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Assessment of Supply Chain Agility in the Automotive Industry of Tehran

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Abstract

In order to achieve greater success in new business environments, companies must have an interaction with suppliers, customers and even competitors and work together to achieve a level of agility beyond the boundaries of company. In fact, companies need to work together within a supply chain so that they can reach to the level of agility beyond each of the companies. Today, the business environment changes due to changes in customer requirements are leading to uncertainty in deciding parameters and it is necessary that the supply chain is flexible in the face of this uncertainty. The successful organization refers to an organization that has competitive advantages in new environments and is able to adapt rapidly with their customer's needs and to market's changes. Therefore, supply chain agility has considerable priority in organizations.

In this paper, supply chain agility indicators in the automotive industry of Tehran and priority of them have been identified. Also the model of supply chain agility in SAZEGOSTAR SAIPA Co. is obtained with regression. To determine the Supply chain agility five classes are considered and the sensitivity analysis model is used for supply chain agility reliability.

Keywords: Agile supply chain, Product Development Flexibility, Sourcing Flexibility, Manufacturing Flexibility, Logistics Flexibility, Information Technology Flexibility.

1. Introduction

In the past two decades, the activities in high-tech industries, fundamentally has changed.

At the beginning of the 21st Century, the world faces significant changes in almost all aspects, especially marketing competition, technological innovations and customer demands. Mass markets are continuing to fragment as customers become increasingly demanding and their expectations rise. These developments have caused a major revision of business priorities and strategic vision (Sharifi and Zhang, 1999). One of the concepts or paradigms of those less than two decades of its life going is the concept of agility. This concept that arose from the need of new organizations is actually the continuation of previous approaches to development such as handicrafts production, mass production and lean production.

First, the term of agility was introduced from the Lehigh University researcher and different definitions of the various approaches for this subject, is presented up to now. Despite the different definitions of agility, all definitions have stressed speed and flexibility as the basic features of an organization (Dove, 1996; Kidd, 1995). Fundamental question for organizations in the third millennium is that "How can supply chain successfully meet with the ongoing, dynamic and non predictable environmental changes?" According to Thomson one of the most important tasks of each organization is running ambiguities.

Supply chain is one of the essential and undeniable elements for success in producing and there is this belief that superior supply chain can be leading to a competitive advantage. Parallel developments in the field of agility and supply chain management lead to introduction of supply chain agility (Christopher, 2000). While the Agility as a strategy for growth has been accepted, as the basis for survival in some environments Business and the idea of creating particular supply chain agility as a logical step for organizations has been suggested.

Agile supply chain can help the organizations in achieving competitive objectives and providing customer's needs in highly competitive markets of current turmoil. Therefore, this research is trying to evaluate automotive industry supply chain agility in Tehran, and the prioritization indicators, and identifying the factors that are more important in supply chain agility in the automotive industry, as organizations recognize its weaknesses and know what aspects need to be improving more.

2. Literature Review

Many attempts to develop a tool for measuring and assessing agility in organizations are applied up to now, because a way to evaluate concepts for any of the requirements such as analysis and planning and control (which are the major elements for management) is unavoidable. Most researchers have used cumulative way to measure and compare the organizations agility. In this technique, agility score elements are gathered together and make the organizational agility (Yusuf, 1993). Other researchers use the concept of paired comparisons and hierarchical process to evaluate and compare organizations in agility (Meade and Rogers, 1997; Ren and Yusuf and Burns, 2001). Some researchers use the network analysis process (Agarwal and Shankar and Tiwari, 2006). And other researchers as well as Lin and colleagues are provided the fuzzy techniques to evaluate agility.

A public commentary from an agile organization based on existing literature, is the ability of an organization to complicate findings or reacts quickly and urgently, with the market changes or increase in market opportunities. Such business is found in processes and structures with more speed and is more adaptable than the others. Also "operation can be flexible and respond quickly" as components of the agile organizations. Supply chain of a company is one of its critical business processes that support agility in organizations. Based on supply chain agility as the ability to adapt or respond quickly to changing market environment (Swafford, Ghosh, Murthy, 2006).

In 1980 research organization was focusing on flexibility. Review research on flexibility shows that the most flexible organization definition is Emphasis on the ability to adapt and respond to change. Agility and flexibility are two separate concepts. While both with the ability to change are in relationship, the relation between flexibility - agility is such as communication between competences - the ability. Ability focusing on the outside of the organization while competence focusing on within the organization and is Introduction of abilities (Teece et. al, 1997; Zhang et. al, 2002). This means that

abilities are achieved from competence (Prahalad and Hamel, 1990; Roth and Jackson, 1995; Teece et. al, 1997). Agile supply chain is adaptable with change, uncertainty and non predictable in business environments and creates the appropriate response to change. Therefore a supply chain requires capabilities that are in fact the features including the ability that the organization should create in order to respond to changes. Supply chain agility is the ability that has been made of flexible supply chain processes, that is competences in internal organizations. Therefore agility and flexibility are two distinct concepts and yet related to each other, and agility is the introduction of flexibility (Swafford, Gosh, Murthy, 2006).

By definition Sharp et al (1999) the supply chain agility is: "Ability of a supply chain to respond quickly to market changes and customer demands." In this paper to evaluate supply chain agility in the automotive industry the Swafford et al.'s model is used. Before the research model, initially expressed some models for supply chain agility are presented by different researchers. Researchers in the decade 1990 became interested to find ways in which manufacturers could make agile supply chains. Many researchers are presented set of conceptual approach, which consists of various models. ZAIN et al are presented a framework model, based on Goldman's model for evaluation the supply chain agility. Cases of this framework include: enriching customers, organize to create competitive advantage, people and information, responding. Agile supply chain components from the perspective of Van Hook et al (2001)are as follows:

- Customer Sensitivity: agile Politics emphasizes on the client and market.
- Virtual Integrated: agile policies emphasize on access, interpret and respond to immediate demands
- Integrated process: agile policies rely on autonomy and accountability to maximize their performance management.
- Integrated Network: agile politics rely on communication networks.

