the supply chain agility of ground–based military products to manufacture diverse products with high quality and speed to promote defensive deterrence potency against threats is highly necessary. The main question is: what practices are included in ground-based military products supply chain agility? What are the most important and most executable practices? How are their relations? Which one does play their role as driver practices and which ones are the affected practices in the military products supply chain agility? What is the impact of such practices on supply chain performance? The present study is designed to provide a model of ground-based military products supply chain agility in order to answer these questions.

2. Literature Review

2-1. Supply chain agility

Supply chain includes all steps that influence customer's demand supply both directly or indirectly. Thus, supply chain includes not only manufacturers and suppliers, but also transportation, warehouses, retailers, and customers [8-13]. Christopher (2000) considered supply chain agility as an attention feature of an organization that worked with market sensitivity, virtualization, integration of processes, and networking with suppliers and customers to meet their changing needs [14]. Therefore, the ability to continuously monitor and interpret supply and demand for market volatility and effective communication with suppliers and customers is a key component of agile supply chain [25-34-40]. Tolone (2000) argued that the supply chain agility represented the effective integration of all components of the supply chain and emphasized close and long-term relationships between consumers and suppliers [37]. Christopher and Towil (2000) also argued that in order to gain a competitive advantage in a changing business environment and ensure the efficiency of their operations, companies must match with suppliers and customers and collaborate to gain an acceptable level of agility [15]. Supply chain agility as the integration of business partners to create new competencies for the fast responsiveness to changing markets and introduce the key factors of the agile supply chain including dynamic structures and communication configuration, the correct, timely and proper cycle of information and management based on market events [7-26]. Agile supply chain is necessary for today's organizations, and its management includes activities related to exclusive strategies that yield products nowhere to be found by consumers [10-21].

2-2. Supply chain agility practices

Supply chain agility is done by a series of practices. These practices are recognized as a set of activities performed by organizations to promote the supply chain effective management [4]. In other words, such practices are taken to execute the supply chain agility approach and to improve supply chain performance [12]. In different studies, practices to execute this approach are taken in addition to expressing the importance of using the agility approach in supply chain. Table 1 presents the results of an earlier research study on the introduction of the agile supply chain practices.

Tab. 1. Introduced practices for supply chain agility in previous research

Row	Practice	Resource
1	The use of information technology to coordinate and integrate in the design, production and development of the product	[26], [19], [2], [36], [4], [16], [38], [5], [20], [31]
2	Application of information technology for Coordination and integration in supply	26, [19], [2], [36], [4], [16], [38], [5], [20], [31]
3	Application of information technology for coordination and integration in delivery	26, [19], [2], [36], [4], [16], [38], [5], [20], [31]
4	Establishing trust-based relationships with suppliers and customers	26, [2], [20], [28], [31]

5	Information stream through the virtual network throughout the entire chain	26, [36], [12], [38], [33], [20], [31]
6	Improvement and integration of processes	26, [2], [31]
7	Customization of products	26, [19], [36], [4], [16], [33]
8	Facilitating quick decision-making	26, [16], [31]
9	Getting demand information as soon as possible	26, [12], [16], [31]
10	Reducing product development cycle time	[36], [12], [16], [5]
11	Ensuring and the growth of customer relationships	26, [2], [16], [20], [28], [31]
12	Increased production of new products	26, [2], [36], [4], [16], [5], [31]
13	Speed on delivery of goods	[2], [36], [4], [16]
14	Market sensitivity	[2], [33], [31]
15	Reducing the time interval between order and delivery	[2], [36], [16], [5]
16	Improved service level	[2], [36], [12],
17	Collaborative Planning and Collaboration	[2], [16], [38], [33], [31]
18	Minimizing uncertainty of delivery	[2], [36], [16]
19	Supplier's ability to resize orders	[36], [4], [16],
20	Supplier's ability to change order time	[36], [4], [16], [5]
21	The ability to change the volume of production and create surplus capacity	[36], [12], [31]
22	The ability to change in the composition of production	[36], [4], [16], [31]
23	Ability to reduce production time	[36], [16], [31]
24	Speeding up the procees of meeting customer needs	[36], [12], [16], [31]
25	Minimizing startup and product changes time	[4], [16], [31]
26	Ability to produce in small and large batches	[4], [16]

The practices mentioned in Table 1 include a set of practices introduced by at least two studies for supply chain agility. Some authors have provided practices, not mentioned in other studies. These are outlined in Table 2.

Tab. 2. Introduced supply chain agility practices in previous research that were repeated only once

Row	Practice	Resource
1	Organizing functional lines, evaluating and selecting suppliers, sharing intellectual property with partners, building existing infrastructure to encourage innovation, vertically integrating, simultaneously implementing activities throughout the supply chain, removing process barriers and organizational walls, performance measures Customer-based, opportunity search to increase value for the customer, speeding up the production of new products, producing significant value-added products for customers	[26]
2	Information sharing through information technology, ease of assembly of products, geographical proximity with supplier and market, and multi-disciplinary forces	[19]
3	Accuracy of data, cost minimization, involvement with suppliers to improve the quality and estimate customer specifications, and elimination of resistance to change	[2]
4	Market transparency, supplier flexibility, and maintenance of surplus inventory to meet customer needs	[12]
5	Involvement of supplier in product development, supplier technical support to increase productivity, outsourcing, utilization of various transportation models, building warehouses near cities to increase delivery speed, processing orders and continuous commitment to interactions, material planning, application of information technology in reverse logistics, supplier performance measurement, technical capacity and supplier process, long-term relationship with suppliers, flat organizational structure, team-oriented decision-making, personnel interchangeability, team building and management, and the learned organization	[38]

2-3. Supply chain performance measures and the impact of supply chain agility on them

