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Original scientific paper

A Supplier Selection Model Emphasizing the Project Risk Management in Drug Production in Pharmaceutical Industry

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Abstract: Risk management is considered to be one of the main phases of project management and one of the eight main areas of the "project management body of knowledge". The complexities involved in the drug production projects on the one hand, and the need for risk assessment and management in such projects on the other hand, make this issue completely clear. According to the risk mitigation strategies in project management and using the academic professors and experts in the field of drug production and pharmaceutical projects, the present study aimed to provide a checklist for selecting supplier in the drug production projects. This was done using the main eight and 30 secondary indicators related to the top supplier selection and four main and nine secondary indicators related to influencing environmental risks. Finally, after reviewing the statistical results obtained from the questionnaires and utilizing the TOPSIS technique, seven main indicators including "quality, flexibility, delivery, technology, information and communication systems, cost and experience" along with 24 secondary indicators were obtained relating to the top supplier selection. Also, the delivery factors group was identified as the most important group based on the Friedman test results.

Keywords: Assessment Model; Pharmaceutical Industry; Project Management; Project Risk; Supplier Selection

1 INTRODUCTION

The pharmaceutical industry is defined as a combination of processes, operations and organizations involved in discovery, creation and production of drugs. According to the diversity in the pharmaceutical industry, the present study is mainly focused on the supplier selection and the factors affecting the supplier selection in the drug production projects so as to mitigate the risk involved in this regard. As organizations always try to improve their market share, increase profit and achieve the competitive advantage, they need to consider the project management principles and standard steps toward it. Organizations in the 1960s and 1970s were always trying to increase the competitive power by standardizing and improving processes towards their customers. These efforts were continued in the 1990s by developing the project management methods considering the strategic suppliers and logistic operations [1].

In recent years, by increasing the supplier organization outside the main organization, the outsourcing organizations have been facing the variety of options when selecting the source of supply. Along with this issue, increasing the commercial competition in global markets has caused organizations to pay more attention to optimizing their processes in all competitive aspects including the supplier selection. The decision makers in the field of outsourcing try to select the alternative among the available suppliers which can meet all of the outsourced process needs in the best possible way [2].

1.1 Problem Statement and Research Background

Organizations in the 1960s and 1970s were always trying to increase the competitive power by standardizing and improving their internal processes in order to produce a more qualified and cost-effective product. They mainly believed that a robust engineering and design together with the integrated and coordinated operations are the prerequisites of achieving the market demands and as a result, increasing their market share [3]. Hence, the organizations were mainly focused on increasing their flexibility.

By increasing the customers' expectations in the 1980s, organizations increasingly became interested in improving flexibility in the production lines and developing new products to meet the customers' needs. Along with improving production processes in the 1990s, and well as utilizing the reengineering methods, managers of many industries found that it was no longer enough to improve the internal processes and flexibility and that they needed to cooperate with the best part and material suppliers who produced with the best quality and at the lowest cost. In addition, the distributors needed to have close relationships with the manufacturer's market development policies. Tab. 1 shows some research related to the present study.

Table 1 Research Related to the Present Study

Title	Method	Researcher /year
Identifying and prioritizing the project risk based on PMBOK with fuzzy approach [4]	AHP, TOPSIS	Olfat et al., 2010
Project Risk assessment and management using value engineering approach [5]	Value engineering approach	Alem Tabriz et al., 2014
The project risk deployment model based on EFQM [6]	EFQM	Amiri et al., 2014
Project risk management assessment in mass production projects [7]	MADM	Bani Asadi ez al., 2005
Tunnel building projects risk management [8]	TOPSIS, SAW, LA	Sayadi et al., 2011