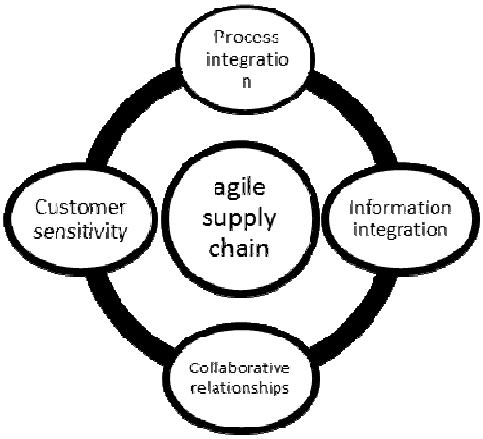
Van Hook (2005) observed characteristics of supply chain operations which are directly associated with supply chain agility:

- Skill in the use and benefit from volatility
- Respond quickly
- Unique response, even in limited volumes

Christopher and Van Hook (2000) measured supply chain agility based on model in Figure (1). Therefore agility is divided to four main categories:

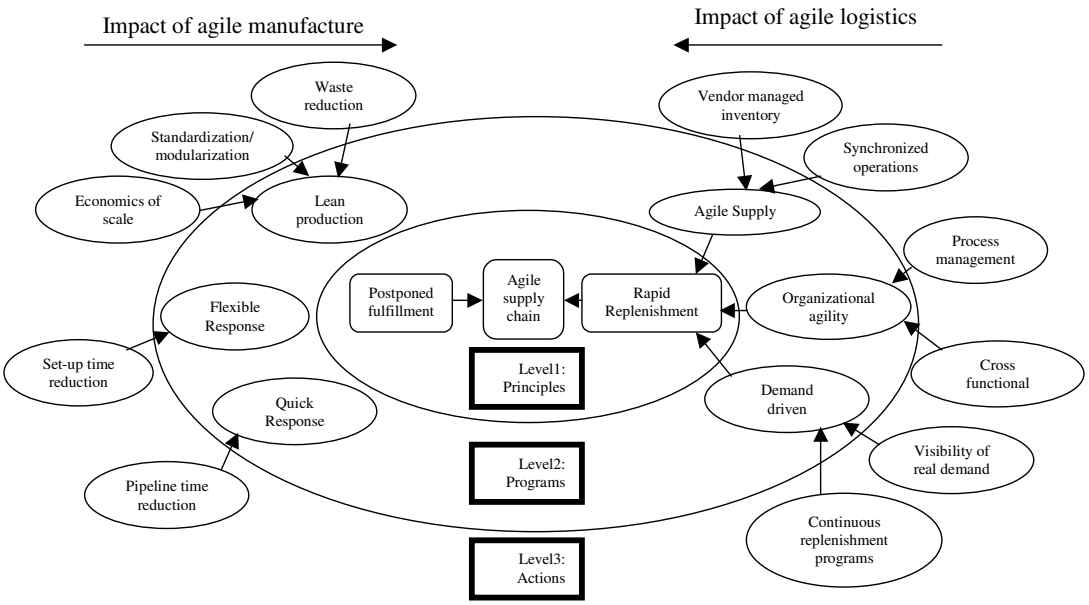
1. Collaborative relationship: This strategy follows the supply chain's ability to attract buyers and visitors for work as collaboration and product development and information system.
2. Process integration: integration as a process based on supply chain means that the supply chain and the central axis that connected companies to a network with specific activities follow target specifics.
3. Information integration: the ability to use information technology for sharing data between buyers and supply visitors, and thus will lead to create the virtual supply chain.
4. Customer sensitivity: the ability to understand and respond if current customer needs as well as comprehensive change and uncertainty is included.

Figure 1: Elements of the supply chain agility



Other models available in the area of supply chain agility, is a model that CHRISTOPHER & TOWILL have presented. They merge the model for supply chain agility, the design is presented; this model is significant in Figure 2, which is a model that has three levels and summarizes the agile concepts.

Figure 2: The model of supply chain agility from CHRISTOPHER & TOWILL



The first level of this model includes basic concepts of agile supply chain. The second level consists of individual program that reaches the first level implementation of these principles is necessary to be considered. The third level includes separate measures that are essential for supporting the second level. Although all the components shown in this model, in a market or a specific production are not necessary, however an agile supply chain may probably, include a large number of these components.

Power and Sohal analyzed the results of 962 Australian industrial companies in their paper to identify some critical factors in the success of supply chain agility, and key success factors in supply chain agility are: participative management style, computer-based technologies, resource management, continuous improvement enablers, supplier relations, just-in-time methodology and technology

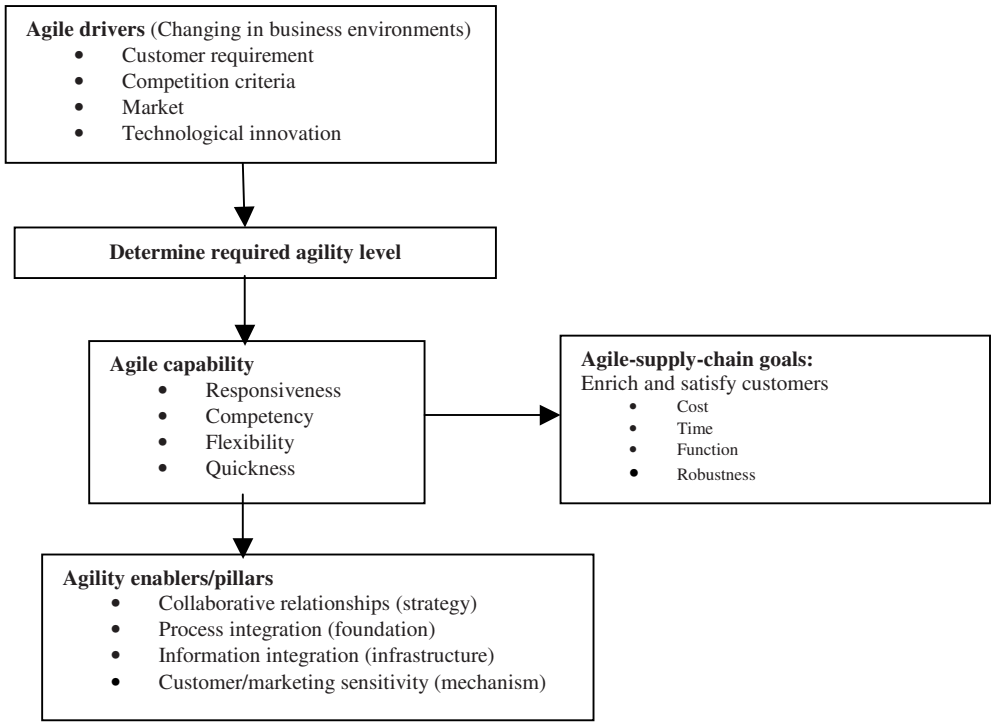
utilization. They advise these success factors that are independent variables to create some dependent variables, which include:

- Site's current performance level: customer satisfaction
- Site's current performance level: average process changeover time
- Site's current performance level: productivity
- Site's current performance level: delivery in full on time
- Site's current performance level: relative technological competitiveness
- Site's current performance level: ratio of annual sales to average total stock
- Competitive advantage through: process technology
- Competitive advantage through: ability to develop new products
- Rating of performance in the area of: product innovation

Power and Sohal in their paper have measured the correlation between dependent and independent variables in very agile organizations and less agile organizations.

Lin et al based on the literature review has presented a conceptual model of agile supply chain, which consists of four major sections: Agile drivers, agile capability, Agile-supply-chain goals and Agility enablers, which in Figure 3 are visible.