Supply chain performance is measured by its success in meeting customers' needs. Thus, measuring supply chain performance is shaped on this basis [39]. Overall, in relevant literature, four criteria are introduced to measure supply chain performance including cost, quality, resilience, and on-time delivery. Some studies have mentioned innovation and customer service level as other criteria [35]. Previous studies have indicated that supply chain agility had impacts on some other measures and led to the improvement of supply chain performance. Cruz (2012) and Morovati Sharifabadi (2016) expressed that diverse products with high quality and delivery speed were always mentioned as customers' priorities, and authors attempted to introduce new managerial approaches to meet the needs. Supply chain agility is one of these approaches [16-29]. In such a conceptual model, Azevedo et al. (2010) studied the impact of supply chain on its performance and competitiveness [4]. The results of their study indicate that the application of agility approach in supply chain would improve supply chain accountability, resilience, and its capability to provide products with high quality and delivery speed, having positive impact on organizational performance through reducing average time of process change, productivity improvement, on-time delivery, and customer satisfaction. In the format of a conceptual model, Azevedo et al. (2011) suggested that the supply chain agility increased speed and customer satisfaction through the ability to produce in small or big batches and changed the time of supplier's order delivery [3]. Carvalho et al. (2011) and Kumar Marwah et al. (2014) expressed that an agile supply chain answered customer's needs rapidly through flexibility, speed, supplier's quality, generating surplus capacity in resources, increasing current level inventory, and reducing production for better delivery time [12–23]. Likewise, by studying the impact of supply chain agility on organizational performance, Cavalho et al. (2011) suggested that the supply chain agility influenced resilience and speed and used it to answer customer needs, cooperation, competencies, and supply chain capabilities [12]. Azfer et al. (2014) indicated that the supply chain supply influenced the operational performance whose most important components include speed, quality, and diversity and would finally lead to customer satisfaction [6]. Abdoli and Valimohammadi (2017) suggested that the supply chain agility influenced speed, accountability, and competitiveness of the chain [1]. Lotfi and Saghari (2017) studied the impact of agile paradigm on supply chain performance outcomes, and concluded that supply chain agility influenced its endurance and improved speed [27]. Sanches and Liu (2018) indicated that supply chain agility had positive impacts on income and market share [32]. Fadaki et al. (2019) asserted that the application of lean supply and agility had impacts on delivery speed improvement [17].

2-4. Military products supply chain

Iranian military product supply chain has three levels including suppliers, manufacturers and end users. Suppliers are either internal or external. Manufacturers are different defensive industries, and their customers include all Iranian military and law enforcement forces. Figure 1 shows a scheme of Iranian ground-based military products supply chain. Military products are mainly categorized in three ground-based groups including types of individual weapons and equipment, cannons, tanks, mortars, military vehicles; air-based group such as missiles, warplanes, unmanned aerial vehicles, and helicopters; marine-based group includes submarines, warships, and boats. Ground-based military products constitute 60% military products. Although, today, air-based and marine-based military products are globally recognized as strategic military products, in global military events, no success is achieved without the aid of ground-based military products, indicating the high importance of such military products. Studies indicate that scientific military research studies have been always outperformed other fields, and many provided products in trading markets have been the result of preliminary research studies in military area including Global Positioning System (GPS) and Internet. Most likely, global military industries are pioneers of utilizing new supply chain approaches including agility. However, the results of previous studies indicate that accessible information resources including reputable websites such Elsevier, Emerald, Springer, IEEE, and scientific papers on military products supply chain agility are not found. Lack of dissemination of military studies in this regard is likely due to its confidential nature, or they are provided in this journal inaccessible to the public. Our study attempted to act as the first study of the Iranian ground-based military products supply chain agility, and no study is so far conducted by such an approach in Iran.

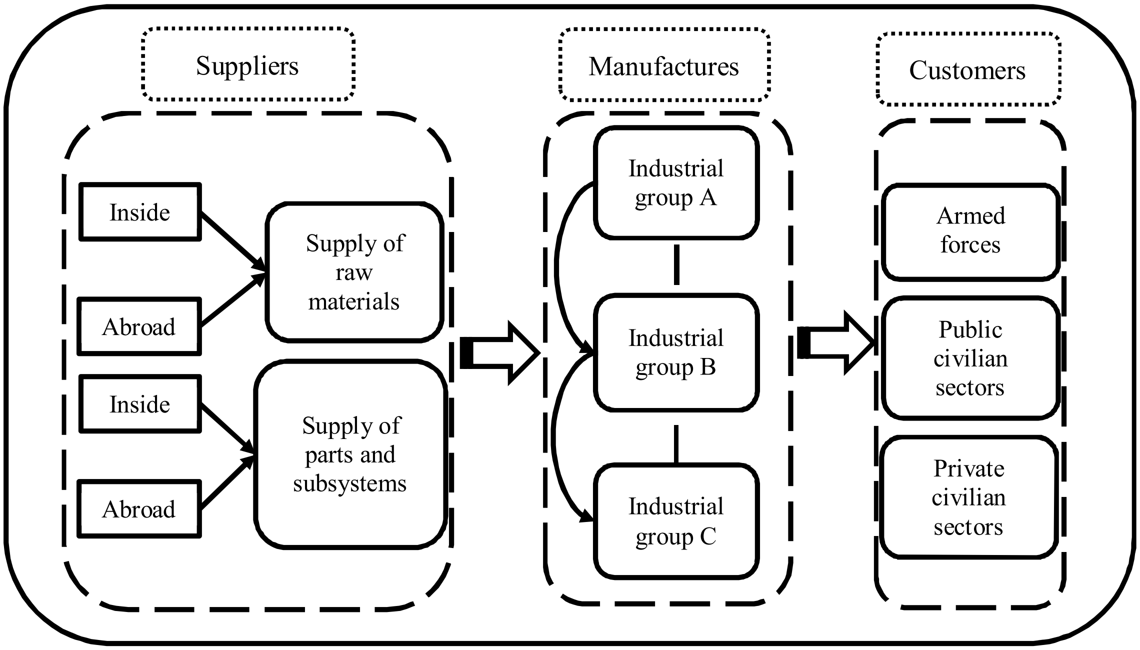

Fig. 1. Supply chain schematic of ground-based military products

3. Research Methodology

To devise a supply chain agility model, one should answer the following questions: what are practices in supply chain agility? What are supply chain performance measures? What are the relations between supply chain performance practices and measures? To answer these questions, the present study is conducted in three steps. First, by reviewing previous studies and acquiring the opinions of academic and industrial experts of supply chain, initial practices on supply chain agility were identified. Then, to categorize such practices, an exploratory factor analysis technique was utilized. Finally, the interpretative structural model and MICMAC techniques were used to analyze relations among supply chain agility practices and their impact on performance. Table 3 summarizes the process of the present study in three steps including tool, techniques, and sample size.

