Investigating the Effect of Timely Delivery of Raw Materials on Supply Chain Using System Dynamics (Case Study of Sesame Industries in Yazd Province)

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***Abstract*:** *In recent years, one of the most important issues in the country's industries is supply chain discussions. On the other hand, one of the factors affecting the supply chain is the impact of the risks on this issue. Therefore, the present study aims to investigate the effect of the timely delivery of raw materials on the whole supply chain performance of the food industry, especially the sesame industries of Yazd province. Reviewing other researches and using the experts' opinions in the food industry, the supply chain risks of food industry were identified and a questionnaire was developed to collect experts' opinions about this risk. Then, using the DEMATEL technique, the collected data was analyzed and the severity of the risk effect was determined. In the next step, the dynamic model of the supply chain of Sesame Industries in Yazd province was developed to identify and evaluate the process and also to recognize the factors affecting it, considering the identified risk factors. One of the other methods used in this research is simulating in VENSIM software, which uses dynamic system tools and software to identify the main variables and their relationships. The results show that this network is heavily influenced by this risk and the change (increase or decrease) in its severity changes the whole network altogether. Hence, due to the sensitivity of this chain, not controlling the risk of timely receipt of raw materials or their non-removal could cause irreparable damage to the sesame industry supply chain.*

Keywords: *supply chain, risk, DEMATEL, system dynamics, timely delivery of raw materials.*

1. Introduction

Given the importance and role of risk in supply chain performance, and in particular the food supply chain, due to its high sensitivity, the need to identify risks and manage them to mitigate the effects of them and, if possible, eliminate some of these risks is clear. On the other hand, supply chain risk management is possible when people involved in different parts of the food supply chain have an accurate and transparent understanding of the risks involved and affecting the various sectors of the chain [12].

2. Literature review

This section offers a brief discussion of terms to enhance understanding of these specific terms.

2.1. Risk

There are several definitions of risk and risk management. For example, the British Standardization Institute defines the risk the possibility or likelihood of a certain risk occurring [11].

The risk in an organization is the likelihood that a particular threat could create a particular vulnerability. Different firms experience different risks. It should be kept in mind that risk factors in different countries can be fundamentally different [2]. The origin of the supply chain risk is unpredictable variables within an organization, network, or environment. These risks are due to uncertainty in future risk events that can occur at any time in the

supply chain [15]. In a complex supply chain network, there is a compulsory need to examine the flexibility and uncertainty for reducing risks. It creates virtual capacity flexibility and is one of the most effective factors to reduce the supply chain risks [15]. Some types of related risks in the industry are:

Economic risk, environmental risk, geographical risk, socio-cultural risk, organizational risk (production, technical, qualitative), transport and logistics risks, and political risk

Of course, the present study attempts to determine the effects of organizational risk (production, technical, qualitative) on the supply chain.

2.2. Organizational risk (production, technical, qualitative)

The risks associated with the technical / technological capability, raw materials, quality and timing of them affects the supply chain performance. The following risk definitions are given in Table 1:

TABLE I: Subrisks Definitions

Subrisks	Definition
technical / technological capability	The ability to manufacture and produce a product that depends on the capabilities and equipment necessary to produce goods or services.
Quality of raw materials	The coverage level of the indices at the expected level for the production from the raw material.
timely delivery of raw materials	The arrival of raw materials during the scheduled time for production to the warehouse of the factory or production plant, which prevents the production from stopping and, as a result, delays in the production of the finished product.

In this study, the effects of timely receipt of raw materials have been studied in detail.

2.3. Supply Chain

A supply chain is a network that covers all activities related to the flow of goods and the conversion of materials from the stage of procurement of raw materials to the stage of delivery of the final product to the consumer. In addition to flow of goods, flow of information and financial resources is also important [1].

With the increasing competitiveness at the national and global level, the efforts of organizations to survive in these markets has increased. This has led to the emergence of Supply Chain Management philosophy (SCM) in recent decades. The supply chain is a network of facilities and distribution centers that perform the tasks of supplying and procuring raw materials, turning them into finished and intermediate products, and distributing these final products to customers [9]. The supply chain of a product can be very small, but today, due to increased production capacities, mass production, widespread storage and distribution channels, the number of supply chain rings has increased exponentially which is very important in this management environment and therefore its integrity. In this structure, the task of supply chain management is to manage the entire network from suppliers to final customers to achieve the best output for the entire system [10].