Figure 3: Conceptual model of agile supply chain from LIN et al



Agile supply chain concerns change, uncertainty and unpredictability within its business environment and makes appropriate responses to changes. Therefore, an agile supply chain requires various distinguishing capabilities. These capabilities include four main elements (Christopher, 2000; Sharp et al., 1999; Giachetti et al., 2003):

- Responsiveness, which is the ability to identify changes and respond to them quickly, reactively or proactively, and also to recover from them
- Competency, which is the ability to efficiently and effectively realize enterprise objectives
- flexibility/adaptability, which is the ability to implement different processes and apply different facilities to achieve the same goals
- Quickness/speed, which is the ability to complete an activity as quickly as possible.

Agility-enabled attributes are supposed to be the aspects of agility content and to determine the entire supply chain behavior, so that agility enabled attributes enable the measuring of supply chain agility. Based on Goldman et al. ,1991; Sharifi and Zhang,1999; Yusuf et al.,1999; Christopher,2000; Sharp et al.,1999; Ren et al.,2001; Ren et al., 2000; Weber,2002, and the finding of this study, key enablers are classified into four categories.

1) Collaborative relationship: this supply chain strategy is the ability to attract the buyers and suppliers to work collaboratively, jointly develop products and share information.
2) Process integration: as the foundation of the supply chain, process integration means that the supply chain is a confederation of partners linked into a network.
3) Information integration: as the infrastructure of the supply chain, it includes the ability to use information technology to share data between buyers and supplies, thus effectively creating a virtual supply chain. Virtual supply chains are information-based rather than inventory-based.
4) Customer/marketing sensitivity: as the mechanism of the supply chain, it includes the ability to read and respond to real customer requirements, and also to master change and uncertainty.

AGRAWAL et.al, (2006) using the Brainstorming in a car factory making has attempted to determine the supply chain variables. The purpose of their Brainstorming sessions is to determine the relationship between variables of supply chain. In this study 15 variables related to supply chain agility have been identified.

1. Market Sensitivity: supply chain being able to prediction and responding to real demand.
2. Delivery speed: the ability to deliver goods or services faster than competitors.
3. The data correction: One of the important factors that affect supply chain performance by the various partners in their decision-making.
4. Introducing new products: the ability to introduce new products for supply chain, which are seeking competitive advantage, is considered very important.
5. Centralized and collaborative planning program: integrated building and effective coordination of the supply chain and reducing excess inventory levels reduced intervals time of delivery sales and to increase customer service.
6. Integrated process: information shared between members of the chain is achieved from using integrated process.
7. Use information technology tools: the use of information technology for sharing data between buyers and suppliers to create a virtual supply chain.
8. Reducing the delivery time: Time from order to delivery is at least the minimum amount and delivery time depends on the competition.
9. Promoting the service: upgrading the level of services that offer customers lead to supply chain performance improvement.
10. Minimizing the cost: this action by identifying ways in which the exchanges in firm are made, are more efficient and finding other ways to reduce the cost of production, and is helping partners minimize the cost.
11. Customer Satisfaction: Customer satisfaction levels understand the value received and the value of the products offered by competitors.
12. Quality improvement: Quality improvement as an essential indicator for success in international market competition has been known by the management of business enterprises around the world.
13. Minimum uncertainty: uncertainty extended over the supply chain leads to inefficient processing performed and added the amount of non value activities.
14. Increased trust: trust between members of the trade relations within the organization, improving communication and dialogue and creating a joint strategic vision.
15. Reducing resistance to change: resistance always has known as the main reason of conflict and adverse factor that is important for the health of any organization.

Faisal et al have offered the following categories with indicators related to supply chain agility (Faisal et al, 2007).

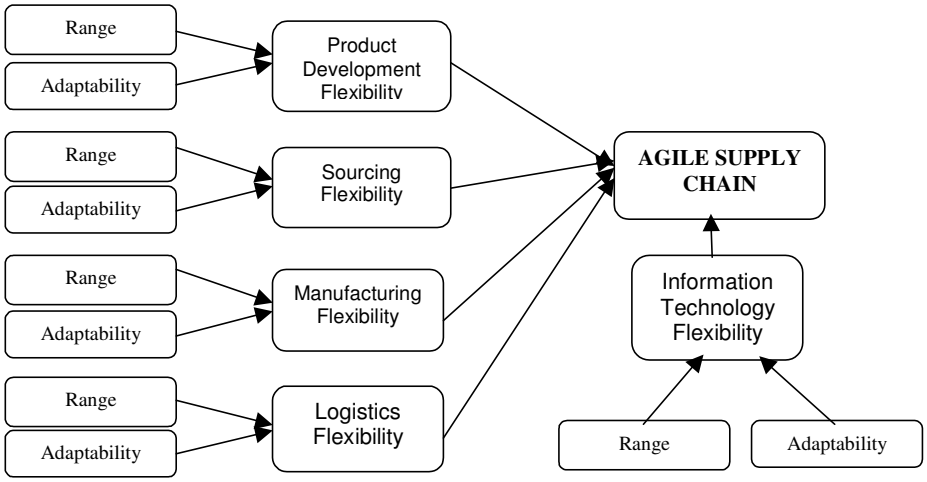
- Integrated process, including: participation planning, access to information and knowledge through the Internet, updated information for everyone at any time, the data associated with the sale, efficiently response to customers, the ability of searching data, beliefs and common goals, high-level coordination, emphasis on outsourcing, trade without the use of paper and soft network applications.
- Integration in process, including: the common basis of product development, lack of storage in the supply chain, multiple team working, infrastructure to encourage innovation and to update combining manufacturing processes in the supply chain.
- Integrated Network, including: senior management commitment to agile actions, decentralized decision making, emphasis on the main merits, targets, standards and relationships based on trust.
- Sensitive markets, including: rapid new product introduction, responding to real demand, demand for customized products, maintaining and increasing the level of customer relations, customer oriented standards, improving quality, reducing costs and increasing the frequency of the product is improved.

GUNASEKARAN et al have offered Key success factors in the supply chain agility include:

- Sharing information timely
- Reduced total life cycle
- Coordination of labor in different parts of supply chain
- Optimal decisions support system
- Reduction of delay time in Materials flow
- Integration in the field of information operations, and flexibility

Based on research in supply chain, Swafford et al have presented flexible structures that affect supply chain agility, including: Product Development Flexibility, Sourcing Flexibility, Manufacturing Flexibility, Logistics Flexibility, Information Technology Flexibility, which are provided in Figure 4.

Figure 4: Conceptual model of agile supply chain from Swafford et al



Swafford et al have defined agile supply chain as a criterion to assess the ability of efficient supply chain in adaptation with competitive environment changes for delivering goods and services.