Tab. 3. The steps of research and its methodology

Step	Outcome	Tools	Technique	Sample size	Sample members
1	Identifying supply chain agility practices through extracted practices from previous studies	Questionnaire	Average comparison	15	Academic and industrial experts
2	Categorizing supply chain practices	Questionnaire	Exploratory factor analysis	214	production managers, procurement managers, quality managers and , ground – based military products supply chain managers
3	Providing military products supply chain agility model	Questionnaire	Interpretative Structural Modeling (ISM)	15	Production, quality and ground – based military products supply chain managers

This research is a mixed, descriptive, and exploratory research. In terms of its purpose, it is an applied research based on exploratory factor analysis (EFA) and interpretation equations. In the first step, objective sampling method is used, and sample size consists of 15 academic and industrial experts in the supply chain. Research population in the second step consists of all production, procurement, quality, and ground-based military products supply chain managers and, due to geographical distribution of these industries countrywide, 250 questionnaires were distributed and data analysis was conducted by 214 questionnaires; the Kaiser-Meyer-Olkin (KMO) measure of Sampling Adequacy was obtained as 0.806. Since it is greater than 0.7, it is shown that the volume is sufficient for exploratory factor analysis. In this regard, the reliability of the questionnaire of the second step was determined by Cronbach's alpha coefficient, indicating that a coefficient of 0.83 leads to appropriate reliability. Since the questionnaire of the third steps is the result of using experts' opinions in the first step, the questionnaire enjoys needed validity. In the third step, objective sampling method and sample size of 15 and the best people in military product supply chain are used, and the final model is provided by using paired comparisons questionnaire and interpretive structure modeling (ISM). The final results and model were evaluated and confirmed by two academic experts familiar with ground-based military products supply chain. In the present study, SPSS20 and MATLAB R2018b software packages are used.

4. Findings and Data Analysis

4-1. Identifying agility practices for the military products supply chain

In this section, based on the taken practices from previous studies (Tables 1 and 2), a 62-item questionnaire was provided to experts, and each item is referred to here as one practice in the supply chain agility. The main question of this questionnaire is that "given each of the practices mentioned in each statement, how much do they produce agility for the defense industry supply chain? To answer this question, the 5-option Likert range ('very low', 'low', 'moderate', 'high', and 'very high') was used. An option with an unrelated title was considered along with the Likert range options. Table 4 presents the demographic characteristics of experts in this study.

Tab. 4. Experts' demographics

Row	Workplace	Number	degree of education	Workplace
1	Faculty member	5	Ph.D.	Shahid Beheshti University and Malek Ashtar University of Technology
2	Senior Managers and Industrial Consultant	4	Ph.D.	Different military industries
3	Production and Supply Chain Managers	6	MA	Different military industries

The initial investigation of questionnaires indicates that none of the provided practices in questionnaire was recognized as irrelevant to supply chain agility. To identify supply chain agility practices of the ground-based military products, upon gathering experts' opinions, each scale was scored from 1 to 5 (1: very low; 2: low; 3: medium; 4: high; 5: very high), and their averages were computed and those practices greater than 3 were recognized as effective practices (the average of 1 – 5 will be 3). Table 5 indicates the average of experts' opinions on each supply chain agility practice taken from previous studies.

Tab. 5. The average of experts' opinions on each supply chain agility practice taken from previous research

Row	Practice	average	Result
1	The use of information technology to coordinate and integrate in product design and development	4.07	Confirmed
2	The use of Information Technology for Coordination and Integration with Suppliers	4.47	Confirmed
3	The use of Information Technology for Coordination and Integration in Production	4.60	Confirmed
4	The use of information technology to coordinate and integrate the orders receipt of the customer and delivery with them	2.73	Refused
5	Establishing trust-based relationships with suppliers	4.07	Confirmed
6	Creating trust-based relationships with customers	2.73	Refused
7	Improvemet and integration of processes	3.87	Confirmed
8	Customization of products	2.87	Refused
9	Facilitating quick decision-making	4.13	Confirmed
10	Obtaining demand information as soon as possible from customers	4.13	Confirmed
11	Reducing product development cycle time	3.93	Confirmed
12	Relationships maintain and grow with customer	3.80	Confirmed
13	Increasing the production of new products	2.67	Refused
14	Speed on delivery of goods and reduce delivery time	3.87	Confirmed
15	Sensitivity to market changes and quick identification of needs	2.87	Refused
16	Improving the level of service (the ratio of demand that can be delivered as soon as possible without the production process upon receipt of the order)	3.80	Confirmed
17	Partnership Planning and Collaborative Communications with Suppliers	3.80	Confirmed
18	Minimizing uncertainty of delivery	2.80	Refused
19	Supplier's ability to resize orders	4.07	Confirmed
20	Supplier's ability to change order time	4.33	Confirmed
21	Ability to change the volume of production and create surplus capacity	4.40	Confirmed
22	The ability to change in the composition of production	2.67	Refused
23	Ability to reduce production time	4.27	Confirmed
24	Speeding up the process of responding to customer needs	2.53	Refused
25	Minimizing the startup time of machinery and equipment	3.80	Confirmed
26	Minimizing the time to prepare the production line for the production of diverse products (fast organization of functional lines)	4.27	Confirmed
27	Ability to produce in small and large batches	2.60	Refused
28	Assessment and selection of supplier	2.93	Refused
29	intellectual property Sharing with partners	1.40	Refused
30	Creating essential infrastructure to innovation encourage	3.80	Confirmed
31	Vertically integration	1.53	Refused

32	Simultaneous implementation of activities across the supply chain	4.20	Confirmed
33	Removal of process barriers and organizational walls	3.87	Confirmed
34	Application of customer-based performance measurement criteria	2.73	Refused
35	Search for opportunities to increase value for the customer	1.80	Refused
36	Speeding up the process of providing new products	3.73	Confirmed
37	Producing significant value-added products for customers	2.53	Refused
38	Multi-skill human resources	4.33	Confirmed
39	information and knowledge Sharing with suppliers	4.13	Confirmed
40	information and knowledge sharing with customers	4.07	Confirmed
41	Ease of assembling products	3.67	Confirmed
42	Geographic proximity to supplier	2.80	Refused
43	Geographic proximity to the market	1.47	Refused
44	Accuracy of data in the entire supply chain	3.00	Refused
45	Interventions in the affairs of suppliers to improve the quality and estimate the desired specifications of customers	1.60	Refused
46	Outsourcing	4.53	Confirmed
47	Cultivating and minimizing resistance to change	2.87	Refused
48	Involving supplier in product development	4.13	Confirmed
49	Providing technical support to increase productivity	3.67	Confirmed
50	Applying different transportation models	1.47	Refused
51	Building warehouses in cities near to increase delivery speed	1.33	Refused
52	Order processing and ongoing monitoring of interactions	1.87	Refused
53	Material planning and control of production operations	4.00	Confirmed
54	The use of Information Technology in reverse logistics	2.73	Refused
55	Performance measurement of suppliers	2.67	Refused
56	Technical capabilities and processor of suppliers	4.07	Confirmed
57	Long-term relationships with suppliers	3.87	Confirmed
58	The flat and flexible organizational structure	4.13	Confirmed
59	Team-oriented decision making	3.67	Confirmed
60	Ability to exchange personnel between different production units	3.47	Confirmed
61	Formation of effective working teams and its managing	3.67	Confirmed
62	Become a learned organization	3.93	Confirmed

According to the results in Table 4, out of a total of 62 practices, 37 practices were identified as the most important agile supply chain practices, and 25 others, although being agile practices, are of less importance and impact on supply chain agile. Four new practices including utilizing new technology and equipment, downsizing surplus staff, using specialized human forces and employees' training and empowerment were proposed as affective practices for supply chain agility by experts, as considered in the third step of the questionnaire.

