World Journal of Environmental Biosciences

Available Online at: **www.environmentaljournals.org**

Volume 9, Supplementary: 106-117

ISSN 2277- 8047

Optimization of Supply Chain Financial Processes Based on Costs and Revenues (Case Study: Car Supply Chain)

Samira Zandi, Aref Famili*

Master in Industrial Engineering, Department of Engineering, Amirkabir University of Technology, Tehra, Iran.

ABSTRACT

Supply chain includes all activities related to the flow and conversion of products from the raw material stage (extraction) to delivery to the final consumer, and also information flows related to them. The purpose of this research is to investigate the optimization of supply chain financial processes based on automobile costs and revenues. This study proposes to design an integrated supply chain for automobile products that includes making long-term decisions to select supplier, finding new warehouses, and making new decisions regarding product distribution and its production. The purpose of the proposed model is to select suppliers, determine the amount of imports, distribute cars and produce their parts. The model has been developed according to combinating various types of cars to produce various products and locating new warehouses and various states of transportation at all levels of the chain. The current research proposes a comprehensive planning model that is able to examine all levels and factors affecting the chain and select and evaluate suppliers. Application of this model is investigated in a case study for Iran, which shows significant savings. By solving this model, the results show a significant reduction in transportation costs, and profit increase.

Keywords: *Car supply chain, Chain financial processes, Optimization, Costs, Revenues, Car suppliers*

Corresponding author: Aref Famili
e-mail ✉ aref.famili @ yahoo.com
Received: 08 September 2020
Accepted: 18 December 2020

1. INTRODUCTION

The key aspects of sustainable supply chain management practices include sustainability of the supply chain network and supply chain environment, application of environment-friendly strategies, and acceptance of social responsibilities; so considering sustainability in the supply chain in addition to regarding financial profitability, adverse environmental effects as well as adverse social effects should be considered and minimized.

High speed, low cost, and communication and interaction between suppliers and customers are key factors in improving supply chain management. There is a strong desire for supply and demand chain integration that creates new opportunities for creation by adding market value. Working together leads to more manageable and more specific proposed value and increases results for value chain partners. There is an interaction between supply and demand; companies need to understand customer demand before they can manage it (creating future demand and, of course, providing the desired level of customer satisfaction). Demand chain management defines supply chain goals, while the supply party supports its capabilities, and shape and maintain the demand (Hosseinzadeh and Mansouri, 2018).

Materials flow management, and information and coordination across the supply chain are done by taking into account three economic, social, and environmental dimensions (Wu et al., 2014). In today's world that the economic growth and development of every country makes its international position, in order to have something to say in the international arena, countries seek to improve their development indicators, thereby in the cycle of improving the economic situation and consequently increasing their effective role to strengthen the economy and play an influential role in the global arena. The car industry as one of the indicators of development has been proposed as one of the major economic institutions (DeGroote and Marx, 2013).

The supply chain is a part of the enterprise that is most affected by changes in such changing and dynamic environments, so that in most cases, the functional constraints of the supply chain are related to its agility, and therefore the supply chain rapidly becomes a limiting factor for the agility of the whole enterprise. In this way, companies can unite with suppliers and customers in order to surpass competitors in global markets and advance operations and activities together and in sync with each other to achieve a level of agility in the supply chain. In this regard, suppliers play an important role in the supply chain, to the extent that the selection of an agile supplier sometimes alone becomes an important and vital issue for the survival of the organization. A supply chain includes a set of activities performed to produce and deliver a product or service from supplier to customer, including planning and managing the supply and demand, procurement of materials, production and scheduling a product or service, warehousing, inventory control and distribution, and delivery and customer service. Supply chain management coordinates all these activities in such a way that customers achieve products with maximum quality and minimum cost (Kazazi et al., 2017).

2. THEORETICAL STRUCTURE

Supply Chain Management

Like any management system and approach, supply chain management needs a performance measurement system to identify success, determine the realization ratio of customers' needs, assist the organization in understanding processes, discover the knowledge that organizations have not been aware of before, and ultimately realize the planned improvements. Performance measurement has had a significant impact on the survival and growth of organizations, in a way that during the past two decades, it has attracted the attention of many researchers and organizations to itself. Parallel with the evolution process of organizations from a single approach to the network approach and supply chain, performance measurement systems have also transformed and moved towards the measurement of network performance and supply chain. In addition, performance evaluation based on reliable data is one of the factors that has been considered necessary for the company to make full use of investment values.

Srivastava (2015) believes that moving towards supply chain stabilization is more value- creating than costly. Accordingly, sustainable supply chain is the connecting ring between the traditional approach and the new approach, taking into account the environmental and social considerations in the business environment.

In the passive view, a kind of additional cost is imposed on the company, while the attitude of managers in the state of value creation is to gain an opportunity to acquire competitive advantage. Another challenge that buyers and suppliers face with, is to select a green supplier, which requires numerous, diverse, yet practical and measurable criteria. The supplier selection process is possible through the proposed process of Van Will (2010) (Rajabzadeh et al., 2017).

Research History

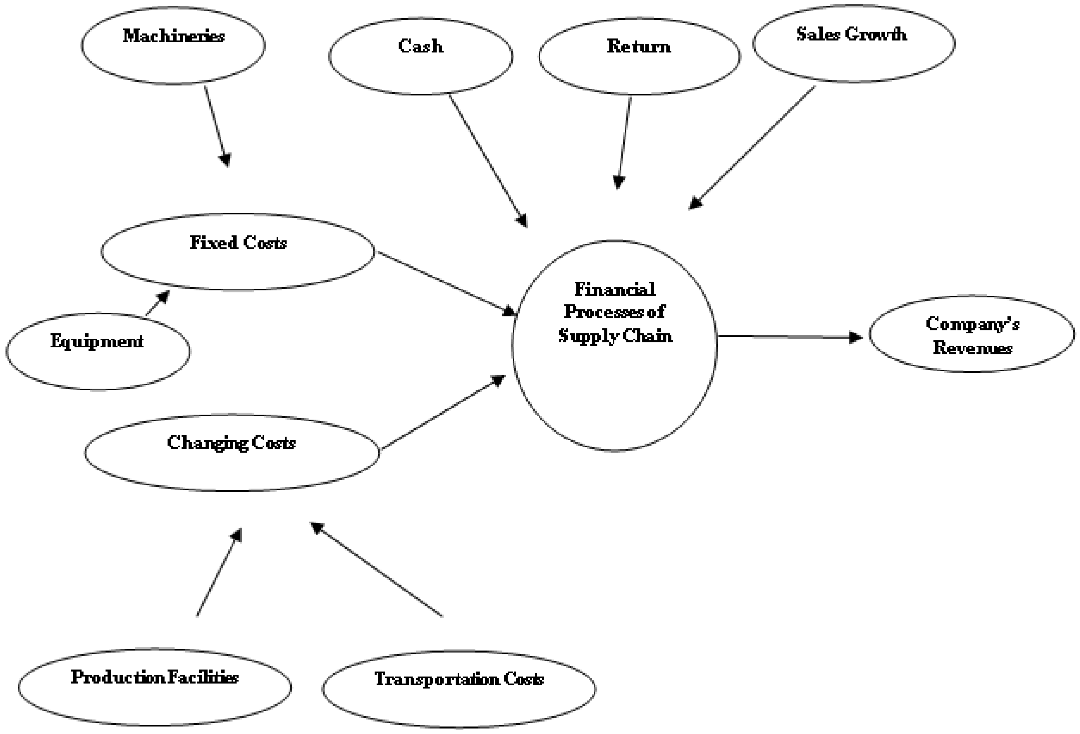
Mathivathanan et al. (2018) examined the supply chain management practices in the Indian car industry. As one of the largest manufacturing sectors, the car industry has a profound impact on society and the environment. The car products transport millions of people and create jobs, but they also create threats to the environment. Sustainable supply chain management practices are special methods that have traditionally been adopted. Supply chain and help changing the industry towards a sustainable supply chain is called sustainable supply chain management. Companies have difficulty to identify the most useful practices and learn how to do these methods. The present study provides a better understanding of the interactions between sustainable supply chain management performances and a specific look at the car industry. The results show that management commitment to sustainability and combining the three-line approach in strategic decision making are the most effective methods to implement sustainable supply chain management. This study provides a basis and foundation for industry managers to understand the interactions between these methods, which increase the likelihood of successful implementation of sustainable supply chain management practices in the car industry.