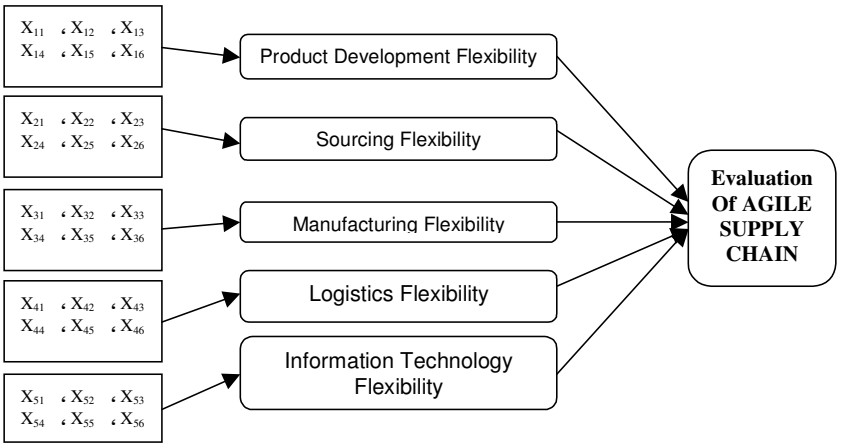
Based on Slack's (1987) concept that flexibility is defined as two dimensional, Swafford et al defined flexibility using two dimensions called range and adaptability. Range is defined as the number of different positions, or flexible options that can be achieved with existing resources. Adaptability is the ability to change the existing number of states (Swafford et al, 2006).

This research is based on Swafford et al model in supply chain agility.

3. The Conceptual Model

This research is based on Swafford et al model in supply chain agility. The conceptual model is presented in figure 5.

Figure 5: Conceptual model



The indicators of supply chain agility model are given in table (1).

Table 1: Index of supply chain agility

1) Product Development Flexibility	Range 1: Number of technologies used by current manufacturing Range 2: Number of product announcements per year Range 3: Percent of asset reusability Adaptability 1: Ability to design multiple products Adaptability 2: Ability to reduce product development cycle times Adaptability 3: Ability to postpone design decisions
2) Sourcing Flexibility	Range 1: Number of different parts Range 2: Number of supplier-buyer relationship options Range 3: Number of suppliers (1st tier, 2nd tier, …) Adaptability 1: Ability to get order sizes changed Adaptability 2: Ability to influence supplier performance Adaptability 3: Ability to change suppliers
3) Manufacturing Flexibility	Range 1: Range of volume levels at which manufacturing can operate Range 2: Number of methods available to increase capacity Range 3: Number of products manufactured per facility Adaptability 1: Ability to change product mix Adaptability 2: Ability to change manufacturing throughput time Adaptability 3: Ability to change workforce capability
4) Logistics Flexibility	Range 1: Number of delivery modes per product Range 2: Number of storage Range 3: Number of customers served Adaptability 1: Ability to add/delete delivery modes Adaptability 2: Ability to change planned delivery times Adaptability 3: Ability to change total storage capacity
5) Information Technology Flexibility	Range 1: Percentage of supply chain directly supported by IT Range 2: Degree of commonality of IT system in supply chain process Range 3: Number of methods supported by IT to analyze the competitive environment Adaptability 1: Ability of the IT system to be adapted to support changing requirements Adaptability 2: Ability of IT system to be adapted to support new distribution channels Adaptability 3: Ability of IT system to interface with other systems (e.g. Internet)

4. The Research Goals

The goals of this research are:

1) Identification of the models of supply chain agility
2) Identification of the effective indicators of supply chain agility in SAZEGOSTAR SAIPA Co.
3) Identified Priorities of the index affecting the automotive industry supply chain agility in SAZEGOSTAR SAIPA Co.
4) Providing and applying a model to evaluate supply chain agility in SAZEGOSTAR SAIPA Co.

5. The Research Questions

1) What are the models of supply chain agility?

2-1) what are the effective indicators of Product Development Flexibility in supply chain agility assessment?

2-2) what are the effective indicators of sourcing Flexibility in supply chain agility assessment?

2-3) what are the effective indicators of manufacturing Flexibility in supply chain agility assessment?

2-4) what are the effective indicators of logistic Flexibility in supply chain agility assessment?

2-5) what are the effective indicators of information technology Flexibility in supply chain agility assessment?

3) Which indicator is more important than another in priorities of the index affecting the automotive industry supply chain agility in SAZEGOSTAR SAIPA Co?

4) Can we provide a model to evaluate supply chain agility in SAZEGOSTAR SAIPA Co?

6. The Hypothesis of Research

1-1) The indicators of product development flexibility are effective in assessment of supply chain agility.

1-2)The indicators of sourcing flexibility are effective in assessment of supply chain agility.

1-3)The indicators of manufacturing flexibility are effective in assessment of supply chain agility.

1-4)The indicators of logistic flexibility are effective in assessment of supply chain agility.

1-5)The indicators of information technology flexibility are effective in assessment of supply chain agility.

2) Information technology flexibility is the most important index of supply chain agility in SAZEGOSTAR SAIPA Co.

3) Multiple regressions are a present ability model for evaluation of supply chain agility.

7. Methodology & Data Analysis

This study is applied in respect of the aim of research method, which uses scientific knowledge to be considered with modeling trend. This uses questioners to collect data for analysis.

Hypothesis (1-1): Statistical hypotheses are as follows:

$$\begin{cases} H_0: \ \rho = 0 \\ \\ H_1: \ \rho \neq 0 \end{cases}$$

H_0 means that there is no correlation between two variables.

The results of spearman correlation are given in table 2.

Table 2: The results of spearman correlation for first Hypothesis

		X11	X12	X13	X14	X15	X16
PDF	Correlation Coefficient	.734	.574	.518	.724	.456	.605
	Sig. (2-tailed)	.000	.008	.019	.000	.043	.005
	N	20	20	20	20	20	20

Considering the above table can show that the validity in all test criteria is less than 5%, so research assumptions are accepted with 95% confidence relationship between variables that can be acknowledged. As a result we can say that product development flexibility indicators in the automotive industry supply chain agility in SAZEGOSTAR SAIPA Co are effective.

Hypothesis (1-2): Statistical hypotheses are as follows:

$$\begin{cases} H_0: \quad \rho = 0 \\ \\ H_1: \quad \rho \neq 0 \end{cases}$$

H_0 means that there is no correlation between two variables.

The results of spearman correlation are given in table 3.

Table 3: The results of spearman correlation for second Hypothesis

		X31	X32	X33	X34	X35	X36
MF	Correlation Coefficient	.880	.631	.820	.488	.760	.745
	Sig. (2-tailed)	.000	.003	.000	.029	.000	.000
	N	20	20	20	20	20	20

Considering the above table can show that the validity in all test criteria is less than 5%, so research assumptions are accepted with 95% confidence relationship between variables that can be acknowledged. As a result we can say that sourcing flexibility indicators in the automotive industry supply chain agility in SAZEGOSTAR SAIPA Co are effective.

Hypothesis (1-4): Statistical hypotheses are as follows:

$$\begin{cases} H_0: \quad \rho = 0 \\ \\ H_1: \quad \rho \neq 0 \end{cases}$$

H_0 means that there is no correlation between two variables.