4-2. Exploratory factor analysis of supply chain agility practices

Upon identifying 37 supply chain agility practices in the first step and adding experts' proposed practices including utilizing new technology and equipment, human resource balance, using specialized human forces and employees' training and empowerment, a 41-item questionnaire was prepared and distributed among 250 production mangers, supply and commercial managers, quality manager, and supply chain managers of defensive industries. Here, 214 of 221 returned questionnaires were usable, considered as the basis of analysis. The main question of the questionnaire was: "to what extent does each practice influence supply chain agility? To answer this question, Likert's five-scale (very low, low, medium, high, and very high) was used. Table 6 indicates experts' demographics in the second step of the research.

Tab. 6. Demographic characteristics of the statistical sample (in the second step of the research)

Type of job	Degree of education	Work experience
procurement Manager (31)	Bachelor (71)	Under 15 years old (3)
Quality Manager (70)	MA (124)	15 to 20 years (95)
Supply Chain Manager (21)	Ph.D. (19)	20 to 25 years (81)
Production Manager (92)		25 years and upper (35)

For factor analysis, the principal component analysis (PCA) method was applied using varimax orthogonal rotation. Based on the initial subscription and extraction contributions, these 41 actions explained more than 64.8% of the total variance of agile supply chain practices. Practices and their factor loads listed in Table 7 show that these practices can be categorized into eight groups.

Tab. 7. Supply chain Agility practices based on exploratory factor analysis

Row	Agile practice	Factors							
		1	2	3	4	5	6	7	8
A. Factor. 1: Using of Information Technology		Percentage of variance:					6.973		
1	The use of information technology to coordinate and integrate product design with its development	0.875							
2	The use of Information Technology for Coordination and Integration with Suppliers	0.847							
3	The use of Information Technology for Coordination and Integration in Production	0.806							
B. Factor. 2: Improve and integration of processes		Percentage of variance;					7.014		
4	Improvement and integration of processes		0.801						
5	Simultaneous implementation of activities across the supply chain		0.724						
6	Outsourcing		0.712						
7	The use of new technology and equipment		0.698						
C. Factor. 3: Workshop level management		Percentage of variance:					9.973		
8	Material planning and control of production operations			0.786					
9	Ability to change the volume of production and create surplus capacity			0.709					
10	Ability to reduce production time			0.684					

11	Minimizing the startup time of machinery and equipment	0.527				
12	Minimizing the time to prepare the production line to produce diverse products	0.522				
13	Speed up in the production of new products	0.489				
D. Factor. 4: supplier Relationship		Percentage of variance:			10.464	
14	Establishing trust-based relationships with suppliers		0.792			
15	Partnership Planning and Collaborative Communications with Suppliers		0.773			
16	Supplier's ability to resize orders		0.751			
17	Supplier's ability to change order time		0.646			
18	Information and knowledge Sharing with suppliers		0.624			
19	Technical capabilities and processor suppliers		0.603			
20	Long-term relationships with the suppliers		0.554			
21	Providing technical support to increase productivity		0.526			
E. Factor. 5: Relationship with customer		Percentage of variance:			6.523	
22	Obtaining demand information as soon as possible from customers			0.691		
23	Information and knowledge sharing with customers			0.642		
24	Relationships maintain and grow with customer			0.613		
25	Improved service level			0.574		
26	Speed on delivery of goods and reduce delivery time			0.563		
E. Factor. 6: organizational structure improvement		Percentage of variance:			8.418	
27	Facilitate quick decision making				0.741	
28	Creating existing infrastructure to encourage innovation				0.733	
29	Removing process barriers and organizational walls				0.662	
30	Team-oriented decision making				0.537	
31	Ability to exchange personnel between different manufacturing units				0.516	
32	Becoming a learning organization				0.442	
33	Flat and flexible organizational structure				0.421	
F. Factor. 7: Human resources management		Percentage of variance:			7.885	
34	Training and empowering employees					0.731
35	Multi-skill human resources					0.709
36	human resources balance					0.662
37	Applying specialist human resources					0.601
38	Formation of effective working					0.553

	teams and its managing								
G. Factor. 8: product design		Percentage of variance:				7.611			
39	Reducing product development cycle time								0.744
40	Involving supplier in product development								0.722
41	Ease of assembling products								0.623
	Cronbach's alpha coefficients	0.89	0.86	0.82	0.78	0.81	0.79	0.80	0.87

Based on the output of the exploratory factor analysis (EFA) presented in Table 6, 41 agile supply chain practices are classified into eight factors. Based on the factors that fall into each category, these practices include the use of information technology, process integration and improvement, workshop management, supplier relationship, customer relationship, organizational structure improvement, human resource management, and new product design. Supplier relationship with 10.446% and customer relationship with 6.523% of the explained total variance of agile supply chain practices are placed in the first and last positions, respectively. As the last row of Table 6 shows, the calculated Cronbach alpha coefficient for all eight factors is greater than 0.7. Thus, it can be concluded that all practices have reliability with respect to all latent variables of the research. Fig. 2 shows the final categorization of agile supply chain practices that are structured according to their contribution to the total variance of numbers 1-8.