Tseng et al. (2019) examined a framework for evaluating the performance of sustainable supply chain management under uncertainty. Developing and evaluating the criterion of sustainable service supply chain management performance are currently considered as key challenges. The main contribution of this article is related to two fields. First, this article has provided valuable support and endorsement for sustainable service supply chain management regarding the nature of network hierarchical relationships with quantitative and qualitative scales. Second, it has addressed the practical implementation of this plan and has improved the managerial efficiency of sustainable service supply chain management.

In a research conducted by Zavosh et al. (2009), it was tried to study the product technology management process in the supply chain of an Iranian car manufacturer by benchmarking the best experiences of the world's top car manufacturers, taking into account the special conditions of Iranian suppliers of auto parts, as well as the components of various parts of the environment. For this purpose, Saipa Company was considered as a sample of car manufacturer and Sazeh Gostar Saipa Company was considered responsible for the supply chain development and management. In this regard, by benchmarking a European car manufacturer (Peugeot-Citroen) and its supply chain, as well as the European Foundation for Quality Management (EFQM) organizational excellence model, as well as the lean thinking approach, the existing product technology management process in Sazeh Gostar Saipa Compant was diagnosed and analyzed and by identifying the root causes of existing complications, suggestions for improving the process of product technology management in this company were provided.

Conceptual Model

The variables under investigation in the form of a conceptual model and a description of how to investigate and measure the variables are shown in the following model:



In the presented conceptual model, it is specified that the fixed cost has been divided into two groups of machineries and parts used in factories, which sometimes include depreciation and breakdown costs too, and vehicle storage capacity costs such as warehouse. Additionally, changing costs are divided into sub-sectors such as production facilities and transportation costs, and replacement and transportation of vehicles to storage areas, as well as factories for the production of parts, that affect available resources, including cash, product return and sales ratio, as well as the revenue and profitability decrease or increase obtained from car sales. This cash, return and sales growth are the same as financial processes of the supply chain, and it is completely clear that fixed and changing costs can specify the company's revenue ratio by affecting the financial processes of the supply chain.

Research Statistical Population and Sample

The statistical population of the present research is all countries that have relations and automobile trade with Iran. The number of experts with the mentioned conditions was 40 people, that due to the small number of the statistical population, the number of samples was equal to 40 people that were selected in the form of a census.

Analysis Methods

The method of analysis was presenting an ideal-fuzzy mathematical model. The new model was solved using related software such as: Gomez, MATLAB, and so on, and the answers were discussed and investigated.

Research Optimization Model

- **Hypotheses**

✓ Determined price for suppliers, WS, for materials;

✓ Manufacturer determines the price, WM, to end products (and the t return rate if return policy is used)

✓ Quantity supplied to parts supplier

✓ Number of exhibitions held by manufacturer Q;

- **Used Variables:**

✓ Q: Quantity ordered by exhibitions

✓ R: Produced parts quantity by the supplier

✓ Ws: Agency's price of raw materials determined by the supplier;

✓ Wm: Agency's product price determined by the manufacturer

- **Parameters:**

✓ P: Product end price

✓ S: Parts price in the market

✓ Cm: Producer's manufacturing cost

✓ Cs: Production cost of parts manufacturer

✓ K: Manufacturing parts by the supplier

✓ D: Random variable of non-negative demand

The following hypotheses are also considered:

- Hypothesis 1:

$$p > w_m > c_m + w_s.$$

- Hypothesis 2:

$$w_s > c_s.$$

- Hypothesis 3:

$$c_s < \mu_1 s.$$

Analytical Hierarchy Process

One of the most famous and nearly the most practical techniques of multidisciplinary decision making is the technique of Analytical Hierarchy Process. The basis of this decision-making method lies in paired comparisons and begins by providing a hierarchical tree. The decision hierarchy tree is a multi-level tree whose goal is located at the first level, and the main criteria, sub-criteria, and finally the options are located at next levels. In the present research, this technique has been widely used to select the optimal decision as well as to rank the factors. The stages of this method are: a) Creating a hierarchy tree, b) Paired comparisons, c) Determining the priorities of the factors of each level d) Calculating the compatibility ratio of the comparisons. Here, Expert Choice software has been used to rank the factors affecting participatory learning with the technique of analytical hierarchy process.

$$C.I = \frac{\lambda_{\max} - n}{n-1} \quad (1)$$

CVR index has been used to determine the validity of the questionnaire. To determine the CVR, experts were asked to examine each item based on a three-part spectrum: "necessary", "useful but not necessary" and "not necessary". The answers were then calculated according to the following formula:

CVR = The number of specialists who have selected the “necessary” option minus the total number of specialists divided by 2

The total number of specialists divided by 2

According to the experts, the validity of the questionnaire was obtained equal to CVR = 0.53, which with regard to the number of 30 experts covered the allowable limit of CVI = 0.33, and for this purpose the validity was confirmed.

Reliability

A test has reliability when the observed scores and its actual scores have a high correlation (Khaki, 2015). Factors affecting the reliability and validity:

In the Table 1 the Cronbach's alpha test has been summarized for the raw sample:

Table 1: Cronbach's Alpha Test for Research Items

Variable	Cronbach's Alpha Coefficient
Service Support	**0.77**
Flexibility	**0.74**
Gaining Competitive Advantage	**0.76**
Supplier Market Share	**0.79**
Quality in Transportation	**0.80**
Discount on Cash Received	**0.73**
Timely Delivery	**0.76**
Honesty	**0.77**
Geographical Location	**0.79**
Past Performance	**0.76**

According to the result obtained from the Table above, it is concluded that the design of the thesis items has been appropriate.