Over the past few years, supply chain management has received a lot of attention. In each supply chain industry, it is of particular importance that its proper performance will result in the satisfaction, loyalty and effectiveness of the supply chain, and ultimately lead to final consumer satisfaction. The secret of the survival of today's organizations lies in understanding the needs of customers and responding quickly to these needs. To succeed in a new business environment, the supply chain needs to be continuously improved [13]. One of the important points in the supply chain is the lack of attention to products such as pharmaceuticals, blood, dairy, chemical industry, fruits, vegetables, mushrooms, flowers, etc., which quickly lost their quality and did not keep them in Special environmental conditions make these products corrupt in a short time. In such a situation, in industries involving perishable products, activities such as supply and demand planning, material supply, production and product planning, product storage, inventory control, distribution, delivery and customer service are transferred to the supply chain level [8].

In order to protect their interests, supply chains must be able to respond quickly to internal and external risk events and maintain their business efficiency and dynamism. In addition, supply chains should be more responsive to unexpected catastrophic events. Because of uncertainty about future risk events that can occur at any point in the supply chain, there are risks in the supply chain. Supply chain performance can be adversely affected by the occurrence of risk events in different stages of the supply chain system. Managing such events is known as Supply Chain Management (SCRM), which has become a critical part of the organization's strategy [14].

3. Method

In this research, firstly, by reviewing other researches and using the opinions of experts in food industry, the organization's risks (production, technical, qualitative) in the food supply chain were identified and a questionnaire was developed by experts in this regard. Then, using the DEMATEL technique, the collected data was analyzed and the severity of the effect of this risk was determined. In the next step, the dynamic model of the system related to the supply chain of sesame industries was designed and developed to identify and evaluate the trends and factors affecting it, taking into account the identified risk factors. After that, the model was mapped into VENSIM software and their relationships simulated. Finally, sensitivity analysis was done.

The statistical population of the study includes all sectors involved in the supply chain. The number of samples used in the Delphi technique section was 15 experts in the supply chain from universities of the whole country and for the DEMATEL technique, 11 experts in the field of supply chain in Yazd province have been used as an expert method. In the Delphi section, a questionnaire was distributed among 20 professors and experts in the food industry of the whole country. After follow-up, only 15 questionnaires were completed and referenced (about 75% of responses). A total of 14 questionnaires were distributed among the experts and professors of the food industry of Yazd province in which 11 questionnaires were completed and referred (78.5% of respondents).

4. Findings and Empirical Results

In this study, DEMATEL technique was used to calculate the severity of the organization's risk (production, technical, qualitative). Table 2 shows the output of questionnaires completed by the experts, of which the mean of the account was considered.

TABLE II: Output Values of the Questionnaires

organization's risk (production, technical, qualitative)	Technical / technological capability (E1)	Quality of raw materials (E2)	Timely delivery of raw materials (E3)
Technical / technological capability (E1)	0.0	3.1	2.8
Quality of raw materials (E2)	3.1	0.0	2.3
Timely delivery of raw materials (E3)	2.8	3.0	0.0

Maximum sum of rows = 5.9, Maximum sum of columns = 6.1, Maximum sum of rows and columns = 6.1

K = 1 / 6.1 = 0.16

After calculating the DEMATEL technique and applying the threshold (number 4.5) for it, in tables 3 and 4 we have:

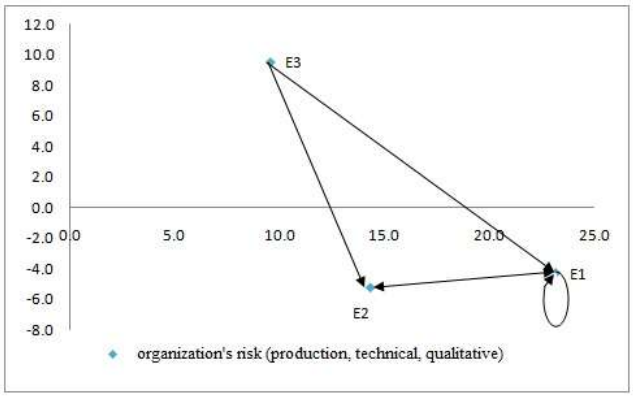
TABLE III: DEMATEL Technique Output

organization's risk (production, technical, qualitative)	E1	E2	E3	sum of columns (R)
E1	4.5	4.9	0.0	9.4
E2	4.5	0.0	0.0	4.5
E3	4.7	4.8	0.0	9.6
sum of rows (D)	13.7	9.8	0.0	

TABLE IV: Mutual Interaction Matrix

organization's risk (production, technical, qualitative)	R	D	D+R	D-R
E1	9.4	13.7	23.2	-4.3
E2	4.5	9.8	14.3	-5.3
E3	9.6	0.0	9.6	9.6

Given the positive value (affecting other risks), we choose this risk to examine among other risks. The schematic diagram of these effects is presented in graph 1 and figure 1.