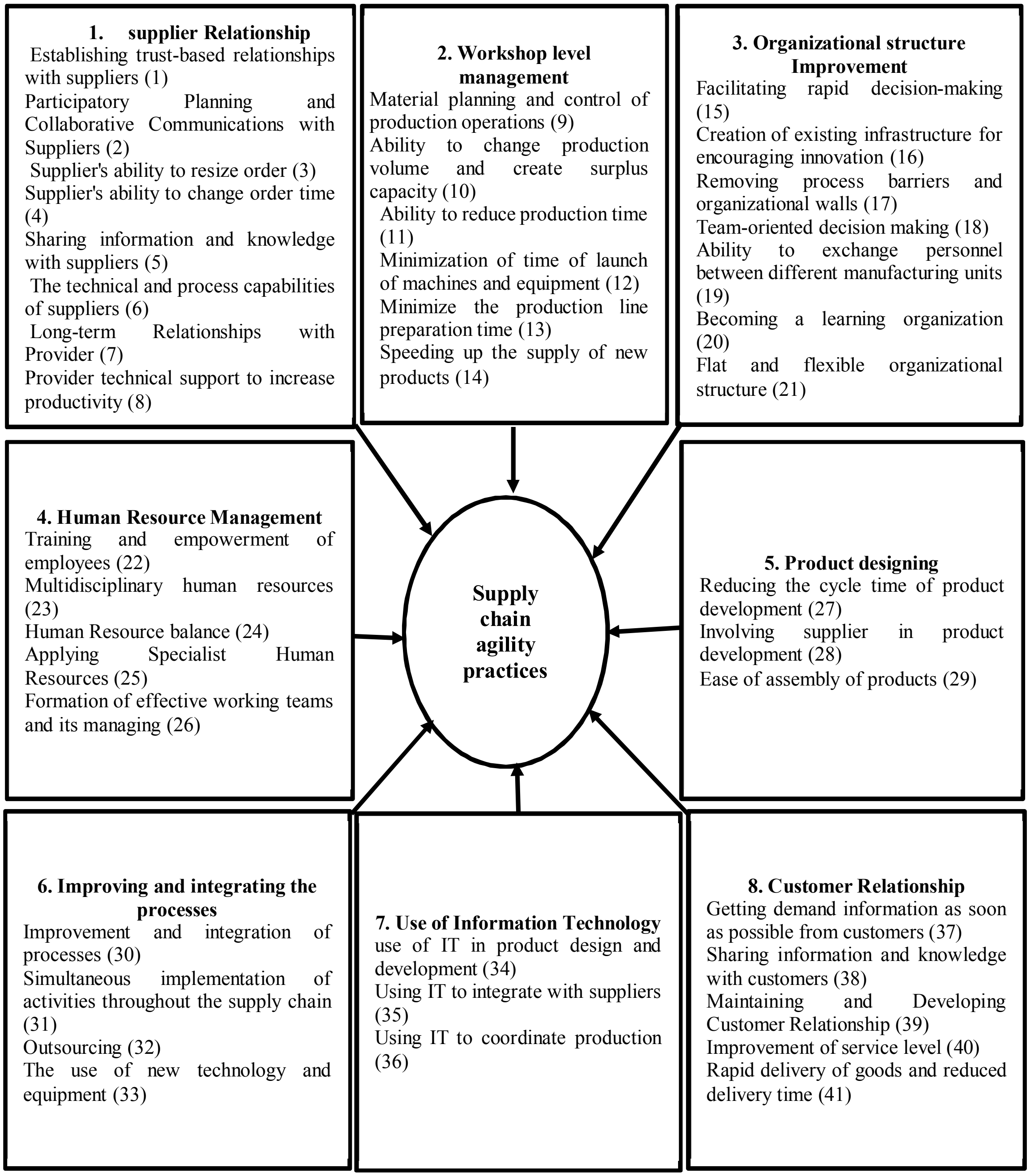

Fig. 2. Categorization of supply chain agility practices in ground-based military products

Table 8 presents the results of the KMO and Bartlett tests for the adequacy of sampling and measuring the fitness of data in the confirmatory factor analysis.

Tab. 8. KMO and bartlett test results

Test name	Result	Explanation
KMO	0.806	The sampling adequacy is very good.
Bartlett	chi-square: 1347.668 Degree of freedom: 724 Significance of the test (sig): 0.000 Significance level: 0.05	There is an appropriate relation between the data structures

4-3. Interpretative structural model on supply chain practices and performance measures

As previous studies in Section 2.3 indicate, the most important measures of the supply chain performance, which agility approach leads to them and is paid attention in most studies, include four measures: speed, diversity, quality, and responsiveness to customers' needs. In the present study, four measures and eight separated practices identified in the previous step were designed in a questionnaire and delivered to 15 experts for pair comparison. An interpretative structural model is a system designing method – especially social and economic systems – coined by Warfield (1973) as a systemic scientist in US George Masson University and was represented by Andrew Sege in 1977. The interpretative structural model was introduced by Agrawal (2006) for supply chain capabilities and was provided by Kannan (2007) in his paper on evaluating and prioritizing suppliers [22].

Interpretative structural model is defined as a process that aims to help human to conceive better what he believes and clearer diagnosis of what he does not know [18]. Interpretative structural model converts weak and ambiguous mental models of systems to clear and well-defined models useful for many purposes [30].

Interpretative structural model studies the dynamic impact of various elements in a system and, semantically, it has three aspects by one letter for each. I: is the interpretative aspect based on collective judgments and opinions of expert to decide how variables have internal relations. S: is the structure based on thematic relations among variables pulling out total structure from a series of complicated variables. M: is the modelling aspect, which shows special relations of variables and total systemic structure. In other words, in ISM, (I: interpretative) is the result of judgment, (S: structural aspect) is the outcome of a series of variables, and (M: modeling) is a schematic graph on special relations and total structure. This analysis is conducted by a procedure [9].

In this method, affecting and radical factors are initially studied and, then, based on experts' opinions, the relations among these factors are identified and rendered graphically. It is a qualitative method since it attempts to achieve experts' mental conception through relations among factors, and it is quantitative since it is based on the questionnaire with numerical analyses that intend to show the relations among variables in a structural model. For the same reason, it is called qualitative-quantitative, or an interpretative structural technique. This technique is used to analyze relations among several variables or factors defined for a problem [22].

The different stages of interpretive structural modeling and the results obtained at each stage are presented in the following:

A. The formation of Structural self-interaction matrix (SSIM)

At this stage, the problem variables are compared in pairs, and the respondents use the following symbols to determine the relationships between the variables.

V- Variable i will help to achieve variable j;

A- Variable j will be achieved by variable i;

X- Variables i and j will help to achieve each other;

O- Variables i and j are unrelated.

The eight practices were placed in the first row and the first column of the questionnaire, and respondents were asked to specify the type of relationship between the two practices based on the presented symbols (V, A, X, O). The final SSIM was prepared regarding the frequency of the relationship between the two practices. Table 9 shows the final SSIM of the practices.