Descriptive Analysis of Data

At first, the descriptive information of the respondents' population in terms of marital status, gender (Figure 1), age (Figure 2), level of education (Figure 3), and activity history (Figure 4) was examined.

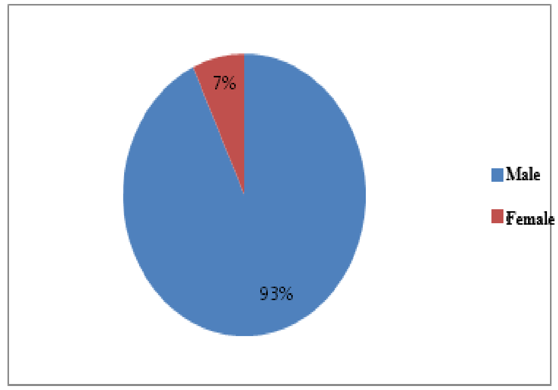


Figure 1: Statistical Sample in Terms of Gender

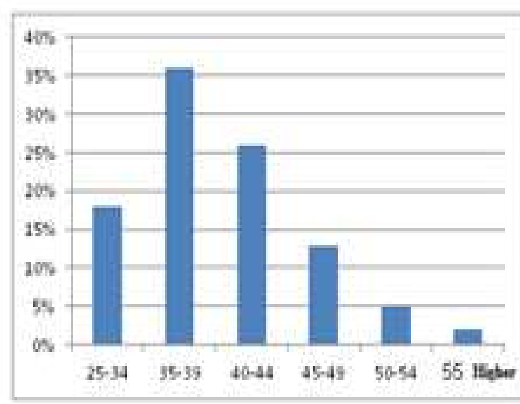


Figure 2: Statistical Sample Characteristics in Terms of Age

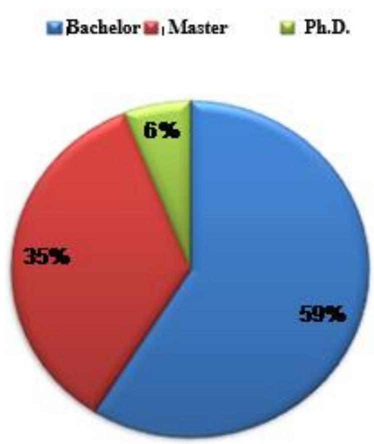


Figure 3: Statistical Sample Education Status

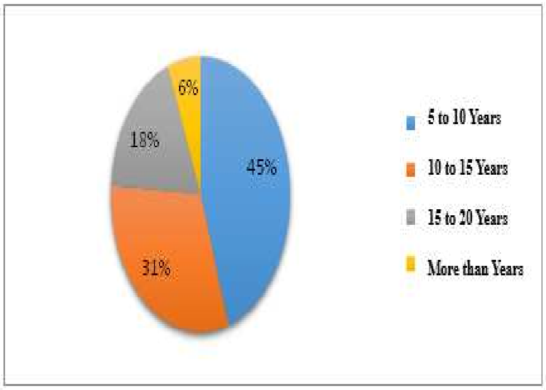


Figure 4: History of Respondents to the Questionnaire

The number of suppliers is 15 whose statistical characteristics have been presented in the Table 2.

Table 2: Factors of Suppliers under Investigation

No	Packaging	Price	Quality	Time	Services
1	1100	950	VP	20	VP
2	100	670	VC	25	VP
3	1010	890	P	5	VC
4	1010	920	G	7	P
5	101	740	M	11	G
6	1100	820	VP	17	M
7	1100	960	VP	12	P
8	101	940	VP	23	G
9	110	710	M	20	M
10	101	670	VC	21	P
11	100	740	VC	18	G
12	1100	750	P	15	VP
13	1100	780	G	16	M
14	1010	740	VP	18	P
15	1100	950	M	20	VP

Each of these suppliers has different characteristics that can be observed in the Table above.

In the Figure 5 the statistical characteristics of suppliers have been presented.

Figure 5: Price

Any supplier who offers a lower price will have priority. Of course, in addition to the price, other factors, such as time, are also considered as Figure 6.

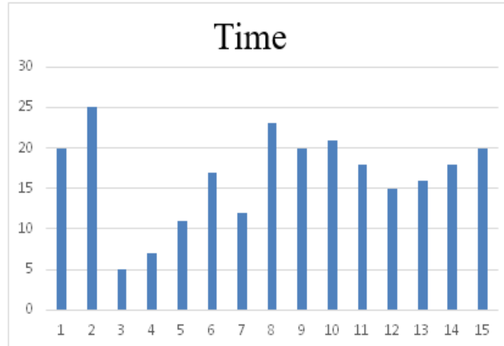


Figure 6: Time

The time of providing services is very different and the shorter the time is, the more are the required points to be selected. The third supplier has the lowest and the second supplier has the highest time.

Inferential Statistics

Each expert was asked to answer 2 of the following questions for each of the 20 potential factors:

What are the criteria for selecting suppliers in the car supply chain?

What is the car supply chain scenario to meet your needs (products/services)?

What are the factors for the supplier(s) selection process in the supply chain?

What is the relationship between the desired factors?

Regarding the second question, based on the importance of each factor from the factors affecting the selection of supplier, scores from 1 to 9 (very low to very high) are assigned.

Table 3: Experts' Opinion Regarding the Importance Ratio of Each One of the Criteria

No.	Name	Mean of Scores Obtained	P-Value	Result
1.	Service Support	4.60	0.000	Confirmed
2.	Flexibility	5.57	0.000	Confirmed
3.	Gaining Competitive Advantage	4.29	0.000	Confirmed
4.	Supplier Market Share	4.42	0.000	Confirmed
5.	Quality in Transportation	6.72	0.000	Confirmed
6.	Discount on Cash Received	3.43	0.001	Confirmed
7.	Timely Delivery	5.41	0.000	Confirmed
8.	Honesty	4.21	0.000	Confirmed
9.	Geographical Location	4.88	0.000	Confirmed
10.	Past Performance	4.72	0.000	Confirmed

Identifying and Determining the Importance of Evaluation Criteria

In this step, the importance of evaluation criteria of the factors affecting the selection of suppliers was identified and then determined. For this purpose, in the first step, by interviewing the experts and summarizing their opinions, 5 criteria were identified as criteria for evaluating the factors affecting the selection of supplier in Table 4.

Table 4: Evaluation Criteria of the Factors Affecting Supplier Selection

No.	Criterion
1.	The Ratio of Impact on Car Production Time
2.	The Ratio of Impact on Car Production Costs
3.	The Ratio of Impact on the Quality of Car Production
4.	The Ratio of Impact on Car Production Risk
5.	The Ratio of Impact on the Scope of Car Production

Then, by designing a paired comparisons questionnaire, experts were asked to specify their idea regarding the importance of each of these criteria according to the range presented in Table 5.