Olfat et al. (2010) identified and prioritized the project risk based on PMBOK standard with fuzzy approach in the interchange building project in the Boushehr Province [4]. According to their research results, the accidents are among the most important risks in the interchange building projects in Boushehr Province that can be dramatically mitigated by utilizing the location principles. Alem Tabriz [5] also assessed and managed the project risk by value engineering approach with the aim of utilizing the value engineering techniques in the civil projects risks management so as to improve the project value and mitigate the probable risks. In their research, they calculated the project value index in the case of implementing reactive measures to the projects risks and assessing the costs of these measures after implementing the risk management work plan based on the PMBOK standard and improving the plan in case of decreasing trend of this index through the international standard of value engineering technique (SAVE). According to their findings, utilizing this framework in the Tehran subways project can cause mitigating and dealing project risks to save 49.6 percent in the projects costs after implementing the value engineering technique on the reactive measures facing the most critical project risk and improving the project value index from -3.2 to -1.6. Bani Asad et al. in 2005 have identified and prioritized the civil project risks in Mehr Housing Project using the MADM technique in Iran [7]. Sayadi in 2011 studied the Tunnel building risk management. They evaluated and ranked a relatively complete set of criteria to use in MADM techniques relating the Tunnel building projects in Seymare Dam in the south west of Iran. Also, the experts' views were gathered using the group decision making techniques and the linear allocation methods. Similarity to the ideal solution and the simple weighted set were used to determine the risk ranks. The risks resulted from the economic factors and commitments/ guarantees have the most and the least ranks, respectively [8].

Table 2 Risks involved in production projects management

Risk	Definition
financial	Change in exchange rate
transit time	Change in the transit time including the transportation and clearance
forecast	Errors in needs estimation that resulted in over or under-estimated inventory
Quality	Damaged, unfinished and different products, parts or material in different areas
Safety	The products that endanger safety
Disruption in business	Inability to produce or selling the product to customers
Survival	Factory bankruptcy
Tools and inventory ownership	Disagreement about the inventory ownership, overuse of a vehicle owned by others
culture	Insufficient information about people, culture and language
Opportunism	The supplier's opportunistic behavior with customer
Oil price	Change in oil price

The Project Risk. Sitkin and Pablo (1992) defined the risk as the "range where uncertainty exists about whether it is fulfilled as the potentially successful or disappointing outcomes" [9]. The measures that probably produce the profitable effects mostly include risks. Richi and Brandly also defined the business risks as follows: the level of dealing with the uncertainties that the company should understand and manage when implementing its strategies to effectively achieve business goals [13]. Tab. 2 presents the common risks in managing the production projects including the pharmaceutical projects.

Christopher (2004) classified the risks involved in the production projects in five classes of supply risks, process risks, demand risks, control risks, and environmental risks [9-11]:

<u>Risk of supplying raw materials:</u> one of the most important risks in production that can result from other risks. When we pay for a product or service while the service provider may not meet it with good quality or in time, we face this king of risks which is called the supply risk.

<u>Process risk:</u> when the product is not produced in timely manner or with the needed quantity or quality.

<u>Demand risk:</u> risk resulting from lack or shortage of demand for a special product.

<u>Control risk:</u> resulting from the insufficient quality control.

Environmental risk: the risk of the environmental effects that can result from the physical, social, political, legal, operational and economic environment. The pharmaceutical market is regulated according to the demand and supply nature in many countries. Considering the competitiveness of the pharmaceutical market, governments should balance between economical and healthcare benefits [9]. The pharmaceutical sector plays an important role in the medical and healthcare system. Due to the increasing population and aging, economic growth and epidemic disease (such as cardiovascular disease, and respiratory chronic cancers and disease), the pharmaceutical industry is increasingly growing [12-14].

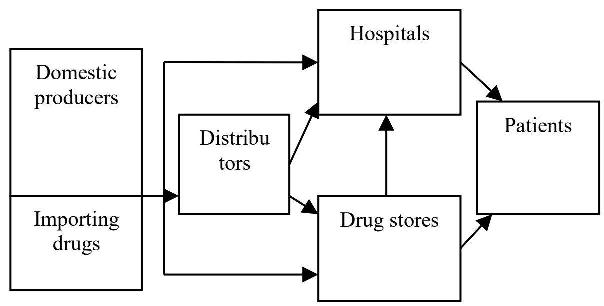

Figure 1 Pharmaceutical industry producers and customers

These are some problems when transition from an planned economy to a powerful company in the pharmaceutical industry:

The ineffective and resultless monitoring [16].

Higher price for a drug means the higher profit for producers [17].

Violation and pricing disproportionately to the preferential prices [18].

Lack of an authorized drug guidance [19, 20].

1.2 Risk Management in Project Management

The term risk, as defined in the PMBOK project management standard 6th version by the PMI institute, has a negative meaning in Persian – it refers to uncertain events in future in project management that can result in an opportunity or threat.

Opportunities or threats can result in some problems if they are ignored while they can be solved with a low cost and turn to valuable opportunities. Hence, the measures that should be taken to deal with them are called risk management.