Tab. 9. The structural self-interaction matrix (SSIM) of agility supply chain practices and performance measures

		12	11	10	9	8	7	6	5	4	3	2	1
1	Suppliers relationship	V	V	V	V	O	A	A	V	A	A	V	X
2	Workshop level management	V	V	V	V	A	A	A	V	A	A	X	
3	Organizational Structure improvement	V	V	V	V	V	V	V	V	V	X		
4	Human resources management	V	V	V	V	V	V	V	V	X			

5	product designing	V	V	V	V	A	A	A	X
6	Improve and integrate the process	V	V	V	V	V	V	X	
7	The use of Information Technology	V	V	V	V	V	X		
8	Customer Relationship	V	V	V	V	X			
9	Speed	V	V	V	X				
10	Diversity	V	X	X					
11	Quality	V	X						
12	responsiveness to customers need	X							

B. The formation of an initial reachability matrix
The SSIM is transformed into a binary matrix, called the initial reachability matrix by substituting V, A, X, and O by 1 and 0 as per the case. The rules for the substitution of 1's and 0's are:

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

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

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

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

By applying these attributes to the final SSIM of the previous step, the initial reachability matrix is formed in accordance with Table 10.

Tab. 10. The initial reachability matrix of agile supply chain practices and performance measures

		1	2	3	4	5	6	7	8	9	10	11	12	Driving power
1	Relation with supplier	1	1	0	0	1	0	0	0	1	1	1	1	7
2	Workshop level management	0	1	0	0	1	0	0	0	1	1	1	1	6
3	Organizational structure	1	1	1	1	1	1	1	1	1	1	1	1	12
4	HR management	1	1	0	1	1	1	1	1	1	1	1	1	11
5	Product design	0	0	0	0	1	0	0	0	1	1	1	1	5
6	Improve and integrate the process	1	1	0	0	1	1	1	1	1	1	1	1	10
7	The use of Information Technology	1	1	0	0	1	0	1	1	1	1	1	1	9
8	Customer Relationship	0	1	0	0	1	0	0	1	1	1	1	1	7
9	Speed	0	0	0	0	0	0	0	0	1	1	1	1	4
10	Diversity	0	0	0	0	0	0	0	0	0	1	1	1	3
11	Quality	0	0	0	0	0	0	0	0	0	1	1	1	3
12	responsiveness to customers need	0	0	0	0	0	0	0	0	0	0	0	1	1
Dependence Power		5	7	1	2	8	3	4	5	9	11	11	12	

C. The formation of the final reachability matrix

Once the initial reachability matrix is obtained, its internal compatibility needs to be established. For example, if practice A leads to B and practice B leads to C, then practice A must also lead to practice C. In addition, if this condition is not met in the initial reachability matrix, the matrix must be modified and compatibility relationships must be corrected. For this purpose, the initial matrix must be brought to power (K + 1) to establish a stable state ($M^k = M^{k+1}$); thus, some of the zero elements become 1, i.e., (1^*). In the present study, given that the compatibility condition in the initial reachability matrix (Table 11) is established, the initial and final reachability matrix is 1.

D. Determination of the level of variables

After determining the reachability set and antecedent set for each practice and determining the intersection set, the leveling of the practices is done. The reachability set for each practice is a set in which the rows appear as 1 in Table 11 and the antecedent set is a set in which the columns appear as 1. Joint practices of these two collections give the intersection set. The practices that the intersection set is identical with the reachability set will be the first priority level. By removing these elements and repeating these steps, the level of all elements is determined in the same way. Table 11 shows the reachability, antecedent, and intersection sets and leveling of agility supply chain practices derived from the final reachability matrix.

Tab. 11. The reachability, antecedent and intersection sets, and leveling of agility supply chain practices and performance measure

		Reachability set	Antecedent set	Intersection set	level
1	Relation with supplier	1-2-5-9-10-11-12	1-2-3-4-6-7	1	6
2	Workshop level management	2-5-9-10-11-12	1-2-3-4-6-7	2	5
3	Organizational structure	1-2-3-4-5-6-7-8-9-10-11-12	3	3	10
4	HR management	1-2-4-5-6-7-8-9-10-11-12	3-4	4	9
5	Product design	5-9-10-11-12	1-2-3-4-5-6-7-8	5	4
6	Improve and integrate the process	1-2-5-6-7-8	3-4-6	6	8
7	The use of Information Technology	1-2-5-7-8-9-10-11-12	4-3-6-7	7	7
8	Customer Relationship	2-5-8-9-10-11-12	3-4-6-7-8	8	6
9	Speed	9-10-11-12	1-2-3-4-5-6-7-8-9	9	3
10	Diversity	10-11-12	1-2-3-4-5-6-7-8-9-10-11	10-11	2
11	Quality	10-11-12	1-2-3-4-5-6-7-8-9-11	11	2
12	responsiveness to customers need	12	1-2-3-4-5-6-7-8-9-10-11-12	12	1

E. Drawing a Structural Interpretative Model

In this step, based on determined levels for supply chain agility practices in the previous step and prerequisites, the final model is drawn and relations among practices and performance measures are determined by arrows. Figure 4 shows the created final diagrams by classifying different levels. This model renders direct and indirect relations between supply chain agility practices and performance measures, and suggests that if one practice cannot impact on chain performance directly, how can it be effective indirectly? This model is important since decision-makers can observe the results of each practice before any operational action.