Graph 1: The Final Graph of the Order of the Factors' Influence on each other

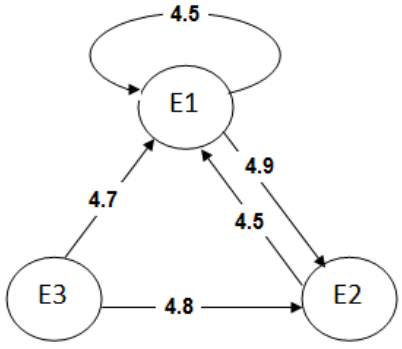


Fig. 1: Grid Relationship Network of Organization Risks (Production, Technical, Qualitative)

In order to investigate the sensitivity of this risk, we first reduced its intensity from 9.6 to 5, and in the next step, we increased the intensity from 9.6 to 14, and we considered the consequences and effects of these changes in accordance with Figs. 2-3.

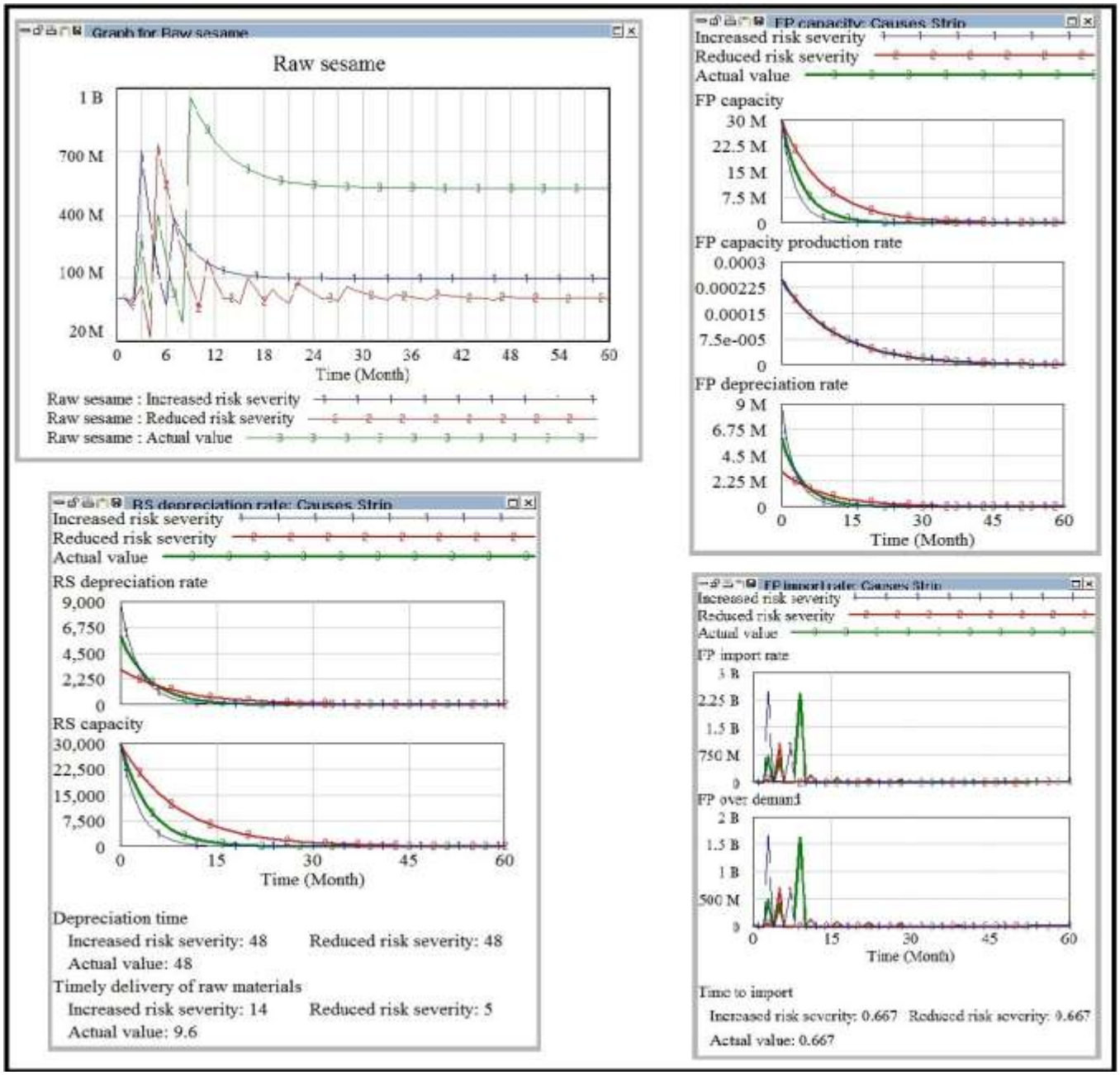


Fig 2: Simulation Results

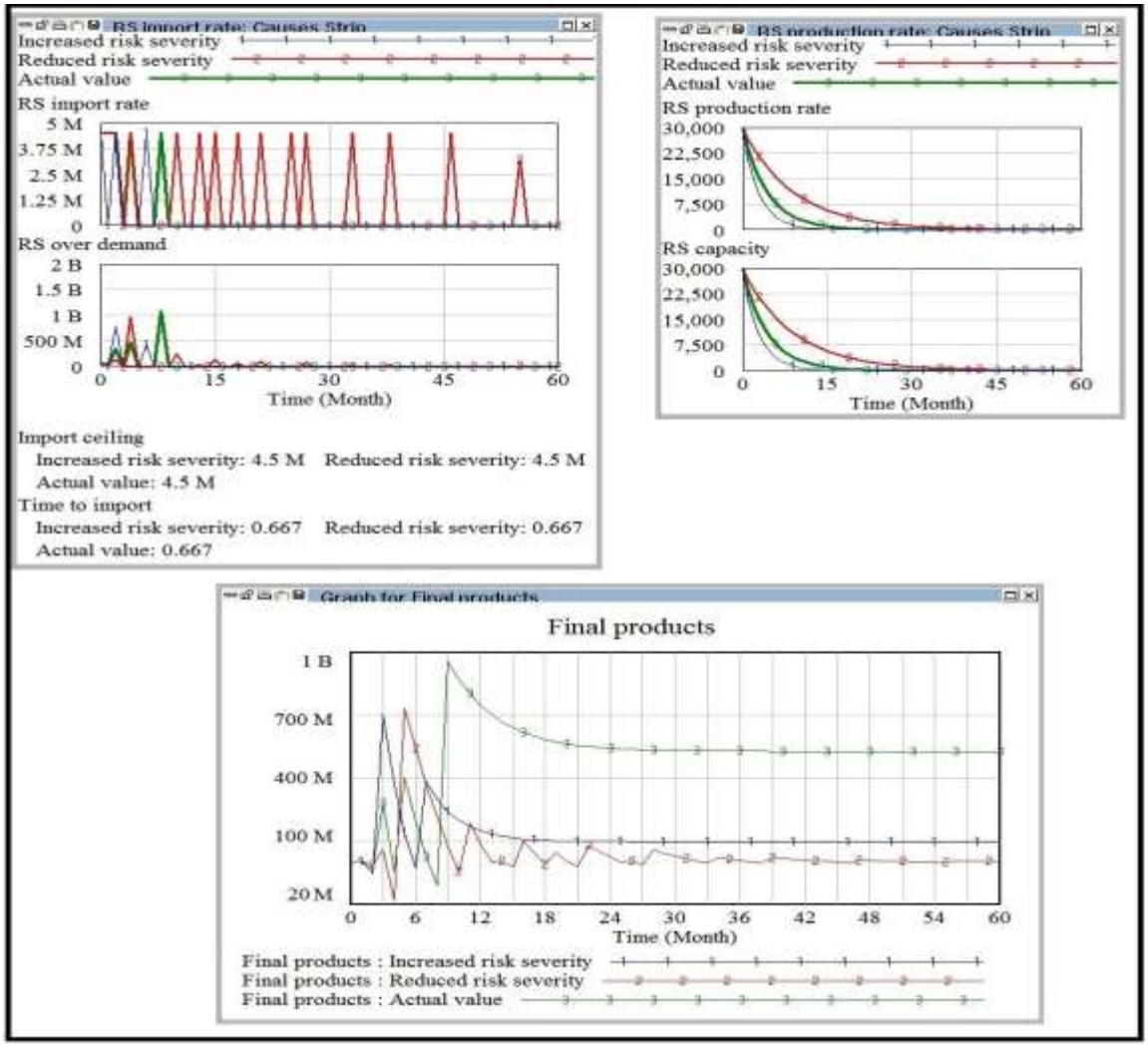


Fig 3: Simulation results

5. Conclusions

After simulating the model in VENSIM software and performing sensitivity analysis, it was found that the supply chain is sensitive to the risk of timely receipt of raw materials, and especially much of the variation in the severity of this risk Are the factors such as raw sesame, FP capacity, FP depreciation rate, RS depreciation rate, RS capacity, FP import rate, FP over demand, RS import rate, RS over demand, RS production rate, and final product. Therefore, those involved in different sectors of the chain should seek predetermined measures such as forecasting and planning of raw materials, as a result of import of raw materials, signing long-term contracts with domestic and foreign suppliers of raw materials, assessing suppliers of materials primary to select the most appropriate ones and etc. to cope with this crisis in order to reduce or mitigate its effects on the supply chain performance of this industry.

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