Risk management is inevitable and it also exists in unorganized projects in an unsystematic and intuitive manner. The point is to achieve the most positive results from the risk management by making it a systematic activity.

According to the PMBOK standard in this regard, the risk management approach should be first determined. Then, risks should be identified and after analysis, the most important one should be selected. Subsequently, the activities to control the important risks and incorporate the obtained results in other plans such as time and cost should be determined. Finally, the results should be evaluated to take necessary actions in case of deviation [21].

Risk management is initiated with managerial planning in the PMBOK standard. Like other managerial plans, risk management plan determines the measures that should be taken in this regard. In addition to methodology, the roles and responsibilities related to risk and the parameters used in future to identify and analyze risk should be determined. After the risk management planning process, risks should be identified in the proper time and with proper tools and consider a hierarchical structure for them which is called the Risk Breakdown Structure (RBS).

After identifying risks based on the PMBOK standard, they should be analyzed from two aspects: quantitative and qualitative. The goal of Qualitative Risk Analysis is to select important risks to plan the proper responses to risk.

After determining the important risks using quantitative and qualitative analyses, they should be planned based on the PMBOK standard during the Risk Management Plan process. After knowing that an event will possibly occur in the future and in that case, has a significant impact on the project, we should think about our response to it. The answer to this question determines the response to the risk.

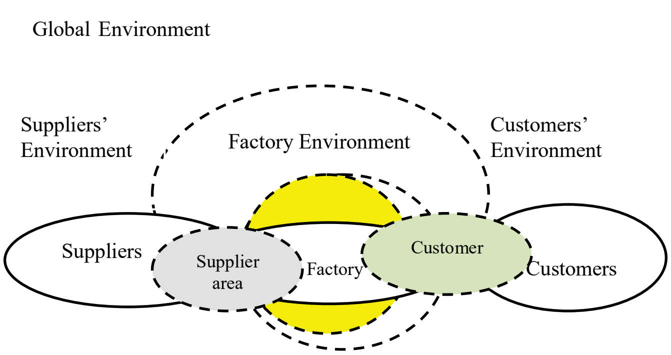

Figure 2 View of risks in the production plants [22]

Tab. 3 shows the risks identified in different stages of production process by different researchers [23].

According to the factors mentioned in different classifications by researchers, the sources of uncertainty have different effects on the organizational decisions.

If the organizational decisions are divided into three different types – operational, tactical and strategic - the interest rate has no effect on strategic decisions, while it has significant effect on operational decisions and a moderate effect on tactical decisions. The other uncertainty sources can also be divided as follows (Tab. 4).

Table 3 The risks identified by different researchers [24]

Identified risks	Researcher
Supplier market risk	Cooke
Quality, delivery, cost, capacity and production tool, technical ability, economical status, management and organization, performance record, guarantees	Dikson
Communication systems, performance controls and workers relationships, information shortage and personal abilities in management and adopting novel procedures	Gooley
Shutting down the transit routes such as docks, conflicts between the management and workers' groups	Machalaba and Kim
Natural and unusual events	Mitroff and Alpalsan
The conflicts between the workers' laws and commercial policies, different cultures and complex managerial structures between the buyer and supplier	Seaman and Stodghill
Terrorism, cyber hackers and natural disasters	Simpson
Natural disasters and technological failures	Stafford et al.
Natural disasters such as flood, earthquake, etc.	Terhune
Price, inventory, technology and quality	Treleven and Schweikhart
Market changes, products, technology, competitors and governmental regulations	Van der Vorst and Heulens
Suppliers communication and integration	Wanger
Capacity constraints, time cycle, disasters, suppliers economical and commercial health, managerial views, increased market price, incomplete information systems and system design changes	Zsidin

Table 4 The effect of uncertainty on the organizational decisions [25]

Uncertainty sources	Operational decisions	Tactical decisions	Strategic decisions
Interest rate	High effect	Moderate effect	--
Supplier delivery time	Low effect	High effect	Low effect
Supplier quality	Moderate effect	Low effect	---
Transportation time	Moderate effect	Moderate effect	Low effect
Random costs	Low effect	High effect	Moderate effect
Political environment	--	--	Moderate effect
Available capacity	Moderate effect	Moderate effect	Low effect
Random demand	Low effect	High effect	Moderate effect
Delay in information access	High effect	Moderate effect	---
Price fluctuations	Low effect	High effect	Low effect

The Fault Tree Analysis (FTA) and Event Tree Analysis (ETA) are considered as two common techniques to study and search for factors and causes contributing to accidental events. Both make logical diagrams to display the faults that distribute through a complex system. FTA investigates all the potential events that resulted in critical events and it is a graphical diagram that shows how system stops [26, 27]. The analysis starts with critical events and then, the essential and sufficiently risky events are identified along with their causes and factors affecting their logical relations using the backward logic. The event tree diagram of the supplier's undesirable performance and its outcomes according to the Brindley and Ritchie paper is displayed in the following figure.