Table 5: Linguistic Variables and Corresponding Numbers to Determine Relative Importance

Linguistic Variables	Equally Important	A Little More Important	More Important	Much More Important	Absolutely Important
Corresponding Numbers	1	3	5	7	9

Thus, each of the 40 experts expressed their views regarding the relative importance of the criteria influencing the evaluation of the factors affecting the failure of car production. For example, Table 6 shows the opinion of one of these experts.

Table 6: Opinion of One of the Experts Regarding the Relative Importance of the Criterion

	The Ratio of Impact on Time	The Ratio of Impact on Costs	The Ratio of Impact on Quality	The Ratio of Impact on Risk	The Ratio of Impact on Scope
The Ratio of Impact on Time		1	1	7	3
The Ratio of Impact on Costs			5	1	3
The Ratio of Impact on Quality				1	1
The Ratio of Impact on Risk					3
The Ratio of Impact on Scope					

After receiving the opinions of all experts, the questionnaires were analyzed using Expert Choice software. Figure 1 shows the output of this software.

As it is observed, the inconsistency rate of the questionnaires is equal to 0.02, which is an acceptable number considering the number of experts (40).

In the following Table 7 the factors affecting supplier selection using Expert Choice have been summarized.

Table 7: Ranking by AHP for Factors Affecting Supplier Selection

Item	Rank	Weigth
Supplier Market Share	First	37.5
Service Support	Sixth	8.3
Quality of Transportation	Seventh	7.5
Flexibility	Eighth	6.25
Discount on Cash Received	Second	31.2
Gaining Competitive Advantage	Fifth	14
Geographical Location	Tenth	5.12
Past Performance	Third	23.3
Timely Delivery	Fourth	17.5
Honesty	Ninth	5.23

Moreover, the output of Expert Choice software for ranking has been presented in the following diagram as Figure 7:

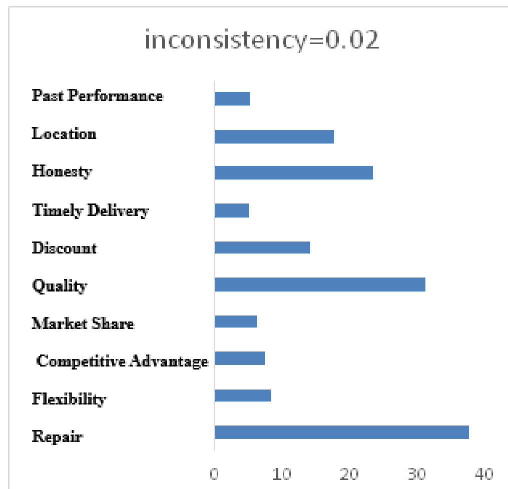


Figure 7: Software Output

Mathematical Optimization

Based on the company's commitment to deliver the products, the mean vector and the variance matrix of the covariance of 6 possible routes, when the process is under control, are as the following form:

$$\Sigma = \begin{bmatrix} 2.98 & 2.52 & 1.63 & 4.45 & 3.88 & 2.72 \\ & 2.37 & 4.18 & 3.73 & 1.85 & 2.31 \\ & & 2.13 & 3.38 & 2.68 & 1.98 \\ & & & 2.10 & 2.15 & 3.41 \\ & & & & 1.72 & 4.06 \\ & & & & & 2.21 \end{bmatrix}$$

$$\mu_0 = \begin{bmatrix} 17 \\ 17 \\ 16 \\ 16 \\ 16 \\ 15 \end{bmatrix} \qquad (2)$$

The goal is to control all delivery routes at the same time. In the classic scheme of sampling in the Hotelling's T2 control diagram, random samples of n size are always collected from the process and their mean ($\vec{\bar{x}}$) are calculated consecutively every h time per hour. Statistical values $T^2 = n(\vec{\bar{x}} - \vec{\mu}_0)' \Sigma^{-1} (\vec{\bar{x}} - \vec{\mu}_0)$ are then plotted on a diagram with a high control (k) limit. As long as the statistical value is lower than the high control limit, the process is called under control. If it is T^2 > k for a subgroup, the process is assumed to be out of control and a search is initiated to discover and identify the cause of the deviation in the process. In general, in the T2 control diagram it is assumed that the correlation structure of qualitative characteristics does not have changes and that the process operates only due to reasons that cause a change in the mean process vector. The value of this shift is usually measured on the Mahalabonis scale and is shown by a $d = \sqrt{(\mu - \mu_0)' \Sigma^{-1} (\mu - \mu_0)}$ symbol that μ indicates the next p vector of the mean of the qualitative indicators in the out-of-control state. In this article, since the mean vector and the variance matrix of the delivery chain process covariance are known (estimated by a large number of preliminary samples), the Hotelling's T2 statistic has a Chi-square distribution with p = 6 degrees of freedom, and therefore a high control limit for the diagram can be considered the percentile of (α* 100) a high percentage of Chi-square distribution $k = \chi^2_\alpha(p)$. If the process is out of control, the diagram statistic has a decentralized Chi-square distribution with p = 6 of the degree of freedom and the decentralized parameter is equal to $\eta = nd^2$.

Faraz and Parsiyan (2006) designed a multivariate control statistical diagram of Hotelling's T2 with DWL sampling design and in a comparison showed that the mentioned design has much better statistical and economic advantages compared to the classical design. In a way, this design improves almost three times the ability of the classic design to identify small to medium changes in the process, and at the same time brings significant economic savings to user organizations. On the other hand, the DWL design is always a better option than the classic design, even for identifying medium to large changes, except for very large changes (shifts greater than 3) in the mean process.

This design uses two sample sizes of n_1 and n_2, and two sampling time intervals of h_1 and h_2 along with two warning lines of w_n and w_h which determine the change in sample size and time interval between subgroups, respectively. The work basis of this diagram is based on determining the sample size and sampling time interval of the i-th subgroup based on the T^2_{i-1} statistical value. The DWL T^2 control diagram is when w_n, defined w_h < as follows:

$$(h_i, n_i) = \begin{cases} (h_2, n_2) & \text{if } w_n \le T^2_{i-1} < UCL \\ (h_2, n_1) & \text{if } w_h \le T^2_{i-1} < w_n \\ (h_1, n_1) & \text{if } 0 \le T^2_{i-1} < w_h \end{cases} \quad (3)$$

Figure 8 is an example of a DWL T^2 control diagram. In this regard, in each time of the process sampling one of the following cases always occurs:

- ✓ State 1: $0 \le T^2 < w_h$ and the process is under control.
- ✓ State 2: $w_h \le T^2 < w_n$ and the process is under control.
- ✓ State 3: $w_n \le T^2 < k$ and the process is under control.
- ✓ State 4: $T^2 \ge k$ and the process is under control.
- ✓ State 5: $0 \le T^2 < w_h$ and the process is out of control.
- ✓ State 6: $w_h \le T^2 < w_n$ and the process is out of control.
- ✓ State 7: $w_n \le T^2 < k$ and the process is out of control.
- ✓ State 8: $T^2 \ge k$ and the process is out of control.