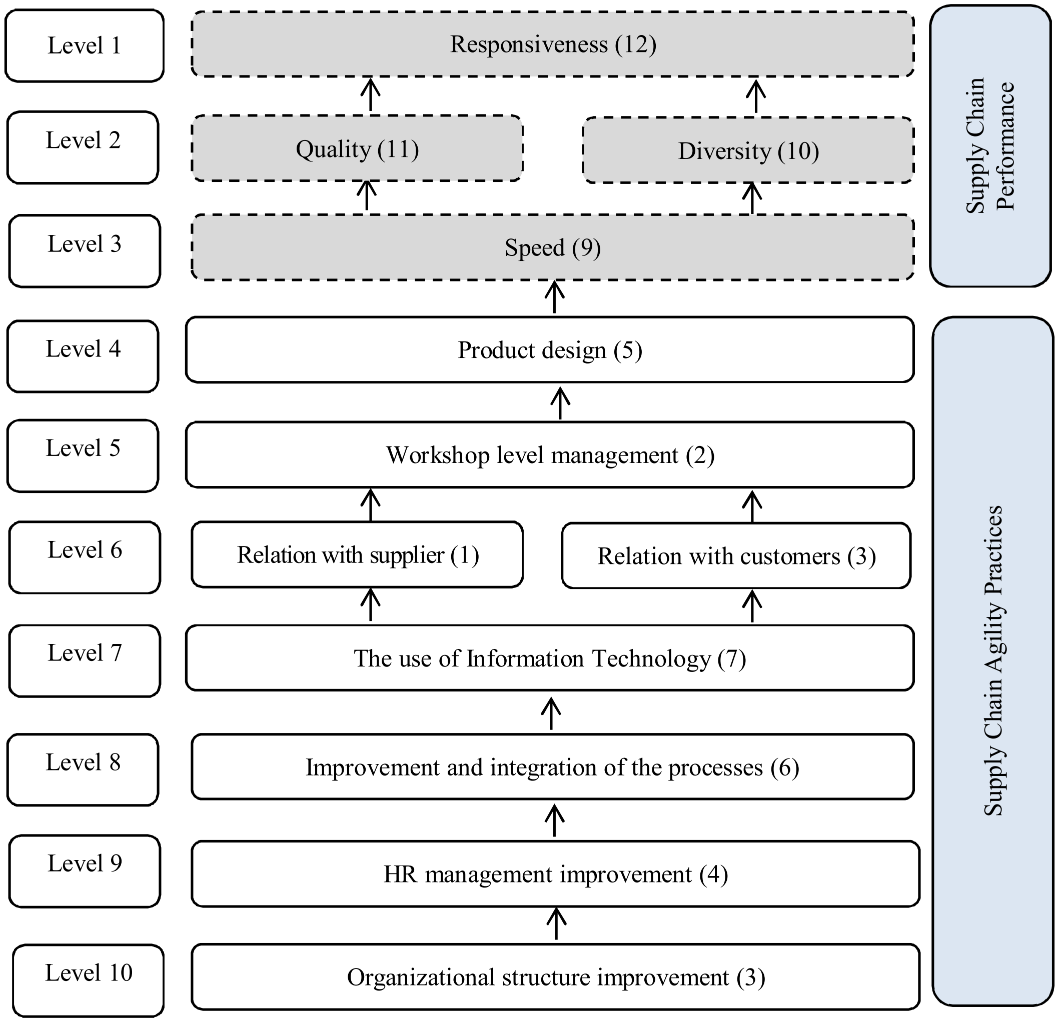

Fig. 3. Supply chain agility model of ground-based military products and its impact on supply chain performance

4-4. Dependence and driving power analysis (MICMAC)

To achieve a better interaction between supply chain agility practices and its performance measures, the MICMAC (Matrix Impact Cross-Reference Multiplication Applied to Classification) analysis is provided. The sum of the row of values in the final reachability matrix for each practice, indicating the degree of driving and the sum of the columns, represents the degree of dependence. Based on these two factors, four groups of elements can be identified in the framework of autonomous (1st square), dependent (2nd square), linkage (3rd square), and independent (4th square). In Table 10, driving and dependency power(s) of each group of supply chain agility practices and performance measures are computed. Layout results of each supply chain agility practice and its performance measures are outlined in Table 11. Power penetration indicated the influence of practices and performance measures.

Driving Power		independent variables						linkage variables						
	12	3				4th square						3th square		linkage variables
	11		4											
	10			6										
	9				7									
	8													
	7					1,8								
	6					1st square		2				2nd square		Dependent p variables
	5								5					
	4									9				
	3											11,10		
	2													
	1												12	
		1	2	3	4	5	6	7	8	9	10	11	12	
	Dependence power													

Fig. 4. Clustering supply chain agility practices and the corresponding performance measures

As seen in Table 5, agility practices and performance measures are put in four squares of the matrix based on dependency power and penetration power.

(a) **1th square (**autonomous variables): this square indicates variables with low dependency on other variables and low penetration power and, in other words, one can consider them being independent of other variables. As seen in Figure 5, no supply chain agility practice and its measures are located in this square, and one can state that there is no independent measure among supply chain agility practices and performance measures, indicating that no agility practice is separated from this system and all performance measures are influenced by agility. Independent variables do not influence and are not influenced by other practices, and their management is focused on executing them as the final priorities.

(b) **2nd square** (dependent variables): it indicates variables with high dependency on other variables and low penetration power and, in other words, one can call them dependent on other variables. Workshop management practices (2) and product design are weak stimulants, yet highly dependent. Speed performance measures (9), diversity (10), quality (11), and accountability (12) are in this square, showing that they are highly dependent and are used as the results of utilizing supply chain agility practices. Thus, they are at the top ranks of the interpretative hierarchical model (Figure 5). High dependency of workshop management practices and product design on other practices shows that they need other practices to be conducted before them to minimize the impacts of those affecting factors at the time of their execution. It is implied here that to ensure supply chain agility, stimulating acts should be executed. Therefore, managers should consider the dependency of such practices and should attempt to perform other supply chain agility practices in higher priority.

(c) **3rd square (**linkage variables): it indicates those variables that have high dependency on other variables and high penetration power. As seen in Figure 5, none of agility practices is located in this square, and none of them is simultaneously influential and under influence. It means that changes in none of agility practices would have impact on other practices and it is not a background for that practice.

(d) **4th square (**independent variables): it shows variables with low dependency on other variables and high penetration power. Practices to improve organizational structure (3), HR management improvement (4), processes improvement and integration (6), and IT utilization (7) are the most important stimulants in supply chain agility. It means that executing such practices would help other supply chain agility practices. Therefore, organizational managers should conduct practices to facilitate their utilization and execution. Focus on executing such practices in the first steps can pave the way for supply chain agility in the next steps.

5. Conclusion and Recommendation

Security is an important predicament respected by all countries, and they attempt to promote their security in any way. Equipping countries to types of military products would improve their security level against other countries' threats. Self-reliance and defensive deterrence against threats are the most important factors that persuade Iran to manufacture military products. Noteworthy, only those military products can yield defense deterrence with proper performance compared to military products of other countries. The rapid production of diverse, high-quality and new military products by advanced countries enforced Iranian military industries supply chain to manufacture rapid and diverse products. Manufacturing military products by such features needs a supply chain agility that can manufacture diverse products rapidly and respond to demands with different volumes. Therefore, military products supply chain agility is necessary. Iranian military products are mainly manufactured in three ground- based, air-based, and sea-based groups, while the ground-based group constitutes 60 percent of military products. Since no global military event has achieved final success without the help of ground-based military products, supply chain agility has received high attention in the present study. For supply chain agility as an operational strategy, relevant practices should be identified. One should note that supply chain agility has impacts on, and/or is impacted by, each other; disregard for this issue and using only a few practices cannot be effective in the supply chain agility. The aim of the present paper is to devise a model to understand the dynamism between supply chain agility and its impact on performance and to show their hierarchical relations, and to indicate that how such practices can improve military products supply chain agility and bring about defense deterrence. By reviewing previous studies comprehensively, 62 initial practices for supply chain agility were identified. By using the technique of gathering the opinions of industrial and academic experts, 41 practices were determined as to be affecting supply chain agility practices in military products. By using an exploratory factor analysis technique, these practices were categorized into 8 groups: workshop level management, organizational structural improvement, human resource improvement, improvement and integration the process, **The use of Information Technology**, relation to suppliers, relation to customers and product design.