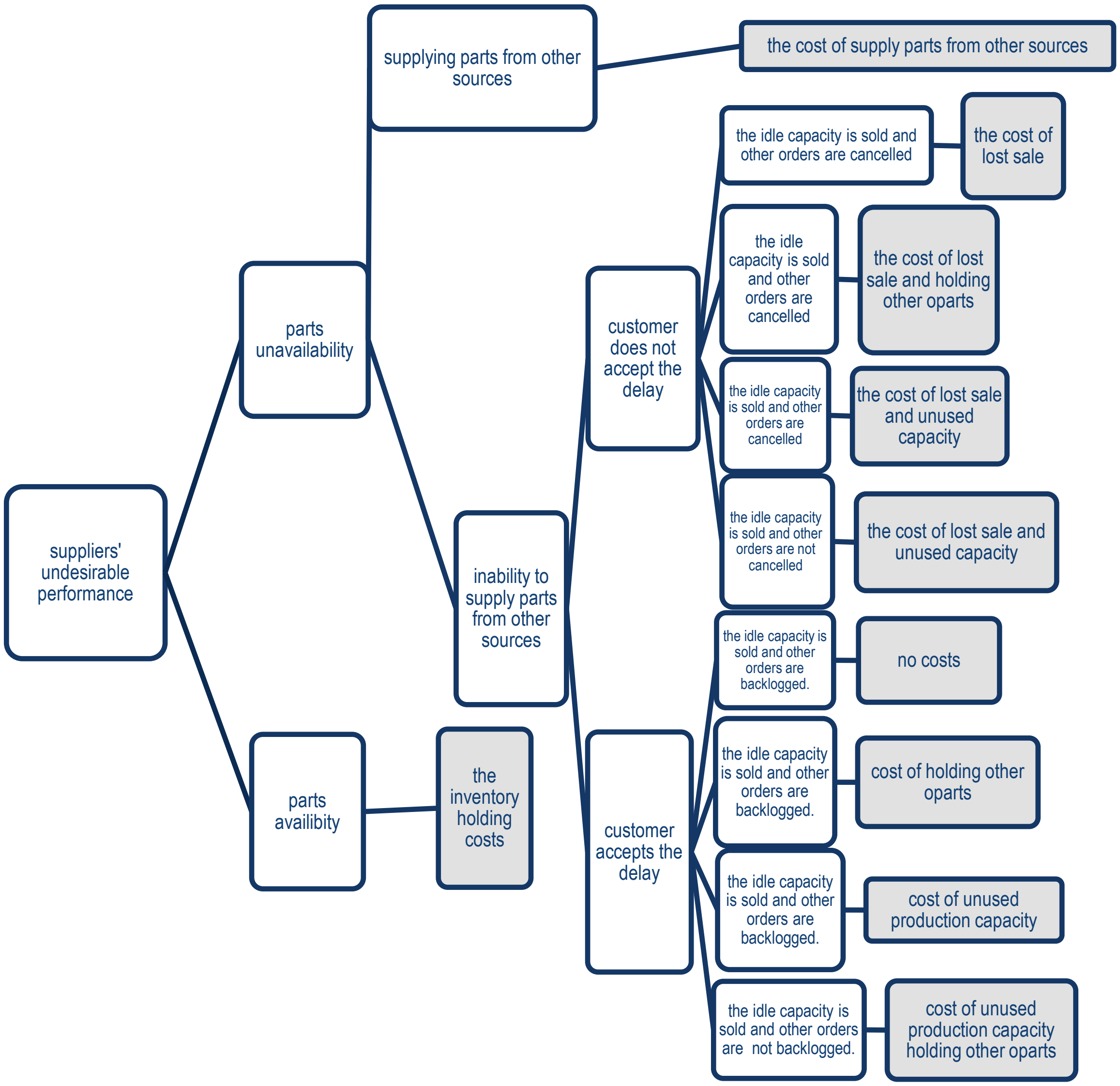

Figure 3 The Fault Tree Diagram of the supplier's undesirable performance and its outcomes