The results of spearman correlation are given in table 4.

Table 4: The results of spearman correlation for fourth Hypothesis

		X41	X42	X43	X44	X45	X46
LF	Correlation Coefficient	.703	.642	.712	.749	.605	.466
	Sig. (2-tailed)	.001	.002	.000	.000	.005	.038
	N	20	20	20	20	20	20

Considering the above table, the validity in all test criteria is less than 5%, so research assumptions are accepted with 95% confidence relationship between variables that can be acknowledged. As a result we can say that logistic flexibility indicators in the automotive industry supply chain agility in SAZEGOSTAR SAIPA Co are effective.

Hypothesis (1-5): Statistical hypotheses are as follows:

$$\begin{cases} H_0: \quad \rho = 0 \\ \\ H_1: \quad \rho \neq 0 \end{cases}$$

H_0 means that there is no correlation between two variables.

The results of spearman correlation are given in table 5.

Table 5: The results of spearman correlation for fifth Hypothesis

		X51	X52	X53	X54	X55	X56
ITF	Correlation Coefficient	.831	.641	.621	.760	.738	.726
	Sig. (2-tailed)	.000	.002	.003	.000	.000	.000
	N	20	20	20	20	20	20

Considering the above table shows that the validity in all test criteria is less than 5%, so research assumptions are accepted with 95% confidence relationship between variables that can be acknowledged. As a result we can say that information technology flexibility indicators in the automotive industry supply chain agility in SAZEGOSTAR SAIPA Co are effective.

Hypothesis (2): Information technology flexibility is the most important index of supply chain agility in SAZEGOSTAR SAIPA Co.

At this paper eigenvector technique, has been used to identify the most important factor and priority scheme of effective indicators in supply chain agility. This step requires knowing the relative importance of the indicators, and the relative importance of each index determines the degree of priority than others. The base of this method to decide lies on paired comparison. Because matrix decision making is not available, so should be used paired comparison by DM.

To determine decision making matrix at this stage three-person team of experts has been selected from the automotive industry companies. Matrix Decision making from their geometric means weights is given in tables. To determine the consistency rate and weights of criteria, expert choice is used. All matrixes have enough consistency rates, and the consistency rate of each matrix is given at below of each table. Criteria variables of decision matrixes are defined in table 6.

Table 6: Decision matrix with the aim of supply chain agility

supply chain agility	Product Development Flexibility	Sourcing Flexibility	Manufacturing Flexibility	Logistics Flexibility	Information Technology Flexibility	weights
Product Development Flexibility	1	2.62	0.55	1.58	0.69	0.196
Sourcing Flexibility	0.38	1	0.48	0.55	0.24	0.083
Manufacturing Flexibility	0.82	2.08	1	1.59	0.38	0.215
Logistics Flexibility	0.63	1.82	0.63	1	0.44	0.138
Information Technology Flexibility	1.44	4.22	2.62	2.29	1	0.367

Consistency rate of decision matrix with the aim of supply chain agility is obtained 0.03, so this matrix has enough consistency rates.

Table 7: Decision matrix with the aim of Product Development Flexibility

Product Development Flexibility	X_{11}	X_{12}	X_{13}	X_{14}	X_{15}	X_{16}	weights
X_{11}	1	0.48	1.26	0.64	1.26	0.79	0.137
X_{12}	2.08	1	0.79	1.26	0.79	1.26	0.184
X_{13}	0.55	1.44	1	1.26	0.55	0.79	0.151
X_{14}	3.24	0.69	0.79	1	0.79	2.08	0.191
X_{15}	0.69	1.26	1.82	1.44	1	1.26	0.195
X_{16}	1.44	0.79	1.26	0.33	0.79	1	0.142

Consistency rate of decision matrix with the aim of Product development Flexibility is obtained 0.05, so this matrix has enough consistency rates.

Table 8: Decision matrix with the aim of Sourcing Flexibility

Sourcing Flexibility	X_{21}	X_{22}	X_{23}	X_{24}	X_{25}	X_{26}	weights
X_{21}	1	0.79	0.48	1.26	1.26	1.26	0.142
X_{22}	1.26	1	0.79	1.59	1.59	1.26	0.165
X_{23}	2.08	1.26	1	1.26	1.26	1.82	0.201
X_{24}	0.79	0.63	1.26	1	0.55	0.55	0.126
X_{25}	1.26	1.59	1.26	1.82	1	0.55	0.191
X_{26}	0.79	0.79	0.55	1.82	1.82	1	0.175

Consistency rate of decision matrix with the aim of Sourcing Flexibility is obtained 0.08, so this matrix has enough consistency rates.

Table 9: Decision matrix with the aim of Manufacturing Flexibility

Manufacturing Flexibility	X_{31}	X_{32}	X_{33}	X_{34}	X_{35}	X_{36}	weights
X_{31}	1	0.79	1.59	0.79	1.26	0.63	0.160
X_{32}	1.26	1	1.26	1.44	0.63	1.26	0.172
X_{33}	0.63	1.82	1	0.63	0.63	1.26	0.141
X_{34}	1.82	0.69	1.59	1	1.59	1.59	0.202
X_{35}	0.79	1.59	1.82	0.63	1	1.26	0.178
X_{36}	1.59	0.79	0.69	0.63	0.59	1	0.147

Consistency rate of decision matrix with the aim of Manufacturing Flexibility is obtained 0.03, so this matrix has enough consistency rates**.**

Table 10: Decision matrix with the aim of Logistics Flexibility

Logistics Flexibility	X_{41}	X_{42}	X_{43}	X_{44}	X_{45}	X_{46}	weights
X_{41}	1	0.69	0.79	0.48	1.59	0.63	0.132
X_{42}	1.44	1	0.79	0.69	1.44	1.26	0.171
X_{43}	1.26	1.26	1	1.26	1.26	0.79	0.180
X_{44}	2.08	1.44	0.79	1	1.59	0.63	0.191
X_{45}	0.63	0.69	0.79	0.63	1	1.59	0.143
X_{46}	1.59	0.79	1.26	1.26	0.63	1	0.183

Consistency rate of decision matrix with the aim of Logistics Flexibility is obtained 0.04, so this matrix has enough consistency rates.

Table 11: Decision matrix with the aim of Information Technology Flexibility

Information Technology Flexibility	X_{51}	X_{52}	X_{53}	X_{54}	X_{55}	X_{56}	weights
X_{51}	1	4.82	3.11	4.38	1.82	6.21	0.368
X_{52}	0.21	1	0.17	0.44	0.16	0.79	0.044
X_{53}	0.32	5.85	1	2.52	0.24	2.29	0.149
X_{54}	0.23	2.29	0.39	1	0.32	1.59	0.082
X_{55}	0.55	6.32	4.22	3.11	1	3.30	0.296
X_{56}	0.16	1.26	0.44	0.63	0.300	1	0.061

Consistency rate of decision matrix with the aim of Logistics Flexibility is obtained 0.05, so this matrix has enough consistency rates**.**

Hypothesis (3): Multiple regressions are a present ability model for evaluation of supply chain agility. In this step of research multiple linear regression models is presented for supply chain agility.