Decision-making on selecting one or more practices does not seem logical since, as already mentioned, these practices have usually mutual impacts and disregard for this issue would cause failure for managers in their operational usage rightly and in achieving effective results. Thus, upon identifying these practices, they should be used based on relation type and their impact on each other. Interpretative structural model is a tool that shows relations among these practices based on experts' analysis and helps managers identify, categorize, and expound direct and indirect impacts of these practices and supply chain agility performance measures. The output of the interpretative structural model is seen as an input for MICMAC analysis, showing the penetration power and dependency among these practices. By applying these techniques in the present study, the military products supply chain agility model is devised by rendering the hierarchy of supply chain agility practices and performance measures. Results indicate that a group of practices has high penetration power and minimum dependency and enjoys high strategic importance, while other groups include practices with high dependency, and one should make all efforts to use stimulating practices before utilizing them. This categorization is a fruitful tool for military production supply chain managers who can focus on practices recognized as basic practices in supply chain agility and influence other practices by understanding the difference between independent/dependent practices and their mutual relations. As the final military products supply chain agility model (Fig. 3) shows, improving the organizational structure is introduced as the most basic action, which shows that, for the defense industry supply chain agility, the most important and most effective practice is to make radical changes in organizational structure to change it to an organizational structure with lower hierarchy, more flexibility and greater capability of forming workgroups, rapid decision-making, creating current infrastructures to encourage innovation and changing a learning organization as the radical features of supply chain agility. Operations in the format of an official and traditional hierarchical organizational structure would seriously slow down operational processes and decision-making in the chain and can trump chain agility. Thus, in the first step, for the military products supply chain agility, organizational structure reengineering and efforts to create a flexible structure are necessary to make cooperation and multidirectional relations among employees, which facilitate the decision-making process. The necessity to improve human resource in military industries is to use multi-skill and specialized manpower, human resource balance, and training and to empower them, requiring to revise the structure based on organizational strategies. It is implied that without modifying organizational structure, downsizing the forces, employing specialized forces and empowering and motivating those for team building, and conducting operation through workgroups are seen as costs with no effectiveness for the organization. As the research's final model indicates, organizational structure improvement should be done prior to human resource management improvement. Supply chains usually consist of several levels at which the coordination and integration of their activities and processes are absolutely necessary to achieve better chain performance. The integration of activities and processes in the chain needs organizational structure improvement and effective human resource management at each level of the chain so that one can create a chain of processes improvement and their integration. In other words, joint cooperation expectation of the three levels of production, supply, and delivery, which have their own structural, procedural, and human resource problems is a wasteful expectation, and it is impossible to integrate activities and their processes to achieve a joint goal, and having a chain with such problems at different level would highly influence their performance. As seen in the provided model in the present study, improving organizational structure and using human resources properly are mentioned as prerequisites to improve and integrate processes in chain. Although information and communication technology is a tool that promotes accuracy and speed, it will have higher effectiveness if it is based on improved structures and processes. In other words, if there is no improvement in structures and human resource management and activities integration, one can say that information and communication technology utilization would not improve chain performance and would add extra load to the chain and even influence its traditional activities. For the same reason, in the final model of the research, information and communication technology utilization is considered as the 4th practice for the supply chain agility. Proper relation to suppliers would have many profits such as their inventory management, their contribution in designing and production, promoting the quality of supplied parts, acquiring their trust, and ensuring their market. In other words, it can pave the way for their agility as an unseparated element of total chain agility. Information technology utilization can facilitate such chain agility. On the other hand, customer relationship has benefits such as identifying customers' needs, conceiving qualitative problems in the view of customer, and conceiving market changes. Information technology utilization can highly help the speed of such activities. Thus, proper relations with suppliers and customers are seen as supply chain agility practices upon information technology utilization by the military industries. As mentioned, supply chain agility means agility at all levels including supply and distribution. In some industries, irrespective of their previous and next levels in the chain, such activities as product precise planning, creating surplus capacity, efforts to decrease production time, minimizing the time of machines commissioning, precise work, and time measurement studies are conducted, which cannot yield better performance of total chain without agility in supply and distribution level. In other words, in a chain in which supply is doing slowly and customer needs are identified rapidly and there is no production, can one claim to have achieved supply chain agility only by conducting agility practices in workshop level and production? For the same reason, in the provided model, improving relations with supplier and customer is proposed as practices taken before improving workshop level management to supply chain managers. Revising the design of products and processes in terms of assembly easiness and reducing the intervals between designing to production can reduce the slowness of chain remarkably and can make it possible to create diverse products in the chain. Although such a practice can be deemed as a key practice in supply chain agility, it is introduced as the final group of the practices, meaning that 7 groups of practices should be taken before it. Moreover, it is implied that, in a concentrated and hierarchical organizational structure of decision-making, it is not possible to improve product and process to increase diverse production speeds without team working culture, modifying the processes, using state-of-the-art technologies, coordination with suppliers, recognizing customers' needs, and proper management in workshop level, which the research model shows it well. As shown by research model, the outcome of 8 groups of practices indicated hierarchically that they would increase production and delivery speed, cause quality improvement, and increase the diversity of military products, which can promote chain accountability potency to supply customers' needs in terms of changes in volumes and types of military products. The researched final model indicates that how the ground-based military products supply chain can improve chain performance in terms of four measures such as speed, quality, diversity, and accountability introduced in previous studies as the most achievable criteria for supply chain agility by using 8 groups of practices in the form of the determined hierarchy. The MICMAC analysis results indicate that, for supply chain agility, managers of military products chains should direct their efforts towards executing organizational structure improvement, human resource improvement, and IT utilization with the highest impact on other practices and can be seen as the main stimulants of agility. Although product design and workshop management are major practices for military products supply chain agility, as the most dependent practices, they are influenced by other practices and focused on organizational structure improvement. Human resource management, process integration, information technology utilization, and relations to customers and managers are prior to them.

Since the interpretative structural model is based on experts' mental judgment, one can use Structural Equation Model (SEM) to confirm the statistical validity of the proposed model. Thus, the application of SEM to confirm the interpretative structural model in the research is recommended for future studies. Since the relationship between practices at a fuzzy interval can show experts' opinions clearer than that at a non-fuzzy interval, the application of the fuzzy interpretative structural model is also recommended for future studies.

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