2 RESEARCH METHOD

The present study is an applied and developmental research since it seeks to select a supplier selection model emphasizing risk management in the country's pharmaceutical industry. It is also a descriptive research in tem of the method and a correlational research. In this study, all four areas of "supply, process, demand and environment" should be investigated in terms of the risks in order to identify and assess them and implement the necessary measures to manage them.

Figure 4 Four areas of risk management in the production projects

According to the research literature and subject, risk management is followed in the "pharmaceutical production projects" and along with it, the environmental risks is also considered considering that they affect all three parts of supply chain including "supply risk".

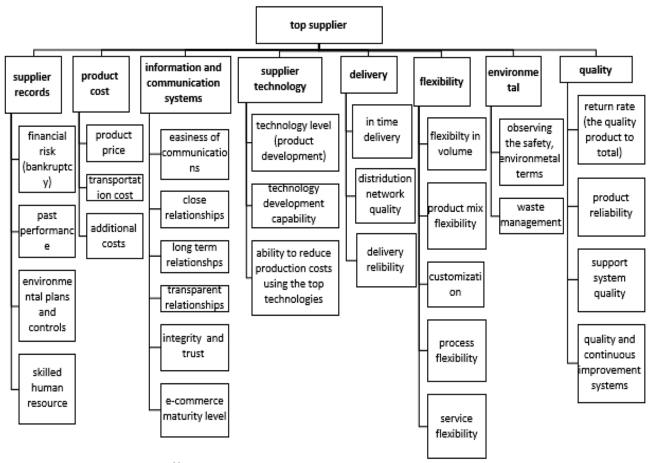

Figure 5 Factors affecting risk management in the pharmaceutical production projects in terms of the supplier [19-22]

The country's pharmaceutical industry is considered in this study as the statistical population. Three large holdings including the Tamin pharmaceutical investment, Alborz investment and Shafadarou Company were also selected as the samples and the data obtained from them were evaluated. The reasons behind selecting these three holdings are:

There are four pharmaceutical producer holdings in the country that hold 75% of drug production share: Tamin pharmaceutical investment including Daroupakhsh and Pars Darou groups, Alborz investment, Shafadarou Company, and HITT. The first three were selected as the samples that hold 65% of the total pharmaceutical market share which is considered as a significant share of pharmaceutical industry. The share of each of these groups is as follows.

Table 5 The market share of the studied holdings

Holding	Production market share	Distribution market share
Tamin pharmaceutical company	22.90	30.65
Alborz	15.86	21.47
Shafadarou	6.55	8.91

Table 6 The research main variables classification

	Variable name	Type	Role
The factors affecting the supplier risk	Quality	rank	independent
	Environmental terms	rank	independent
	Flexibility	rank	independent
	Delivery	rank	independent
	Supplier technology	rank	independent
	Information and communication systems	rank	independent
	Product cost	rank	independent
	Supplier experience	rank	independent
The factors affecting the environmental risk	Economic issues	rank	independent
	Political issues	rank	independent
	Cultural/social issues	rank	independent
	Natural disasters	rank	independent

It should be noted that since the supplier companies do not operate separately and individually, and they are subsidiaries of the producing companies, then a separate market share is not considered for them. The available sampling with the purposeful/judgmental approach is used as the research sampling method. The research main variables are as can be seen in Tab. 6. Since the validity and reliability are two main criteria for testing the measures accuracy and quality, [28], the content validity is used in this study to determine the validity. The professors and experts were asked regarding two options of the question relevance with the subject and its clarity. The reliability was also assessed by the Cronbach's Alpha coefficient as one of the most common tools for this purpose. As the scale with the Cronbach's Alpha coefficient higher than 0.7, it is reliable and the current scale is confirmed with the coefficient higher than 0.8 [29, 30]. After modifications and verifying the questionnaire's validity and reliability, it is used as the data gathering tool.