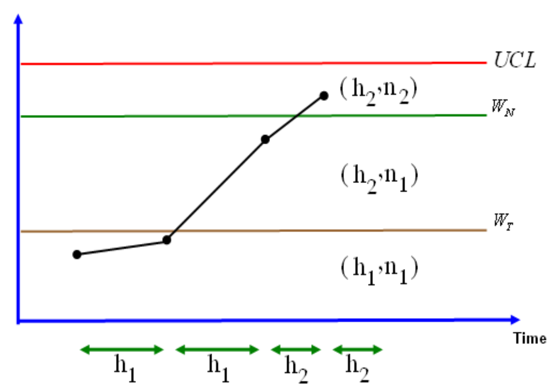


Figure 8: DWL T2 Multivariate Control Diagram

When the $T^2 \ge k$ control diagram declares a warning indicating that the process is out of control, the search is investigated to find specific causes and eliminate them. If the process is under control, this warning is a false alarm (state 4). Having observed a real warning (rather than a false alarm), since the process of sampling from the process and drawing points on the control diagram stops as monitoring, therefore, state 8 can be called the absorbing state in Markov chains. The basic concepts of Markov chains used in this section can be found in Cenlar (1975). Now, assuming an exponential distribution of the time duration of the occurrence of changes in the mean of the process with the mean of $\frac{1}{\lambda}$, for a Markov chain with the above transient state, the probability matrix of the temporal state change is as follows:

$$\mathbf{P}=\begin{bmatrix} p_{11} & p_{12} & p_{13} & p_{14} & p_{15} & p_{16} & p_{17} & p_{18} \\ p_{21} & p_{22} & p_{23} & p_{24} & p_{25} & p_{26} & p_{27} & p_{28} \\ p_{31} & p_{32} & p_{33} & p_{34} & p_{35} & p_{36} & p_{37} & p_{38} \\ p_{41} & p_{42} & p_{43} & p_{44} & p_{45} & p_{46} & p_{47} & p_{48} \\ 0 & 0 & 0 & 0 & p_{55} & p_{56} & p_{57} & p_{58} \\ 0 & 0 & 0 & 0 & p_{65} & p_{66} & p_{67} & p_{68} \\ 0 & 0 & 0 & 0 & p_{75} & p_{76} & p_{77} & p_{78} \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix} \quad (4)$$

In which p_{ij} indicates the conditional probability of changing the status from the current state of j on the previous state of i. We also have $\eta_1 = n_1 d^2$, $\eta_2 = n_2 d^2$ and in addition, the symbol $F(x, p, \eta)$ represents the cumulative distribution function of the Chi-square at the point x with p degree of freedom and with the decentralized parameter of η. Now we have:

$$p_{11} = p_{21} = \Pr(0 \le T^2 < w_n) \times e^{-\lambda h_1} = F(w_n, p, \eta = 0) \times e^{-\lambda h_1}$$
$$p_{12} = p_{22} = \Pr(w_n \le T^2 < w_h) \times e^{-\lambda h_1} = \left[F(w_h, p, \eta = 0) - F(w_n, p, \eta = 0)\right] \times e^{-\lambda h_1}$$
$$p_{13} = p_{23} = \Pr(w_h \le T^2 < k) \times e^{-\lambda h_1} = \left[F(k, p, \eta = 0) - F(w_h, p, \eta = 0)\right] \times e^{-\lambda h_1}$$
$$p_{14} = p_{24} = \Pr(T^2 \ge k) \times e^{-\lambda h_1} = \left[1 - F(k, p, \eta = 0)\right] \times e^{-\lambda h_1}$$
$$p_{15} = \Pr(0 \le T^2 < w_n) \times (1 - e^{-\lambda h_1}) = F(w_n, p, \eta = n_1 d^2) \times (1 - e^{-\lambda h_1})$$
$$p_{16} = \Pr(w_n \le T^2 < w_h) \times (1 - e^{-\lambda h_1}) = \left[F(w_h, p, \eta = n_1 d^2) - F(w_n, p, \eta = n_1 d^2)\right] \times (1 - e^{-\lambda h_1})$$
$$p_{17} = \Pr(w_h \le T^2 < k) \times (1 - e^{-\lambda h_1}) = \left[F(k, p, \eta = n_1 d^2) - F(w_h, p, \eta = n_1 d^2)\right] \times (1 - e^{-\lambda h_1})$$
$$p_{18} = \Pr(T^2 \ge k) \times (1 - e^{-\lambda h_1}) = \left[1 - F(k, p, \eta = n_1 d^2)\right] \times (1 - e^{-\lambda h_1})$$
$$p_{25} = \Pr(0 \le T^2 < w_n) \times (1 - e^{-\lambda h_1}) = F(w_n, p, \eta = n_2 d^2) \times (1 - e^{-\lambda h_1})$$
$$p_{26} = \Pr(w_n \le T^2 < w_h) \times (1 - e^{-\lambda h_1}) = \left[F(w_h, p, \eta = n_2 d^2) - F(w_n, p, \eta = n_2 d^2)\right] \times (1 - e^{-\lambda h_1})$$
$$p_{27} = \Pr(w_h \le T^2 < k) \times (1 - e^{-\lambda h_1}) = \left[F(k, p, \eta = n_2 d^2) - F(w_h, p, \eta = n_2 d^2)\right] \times (1 - e^{-\lambda h_1})$$
$$p_{28} = \Pr(T^2 \ge k) \times (1 - e^{-\lambda h_1}) = \left[1 - F(k, p, \eta = n_2 d^2)\right] \times (1 - e^{-\lambda h_1})$$
$$p_{31} = p_{41} = \Pr(0 \le T^2 < w_n) \times e^{-\lambda h_2} = F(w_n, p, \eta = 0) \times e^{-\lambda h_2}$$
$$p_{32} = p_{42} = \Pr(w_n \le T^2 < w_h) \times e^{-\lambda h_2} = \left[F(w_h, p, \eta = 0) - F(w_n, p, \eta = 0)\right] \times e^{-\lambda h_2}$$
$$p_{33} = p_{43} = \Pr(w_h \le T^2 < k) \times e^{-\lambda h_2} = \left[F(k, p, \eta = 0) - F(w_h, p, \eta = 0)\right] \times e^{-\lambda h_2}$$
$$p_{34} = p_{44} = \Pr(T^2 \ge k) \times e^{-\lambda h_2} = \left[1 - F(k, p, \eta = 0)\right] \times e^{-\lambda h_2}$$
$$p_{35} = p_{45} = \Pr(0 \le T^2 < w_n) \times (1 - e^{-\lambda h_2}) = F(w_n, p, \eta = n_2 d^2) \times (1 - e^{-\lambda h_2})$$
$$p_{36} = p_{46} = \Pr(w_n \le T^2 < w_h) \times (1 - e^{-\lambda h_2}) = \left[F(w_h, p, \eta = n_2 d^2) - F(w_n, p, \eta = n_2 d^2)\right] \times (1 - e^{-\lambda h_2})$$
$$p_{37} = p_{47} = \Pr(w_h \le T^2 < k) \times (1 - e^{-\lambda h_2}) = \left[F(k, p, \eta = n_2 d^2) - F(w_h, p, \eta = n_2 d^2)\right] \times (1 - e^{-\lambda h_2})$$
$$p_{38} = p_{48} = \Pr(T^2 \ge k) \times (1 - e^{-\lambda h_2}) = \left[1 - F(k, p, \eta = n_2 d^2)\right] \times (1 - e^{-\lambda h_2})$$
$$p_{55} = \Pr(0 \le T^2 < w_n) = F(w_n, p, \eta = n_1 d^2)$$
$$p_{56} = \Pr(w_n \le T^2 < w_h) = F(w_h, p, \eta = n_1 d^2) - F(w_n, p, \eta = n_1 d^2)$$
$$p_{57} = \Pr(w_h \le T^2 < k) = F(k, p, \eta = n_1 d^2) - F(w_h, p, \eta = n_1 d^2)$$
$$p_{58} = \Pr(T^2 \ge k) = 1 - F(k, p, \eta = n_1 d^2)$$
$$p_{65} = p_{75} = \Pr(0 \le T^2 < w_n) = F(w_n, p, \eta = n_2 d^2)$$
$$p_{66} = p_{76} = \Pr(w_n \le T^2 < w_h) = F(w_h, p, \eta = n_2 d^2) - F(w_n, p, \eta = n_2 d^2)$$
$$p_{67} = p_{77} = \Pr(w_h \le T^2 < k) = F(k, p, \eta = n_2 d^2) - F(w_h, p, \eta = n_2 d^2)$$
$$p_{68} = p_{78} = \Pr(T^2 \ge k) = 1 - F(k, p, \eta = n_2 d^2)$$