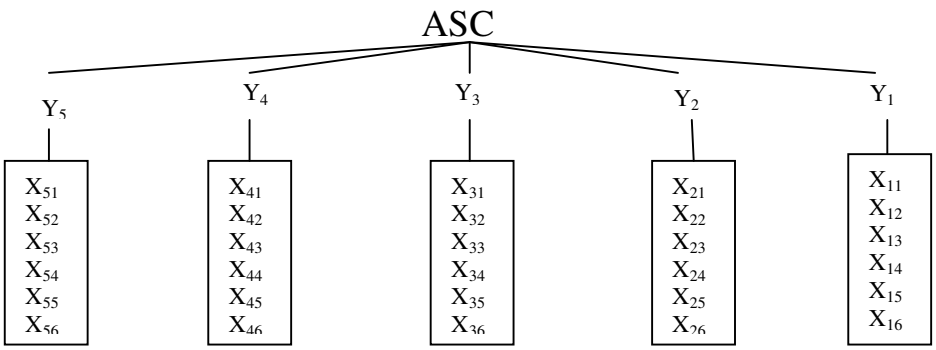
Regression Analysis is a method for modeling and data analysis. The purpose of regression analysis is expression of the form of dependent variables in a function of independent variables. This model can be stated as follows:

$$Y= B_0 + B_1X_1 + B_2X_2 + \ldots + B_KX_K \quad (1)$$

The methods of selection multiple variables in regression are: 1) Forward, 2) backward, 3) stepwise. In this research stepwise selection method was used. To determine each regression equation of agility and selection of variables SPSS 16.0 software was used.

With Stepwise selection methods per indicators of flexibility that have relation with supply chain agility have been identified. Equations obtained for each dimension is provided in follows, in Figure 6 the hierarchies of dimensions are shown.

Figure 6: Hierarchical variables to identify regression models



Regression equation of supply chain agility is obtained as follows:

$$ASC = 0.672 + 0.202Y_1 + 0.087Y_2 + 0.214Y_3 + 0.157Y_4 + 0.367Y_5 \quad (2)$$

Y_1: Product Development Flexibility
Y_2: Sourcing Flexibility
Y_3: Manufacturing Flexibility
Y_4: Logistics Flexibility
Y_5: Information Technology Flexibility

Regression equation of Product Development Flexibility (Y_1)

$$Y_1 = 0.329 + 0.131X_{11} + 0.178X_{12} + 0.148X_{13} + 0.195X_{14} + 0.189X_{15} + 0.149X_{16} \quad (3)$$

Regression equation of Sourcing Flexibility (Y_2)

$$Y_2 = 1.497 + 0.155X_{21} + 0.152X_{22} + 0.155X_{23} + 0.182X_{24} + 0.167X_{25} + 0.185X_{26} \quad (4)$$

Regression equation of Manufacturing Flexibility (Y_3)

$$Y_3 = 0.919 + 0.157X_{31} + 0.214X_{32} + 0.167X_{33} + 0.207X_{34} + 0.159X_{35} + 0.113X_{36} \quad (5)$$

Regression equation of Logistics Flexibility (Y_4)

$$Y_4 = 0.795 + 0.115X_{41} + 0.178X_{42} + 0.173X_{43} + 0.223X_{44} + 0.151X_{45} + 0.165X_{46} \quad (6)$$

Regression equation of Information Technology Flexibility (Y_5)

$$Y_5 = 4.585 + 0.348X_{51} + 0.092X_{52} + 0.152X_{53} + 0.179X_{54} + 0.157X_{55} + 0.166X_{56} \quad (7)$$

8. Sensitivity Analysis

To determine the scope changes of independent variables, organizations can increase their supply chain agility; and the sensitivity analysis of obtained model is used. Before sensitivity analysis, supply chain agility is derived in current situation of organization. For the determination of supply chain agility in the current situation, the current values of the Y in the table 12 are given, so from the equation agility of supply chain the number of supply chain agility in the current situation of organization has achieved 30.75.

Table 12: Current values dimensions of supply chain agility

Current values	Dimensions of agility
25.22	Y_1
33.66	Y_2
26.28	Y_3
28.14	Y_4
32.75	Y_5

To determine agility the five classified levels with equal distances is assumed and are given in table 13. Considering that the amount of supply chain agility number 30.75 is obtained, we conclude that the agility in supply chain of SAZEGOSTAR SAIPA Co. is located in the D category.

Table 13: Category of Agility Status

Agility	Class
80-100	A
60-80	B
40-60	C
20-40	D
0-20	E

Supply chain agility equation equals the number 50 (average 40 and 60 in category C), for the organization wants to improve its supply chain and is placed in the higher category.

The value of Y_1 is obtained as follows.

$0.672 + 0.202Y_1 + 0.087Y_2 + 0.214Y_3 + 0.157Y_4 + 0.367Y_5 = 50$

$0.672 + 0.202(Y_1) + 0.087(33.66) + 0.214(26.28) + 0.157(28.14) + 0.367(32.75) = 50$

$Y_1 = 120.4$

And so other values include:

$Y_2 = 254.8$

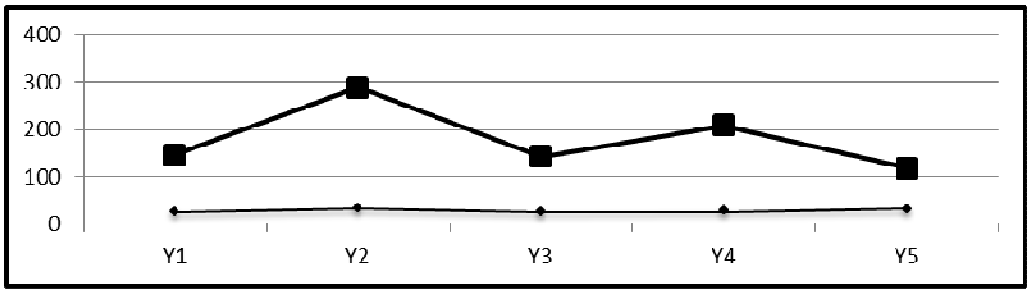
$Y_3 = 116.2$

$Y_4 = 179.9$

$Y_5 = 85.18$

Figure 7 has shown the current state of the dimensions of supply chain agility in SAZE GOSTAR SAIPA and desirable aspects of these for supply chain agility that are exposed in the category C. As is clear, the current state of supply chain agility is a lower chart and optimal conditions of supply chain agility for the organization are in upper chart.

Figure 7: Current status and desirable aspects of dimensions in the supply chain agility



Due to the range obtained for Product Development Flexibility, range of product development Flexibility effective index change is obtained on the following:

$0.329 + 0.131X_{11} + 0.178X_{12} + 0.148X_{13} + 0.195X_{14} + 0.189X_{15} + 0.149X_{16} = 120.4$

$0.329 + 0.131X_{11} + 0.178(25.5) + 0.148(26) + 0.195(26) + 0.189(23.5) + 0.149(22) = 120.4$

X_{11}= 754.9

So the other X values includes:

X_{12} = 560.1

X_{13} = 668.9

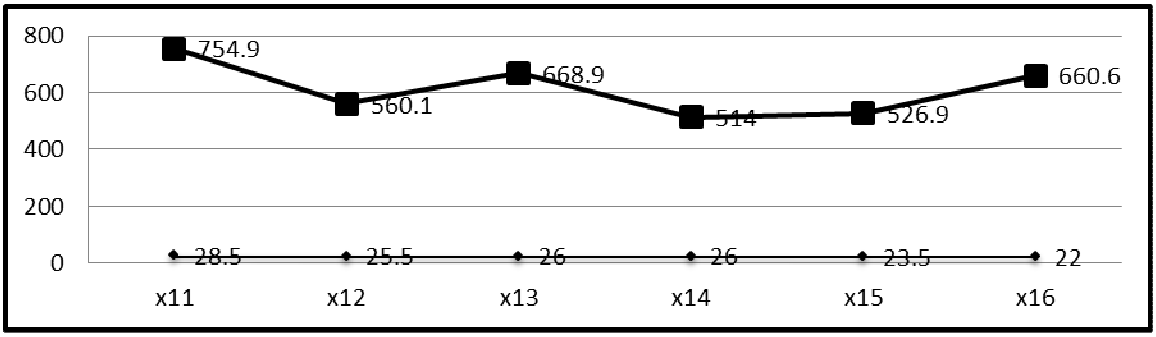
X_{14} = 514

X_{15} =526.9

X_{16}= 660.6

Figure 8 has shown the current state of the dimensions of product development flexibility in SAZE GOSTAR SAIPA and desirable aspects of these for supply chain agility to be exposed in the category C.

Figure 8: Current status and desirable aspects of dimensions in product development flexibility



Due to the range obtained for Sourcing Flexibility, range of Sourcing Flexibility effective index change is obtained on the following:

$1.497 + 0.155X_{21} + 0.152X_{22} + 0.155X_{23} + 0.182X_{24} + 0.167X_{25} + 0.185X_{26}= 254.8$

$1.497 + 0.155X_{21} + 0.152(40) + 0.155(33.5) + 0.182(25) + 0.167(49) + 0.185(22) = 254.8$

X_{21}= 1453.08

So the other X values includes:

X_{22}= 1485.04

X_{23}= 1450.5

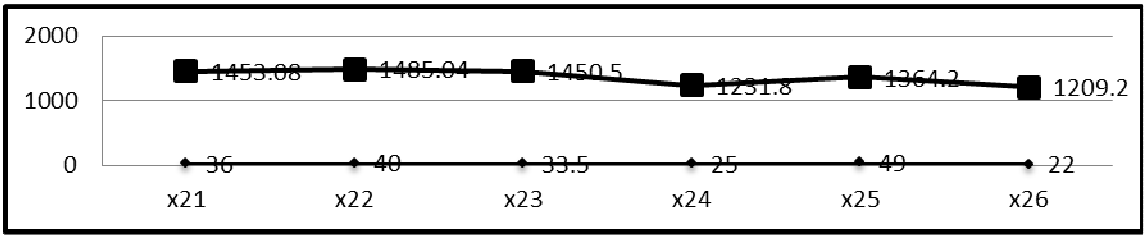
X_{24}= 1231.8

X_{25}= 1364.2

X_{26}= 1209.2

Figure 9 has shown the current state of the dimensions of sourcing Flexibility in SAZE GOSTAR SAIPA and desirable aspects of these for supply chain agility to be exposed in the category C.

Figure 9: Current status and desirable aspects of dimensions in sourcing Flexibility



Due to the range obtained for Manufacturing Flexibility, range of Manufacturing Flexibility effective index change is obtained on the following:

$0.919 + 0.157X_{31} + 0.214X_{32} + 0.167X_{33} + 0.207X_{34} + 0.159X_{35} + 0.113X_{36}= 116.2$

$0.919 + 0.157X_{31} +0.214(26.5) +0.167(30.5) +0.207(26.5) +0.159(26.5) +0.113(28.5) =116.2$

X_{31}= 283.4

So the other X values includes:

X_{32}= 436.9

X_{33}= 556.4

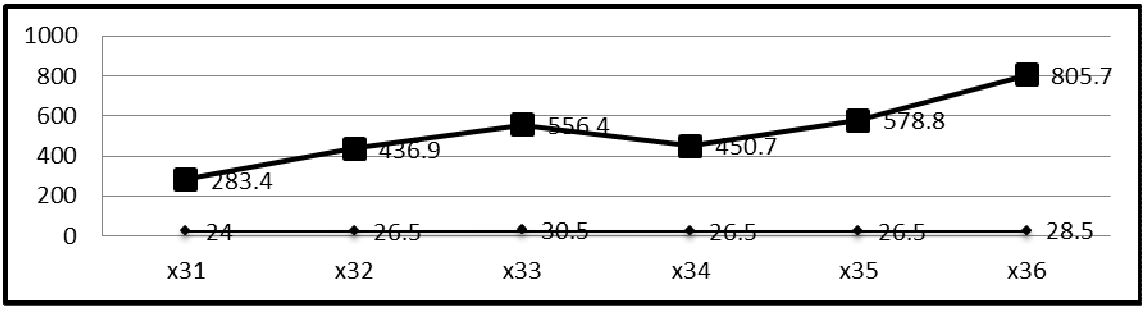
X_{34}= 450.7

X_{35}= 578.8

X_{36}= 805.7

Figure 10 has shown the current state of the dimensions of manufacturing Flexibility in SAZE GOSTAR SAIPA and desirable aspects of these for supply chain agility to be exposed in the category C.

Figure 10: Current status and desirable aspects of dimensions in manufacturing Flexibility



Due to the range obtained for Logistics Flexibility, range of Logistics Flexibility effective index change is obtained on the following:

$0.795 + 0.115X_{41} + 0.178X_{42} + 0.173X_{43} + 0.223X_{44} + 0.151X_{45} + 0.165X_{46}=179.9$

$0.795 +0.115X_{41} +0.178(32) +0.173(32.5) +0.223(28) +0.151(34.5) +0.165(30) = 179.9$

X_{41}= 1316

So the other X values includes:

X_{42}=869.5

X_{43}= 894.2

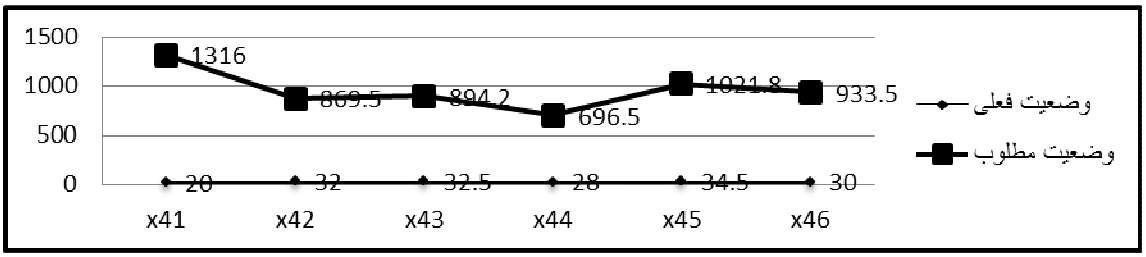
X_{44}=696.5

X_{45}=1021.8

X_{46}= 933.5

Figure 11 has shown the current state of the dimensions of logistic Flexibility in SAZE GOSTAR SAIPA and desirable aspects of these for supply chain agility to be exposed in the category C.