According to the properties of Markov chain, the mathematical expectation of the time duration required from the beginning of the process to reach the adsorbing state is obtained from the following form:

$$ATC = \mathbf{b}'(\mathbf{I}-\mathbf{Q})^{-1}\mathbf{h} \quad (5)$$

In which Q is the same as the position change matrix of P in which the row and column related to the adsorbing state have been eliminated, and the $\mathbf{b}' = (0,\ 0,\ 1,\ 0,\ 0,\ 0,\ 0)$ vector represents the initial probabilities and the I is a single matrix of degree seven and $\mathbf{h}' = (h_1,\ h_2,\ h_2,\ h_2,\ h_1,\ h_2,\ h_2)$ is the vector of the sampling time intervals. Furthermore, the average time required from the occurrence of the shift to receive a warning from the control diagram (AATS) is defined as follows:

$$AATS = ATC - \frac{1}{\lambda} \quad (6)$$

In addition, to calculate the average number of false alarms (ANF), the average number of process sampling (ANS) and the average of samples collected from the process (ANI), according to the preliminary properties of the Markov chain can be written as:

$$ANF = \mathbf{b}'(\mathbf{I}-\mathbf{Q})^{-1}(0,\ 0,\ 0,\ 1,\ 0,\ 0,\ 0)' \quad (7)$$

$$ANS = \mathbf{b}'(\mathbf{I}-\mathbf{Q})^{-1}(1,\ 1,\ 1,\ 1,\ 1,\ 1,\ 1)' \quad (8)$$

$$ANI = \mathbf{b}'(\mathbf{I}-\mathbf{Q})^{-1}(n_1,\ n_1,\ n_2,\ n_2,\ n_1,\ n_1,\ n_2)' \quad (9)$$

The Average Time of a Qualitative Cycle

According to the DWL model, the average time of each qualitative cycle is in the form of the total result of the following times:

- The average time spent from the start of the process to its identification and discovery, which is expressed in the form of the ATC Markov concept
- The average time spent for interpreting the results of a subgroup that has declared an out-of-control warning, shown as E
- The average time spent for searching, discovering and finding specific causes of deviations shown by the T_1 symbol
- The average time spent for eliminating the specific causes and repair the process shown by the T_2 symbol.

Therefore, the average time of each qualitative cycle can be calculated as follows:

$$E(T) = ATC + \bar{n}E + T_1 + T_2 = 1/\lambda + AATS + \bar{n}E + T_1 + T_2 \quad (10)$$

In which

$$\bar{n} = n_1(p_{18} + p_{28} + p_{58} + p_{68}) + n_2(p_{38} + p_{48} + p_{78})$$

and indicates the average sample size of a subgroup that has declared an out-of-control warning.

Genetic Algorithm and Economic Design of DWL T2 Control Diagram

The purpose of economically and statistically optimal designing of the DWL T2 control diagram for monitoring the delivery process is to find the values of the control diagram parameters in a way that minimizes the expected cost per hour of the delivery process and at the same time has a low error type of I, and a desirable level. Actually:

$$\begin{aligned} &\min E(A) \\ &s.t: \\ &\alpha \le 0.005 \\ &k > 0 \\ &0 < w_h < w_n < k \\ &1 \le n_1 < n_2 \\ &0.1 \le h_2 \le h_1 \le 8 \\ &n_1\ , n_2 \in Z^+ \end{aligned} \quad (11)$$

The above optimization problem has discrete and continuous decision variables and a non-convex response space. Therefore, it is not possible to solve this model using classical benchmarking methods. Genetic algorithm is a meta-initiative search method introduced by Holland in 1975. The genetic algorithm for optimizing the objective function does not require mathematical and complex analysis of the desired function and is widely used in many fields of optimization. In fact, the goal of the genetic algorithm is to achieve a general rather than a local optimum, without complicating the response space. In fact, the genetic algorithm starts from a small set of possible responses (population) in a parallel process to generate a new generation or new population. This repetitive process is derived from the genetic issues of the evolution of organisms and generates the new generation like the survival process completely randomly from the present generation.

In general, the genetic algorithm has the following key parameters:

- Population
- Selection Strategy
- Mating Operator
- Mutation Operator
- Elitism Operator

Integrated Criterion

The advancement of enterprise services computerization for the customer has created a new challenge; how to control all major business processes through on-line software design is an integrated solution known as enterprise resources planning of the process of managing all resources and using them in the whole set with a coordinated behavior; this process includes planning and managing the use of all resources of the enterprise and its main goal is to integrate all parts, resources and duties of a company in a single information system that can meet all the needs of the enterprise. To create performance criterion, we analyze the integrated supply chain problem for the first time. Integrated supply chain is expected to be PT benefit.

$$\Pi_T = E[p\min(Q,D) - s[Q-\varepsilon R]^+ - c_s R - c_m Q] = p\left[\int_0^Q xf(x)dx + \int_Q^{+\infty} Qf(x)dx\right] - s\int_A^{Q/R}(Q-yR)g(y)dy - c_s R - c_m Q = pS(Q) - s\int_A^{Q/R}(Q-yR)g(y)dy - c_s R - c_m Q \quad (12)$$

..., where the per capita revenue of total revenue obtained from sales of the third fourth quarter for the production of material and consumption products and resistance to purchase raw materials from this market is available in the market.