Figure 11: Current status and desirable aspects of dimensions in logistic Flexibility



Due to the range obtained for Information Technology Flexibility, range of Information Technology Flexibility effective index change is obtained on the following:

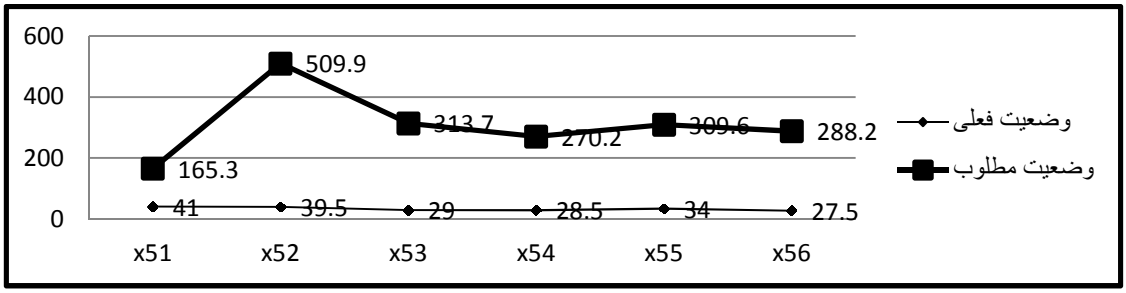
$4.585 + 0.348X_{51} + 0.092X_{52} + 0.152X_{53} + 0.179X_{54} + 0.157X_{55} + 0.166X_{56}= 85.18$

$4.585 +0.348X_{51} +0.092(39.5) +0.152(29) +0.179(28.5) +0.157(34) +0.166(27.5) = 85.18$

X_{51}= 165.3
So the other X values includes:
X_{52}= 509.9
X_{53}= 313.7
X_{54}= 270.2
X_{55}= 309.6
X_{56}= 288.2

Figure 12 has shown the current state of the dimensions of information technology Flexibility in SAZE GOSTAR SAIPA and desirable aspects of these for supply chain agility to be exposed in the category C.

Figure 12: Current status and desirable aspects of dimensions in information technology Flexibility



9. Conclusion

In this study the indicators affecting the supply chain agility have been identified in SAZEGOSTAR SAIPA. The results prove that among the five dimensions of supply chain agility, Information Technology Flexibility is the most important indicator. Then the order of importance in supply chain agility dimensions is Manufacturing Flexibility, Product Development Flexibility, Logistics Flexibility and Sourcing Flexibility. Also Sensitivity analysis results indicate that the model for the organization placed in Category C supply chain agility, Information Technology Flexibility have minimal change and Sourcing Flexibility have maximum change in supply chain agility. Domain change index for the five dimensions of supply chain agility for organization to be placed in Category C is given on the table 14.

Table 14: Domain change Dimensions of supply chain agility

Dimensions of supply chain agility	Current status	Desirable status	Change
Product Development Flexibility	25.22	120.4	95.18
Sourcing Flexibility	33.66	254.8	221.14
Manufacturing Flexibility	26.28	116.2	89.92
Logistics Flexibility	28.14	179.9	151.76
Information Technology Flexibility	32.75	85.18	52.43

Domain change index for product development flexibility for organization to be placed in Category C is given on the table 15.

Table 15: Domain change Dimensions of product development flexibility

Dimensions of product development flexibility	current status	desirable status	Change
Number of technologies used by current manufacturing	28.5	754.9	726.4
Number of product announcements per year	25.5	560.1	534.6
Percent of asset reusability	26	668.9	642.9
Ability to design multiple products	26	514	488
Ability to reduce product development cycle times	23.5	526.9	503.4
Ability to postpone design decisions	22	660.6	638.6

Domain change index for sourcing flexibility for organization to be placed in Category C is given on the table 16.

Table 16: Domain change Dimensions of sourcing flexibility

Dimensions of sourcing flexibility	current status	desirable status	Change
Number of different parts	36	1453.08	1417.08
Number of supplier-buyer relationship options	40	1485.04	1445.04
Number of suppliers (1st tier, 2nd tier, …)	33.5	1450.5	1417
Ability to get order sizes changed	25	1231.8	1206.8
Ability to influence supplier performance	49	1364.2	1315.2
Ability to change suppliers	22	1209.2	1187.2

Domain change index for manufacturing flexibility for organization to be placed in Category C is given on the table 17.

Table 17: Domain change Dimensions of manufacturing flexibility

Dimensions of manufacturing flexibility	Current status	Desirable status	Change
Range of volume levels at which manufacturing can operate	24	283.4	259.4
Number of methods available to increase capacity	26.5	436.9	410.4
Number of products manufactured per facility	30.5	556.4	535.9
Number of products manufactured per facility	26.5	450.7	424.2
Ability to change manufacturing throughput time	26.5	578.8	552.3
Ability to change workforce capability	28.5	805.7	777.2

Domain change index for logistic flexibility for organization to be placed in Category C is given on the table 18.

Table 18: Domain change Dimensions of logistic flexibility

Dimensions of logistic flexibility	Current status	Desirable status	Change
Number of delivery modes per product	20	1316	1296
Number of storage	32	869.5	837.5
Number of customers served	32.5	894.2	861.7
Ability to add/delete delivery modes	28	696.5	668.5
Ability to change planned delivery times	34.5	1021.8	987.3
Ability to change total storage capacity	30	933.5	903.5

Domain change index for information technology flexibility for organization to be placed in Category C is given on the table 19.

Table 19: Domain change Dimensions of information technology flexibility

Dimensions of information technology flexibility	current status	desirable status	Change
Percentage of supply chain directly supported by IT	41	165.3	124.3
Degree of commonality of IT system in supply chain process	39.5	509.9	470.4
Number of methods supported by IT to analyze the competitive environment	29	313.7	284.7
Ability of the IT system to be adapted to support changing requirements	28.5	270.2	241.7
Ability of IT system to be adapted to support new distribution channels	34	309.6	275.6
Ability of IT system to interface with other systems (e.g. Internet)	27.5	288.2	260.7

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