Optimal Supply Chain Profit

Decentralized Structure

In this structure, each member alone decides to increase its profit. Stackelberg game has been intended that provides the leader. The supplier first decides about the agency price and then the manufacturer decides about the sales price and the sustainability level. The manufacturer's profit function with the agency price w is as follows:

$$\Pi_M(s,p) = pD(s,p) - wD(s,p) - c_e\left[(a-bs)D(s,p) - K\right] - \frac{1}{2}C_l S^2 \quad (13)$$

In the above function, the first sentence is the total revenue obtained from sales and the second sentence is the total cost of ordering raw materials from the supplier. The third sentence is the cost of purchasing additional published carbon rights and the last sentence is the cost of investment for sustainability.

In make-to-order settings, the supplier's sales quantity is equal to the manufacturer's order. The supplier's revenue function is as follows:

$$\Pi_S(w) = (w - c_m)D(s,p) \quad (14)$$

By regarding the first derivative of the producer's profit function relative to the variables zero, the optimal quantities of the sustainability level and the sales price are obtained. Additionally, by regarding the first derivative of the supplier's profit function zero, the optimal quantity of the agency price is obtained.

The total profit of the supply chain in a decentralized structure is as follows:

$$\Pi^*_d(s^*_d, p^*_d) = \Pi^*_M(s^*_d, p^*_d) + \Pi^*_s(w^*_d) = \frac{3c_l(D_0 - \beta c_m - c_0\alpha\beta)^2}{8\lambda_2} + c_e K \quad (15)$$

Centralized Structure

In this structure, producers and suppliers cooperating with each other decide about the sales price and the sustainability level to increase the profit of the entire supply chain. The profit function of the whole chain is as follows:

$$\Pi_C(s,p) = pD(s,p) - c_m D(s,p) - c_e\left[(a-bs)D(s,p) - K\right] - \frac{1}{2}C_l S^2 \quad (16)$$

In the above equation, the first sentence is the revenue obtained from sales, the second sentence is order costs, the third sentence is the cost of purchasing additional published carbon rights, and the last sentence is the cost of investment for sustainability. There are optimal quantities of sustainability level and sales price that maximize the profit function.

The optimal supply chain profit function in the centralized structure is located in the following range:

$$\Pi^*_d(s^*_d, p^*_d) \le \Pi^*_C(s^*_c, p^*_c) \le \frac{4}{3}\Pi^*_d(s^*_d, p^*_d) \quad (17)$$

As a result, the lowest supply chain profit is in the decentralized structure and the highest profit is in the centralized or coordinated state. The difference between the minimum and maximum profit is 1.3. Demand in the centralized structure is twice that of in the decentralized structure; the supplier expects the producer to increase the order ratio so that his profit increases.

We have the optimal supply chain profit:

$$\Pi^c_T = p\int_0^{Q^c} xf(x)dx \quad (18)$$

The Problem of Exhibitions in the Supply Chain:

The problem of exhibitions is presented by the following equation:

$$\Pi_r = E[p\min(Q,D) - w_m Q] = pS(Q) - w_m Q \quad (19)$$

Problem of Parts Suppliers in the Supply Chain:

The problem of parts supplier is expressed by the following equation:

$$\Pi_s = E[w_s Q - c_s R - s[Q-\varepsilon R]^+] = w_s Q - c_s R - s\int_A^{Q/R}(Q-yR)g(y)dy \quad (20)$$

Finally, after numerical analysis of the mathematical models presented above, the following diagrams as Figures 9 to 14 have been presented:

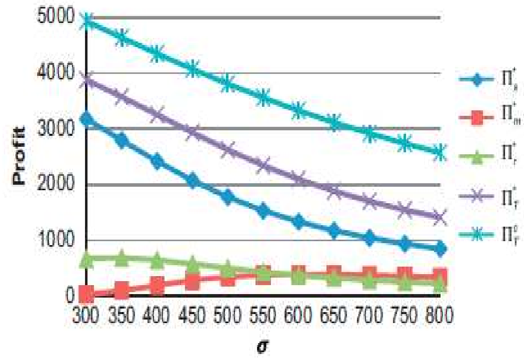


Figure 9: The Impact of Demand Uncertainty on Profitability

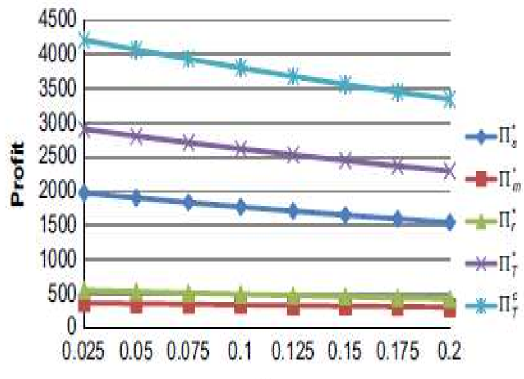


Figure 10: The Impact of Supply Uncertainty on Profitability

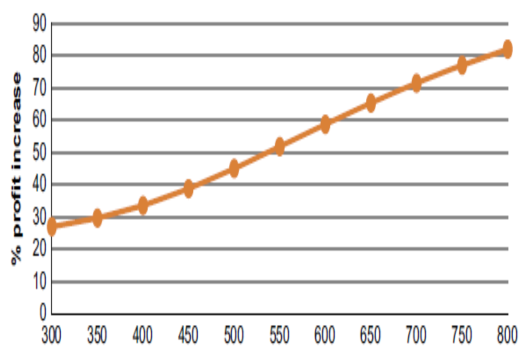


Figure 11: The Impact of Demand Uncertainty on Coordination Efficiency

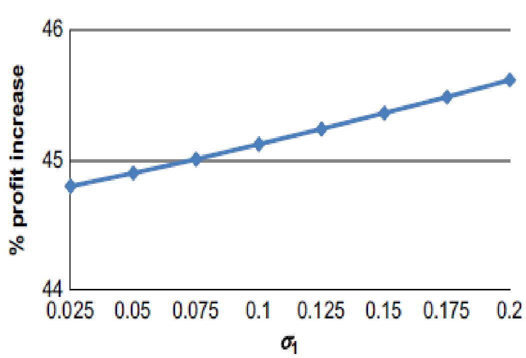


Figure 12: The Impact of Supply Uncertainty on Coordination Efficiency

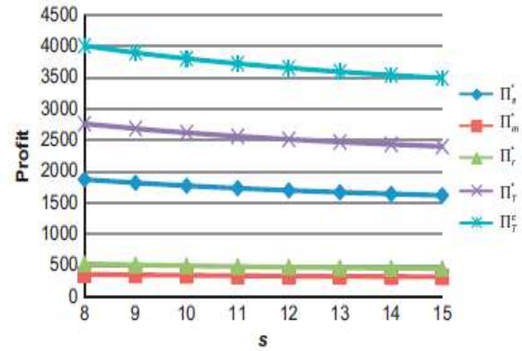


Figure 13: The Impact of Market Price Spot on Profit

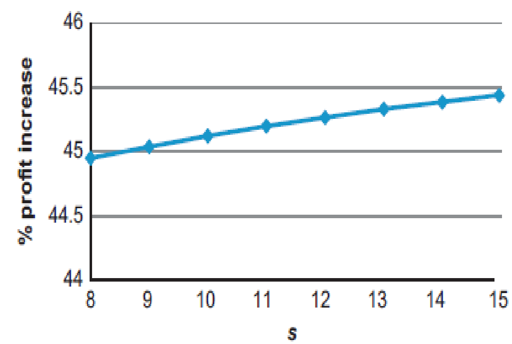


Figure 14: The Impact of Market Price on Coordination Efficiency

In the diagram above the impact of price on coordination efficiency has been presented, in which, it is specified that there is a direct and significant relationship between price and coordination efficiency.

3. CONCLUSION

Basically, the issue of supplier selection includes the following two types:

- Selecting a supplier when there are no restrictions. In other words, all suppliers can meet the buyer's needs in demand, quality, delivery time, and so on.
- Selecting a supplier when suppliers have a number of constraints in capacity, price, and so on. In other words, there is no supplier who can meet all the needs of the buyer, and the buyer needs to buy some of his demands from one supplier and meet his remaining demands from other suppliers.

In this research, it has been firstly tried to level the factors affecting the agile supplier using the interpretive structure model, and then in the framework of a diagram the propulsive and dependence power has been presented. The results of this process help suppliers to be able to select a more appropriate route to increase the level of their speed, accuracy and competitive ability. A research has been conducted by Canan in 2009 that is relatively similar to this research, but the obtained results are different from each other, and in the next level cost reduction factor is located. By looking at the classification of speed and accuracy variables, it can be found out that the variables of delivery time and reduction of delay time have a lot of propulsive power, while the variables of customer satisfaction and information accuracy have a minimum dependence and propulsive power. In addition, the variables located in the linker category have both high propulsive power and high dependency ratio. To increase the level of speed and accuracy of suppliers by developing these variables, their dependence ratio should be considered. So, with a slight increase in one of these variables, a change in the speed and accuracy of the supplier can never be observed.

Then, using the mathematical planning model, the relationship between the performance efficiency of the supply chain and its suppliers and the price was investigated. In this model, the assumptions include price determined for suppliers, producer's price, quantity of parts supplied for supplier, number of exhibitions, and the raw materials of the manufacturer's parts. The research variables include the quantity ordered by the exhibitions, the quantity of parts produced by the supplier, the agency's price of the raw materials determined by the supplier and the agency's price of the product determined by the manufacturer. The research parameters were determined as end product price, price of parts in the market, producer's manufacturing cost, production cost of parts manufacturer, production of parts from supplier, non-negative demand random variable and the model was designed based on objective function and model constraints. In this regard, according to the criterion of customer and supplier integration, the optimal profit of the supply chain was analyzed in two parts: decentralized structure and centralized structure, which was analyzed with the cooperation of customer and supplier and the leadership of one on another, thus the agency's price and the supplier's major price were expressed as other supply pricing models with similar equations. For this purpose, with the analysis and outputs presented to investigate the problem of exhibitions, the supplier's problem and the manufacturer's problem were analyzed according to the input data, which finally after numerical analysis of the results, it was indicated that there is a direct and significant relationship between price and coordination efficiency.

Research Suggestions

Organizations can use the above method to select their supplier and focus on strong driver variables that have been used and extracted to solve the desired problem to increase the performance, speed and accuracy of suppliers.

- ✓ Selection of suppliers modeled by artificial intelligence in future researches
- ✓ Introducing new and meta-innovative methods for solving models with verbal variables
- ✓ Applying the model presented in other industries and sectors to access the actual output in the case study.

REFERENCES

1. Cinlar, E., (1975). *Introduction to Stochastic Processes*. Englewood Cliffs, N.J.: Prentice-Hall publication, United States
2. DeGroote, S. E., & Marx, T. G. (2013). The impact of IT on supply chain agility and firm performance: an empirical investigation. *International Journal of Information Management, 33*(6), 909-916.
3. Faraz, A. & Parsian, A., (2006), Hotelling's T2 Control chart with Double Warning Lines. *Journal of Statistical Papers, 47*(4)
4. Hosseinzadeh Shahri, M., & Mansouri, F. (2018), Development of Demand Chain Management Model in Insurance Industry, Using Causal Mapping Method, *Journal of Management Researches in Iran, 18* (3)
5. Kannan, G., Pokharel, S., & Kumar, P. S. (2009). A hybrid approach using ISM and fuzzy TOPSIS for the selection of reverse logistics provider. *Resources, conservation and recycling, 54*(1), 28-36.
6. Kazazi, A., & Sohrabi, R. (2017), Presenting the Components and Indicators of Assessing the Supply Chain Agility of the National Iranian Oil Company, *Transformation Management Research Paper, 2*(4).
7. Khaki, Gh., (2015), Research method with dissertation approach. Fouzhan publication, 3rd edition, Tehran, Iran.
8. Mathivathanan, D., Kannan, D., & Haq, A. N. (2018). Sustainable supply chain management practices in Indian automotive industry: A multi-stakeholder view. Resources, *Conservation and Recycling*, 128, 284-305.
9. Rajabzadeh, A., Khadivar, A., & Kazemi, A., (2017), Investigating the Effect of Supply Chain Model on Improving the Quality of Services Provided to the Customers and Compiling Main Components, *Quarterly Journal of Business Research Paper*, No. 43.
10. Srivastava S.K. (2015) Green supply-chain management: a state-of-the-art literature review, *International Journal of Management Reviews, 9*(1), 53-80.
11. Tseng, M. L., Lim, M. K., Wong, W. P., Chen, Y. C., & Zhan, Y. (2019). A framework for evaluating the performance of sustainable service supply chain management under uncertainty. *International Journal of Production Economics*, 195, 359-372.
12. Wu, H. Y., Lin, Y. K. & C. H. Chang (2014), Performance Evaluation of Extension Education Centers in Universities Based on the Balanced Scorecard, *Evaluation and Program Planning, 34*: 37-50.
13. Zavosh, Gh., Adineh, A. & Sheikhzadeh, M. (2009), Study of product technology management for the supply chain. The first national conference of local content on internal power development, Tehran, Iran.