Table 7 The Cronbach's Alpha coefficient among indicators

No. of questions	Cronbach's Alpha coefficient
39	.806

Table 8 The Cronbach's Alpha coefficient among groups

No of groups	Cronbach's Alpha coefficient
9	.732

The questionnaire was then distributed among mangers in supply, production, planning and logistics sectors. In case of non-availability of the managers in one sector, the questionnaire was filled by the informed expert (which occurred in less than 10% cases). Two questionnaires were removed due to the incomplete information and lack of answers for more than half of the questions. Finally, 62 questionnaires were analyzed. Questions on the respondents' education, experience, tenure and position were provided below. As can be seen, three respondents have a diploma, one has an associate degree, 27 respondents have a license, and 29 respondents have a master degree.

Table 9 Classification based on Education

Education	Frequency	% of Frequency
Diploma	3	4.8
Associate degree	1	1.6
Graduate	27	43.5
Master and above	29	46.8
Not answered	2	3.2
Total	62	100

Table 10 Classification based on Experience

Experience	Frequency	% of Frequency
Lower than 1 year	1	1.6
1-5 years	10	16.1
5-10 years	16	25.8
More than 10 years	31	50
Not answered	4	6.5
Total	62	100

In terms of working experience, one, 10, 16 and 31 respondents have 1 year, 1-5 years, up to 10 years, and more than 10 years of experience, respectively.

In this section, in addition to the descriptive statistics results related to components, the One-Sample T Test was also used with the 95% confidence to examine the components' significance. The table below shows the related information.

Table 11 Descriptive statics related to quality

Questions 1-5		Very low	Low	Mode Rate	High	Very high	SD	*T*	sig	Result
The high return rate of the products received from the supplier	Freq	0	0	4	30	28	0.6	17.9	0	Confirmed
	freq %	0	0	6.5	48.4	45.2				
The good quality of the supplier support system	Freq	0	1	4	34	23	0.6	15.2	0	Confirmed
	freq %	0	1.6	6.5	54.8	37.1				
The quality management and continuous improvement systems in the supplier's factory	Freq	0	0	16	27	19	0.7	10.9	0	Confirmed
	freq %	0	0	25.8	43.5	30.6				
The sense and mentality of the mutual participation and coordination	Freq	0	2	11	31	18	0.7	10.6	0	Confirmed
	freq %	0	3.2	17.7	50	29				
Having the authorized certificates and GMP	Freq	0	0	3	16	42	0.5	22.1	0	Confirmed
	freq %	0	0	4.9	26.2	68.9				

3 DATA ANALYSIS

The One-Sample T Test was also used with the 95% confidence to examine the components' significance. According to the results, as the significance level is *P* value $< a = 0.05$, and *T* has a positive sign, then all the components are confirmed. On the other hand, as *T* is positive, and the Test value is considered at 3, then the resultant components are all more than 3 (average option). The test was also repeated on the groups:

Table 12 The T-test on groups

Group	*T*	Significance	Result
Quality	21.292	0.000	Confirmed
Environmental factors	7.371	0.000	Confirmed
Flexibility	14.956	0.000	Confirmed
Delivery	28.654	0.000	Confirmed
Technology	15.838	0.000	Confirmed
Information and communication systems	16.229	0.000	Confirmed
Cost	21.383	0.000	Confirmed
Record	9.116	0.000	Confirmed

According to Tab. 12, it is found that the significance of all components is confirmed. In other words, all components and groups are proper tools to evaluate variables and the research conceptual model. In addition, according to the One-sample T-test, it is found that the significance of each component/group is more than 3 (the test value) in .05 significance level. The questionnaire components are classified by two methods: Fuzzy TOPSIS and Friedman test using the SPSS software which are described below:

The first method of classification: Fuzzy TOPSIS

The Fuzzy theory is used in the uncertainty conditions which is a mathematical precise and systematic way of modelling the vague priorities [31, 32]. The questionnaire is designed based on the Likert scale and the options are very high, high, moderate, low, and very low with 1 for very low and 5 for very high. The linguistic numbers provided in table 13 are used in order to use triangular fuzzy numbers and based on the studies on different papers.

Table 13 Linguistic Variables [31]

Very low	1	(0 ,0.1 ,0.2)
Low	2	(0.1 ,0.25 ,0.4)
Moderate	3	(0.3 ,0.5 ,0.7)
High	4	(0.6 ,0.75 ,0.9)
Very high	5	(0.8, 0.9, 1)

All questions have the positive meaning and the weights of all the questions are equal and 1. The final result of the components is presented in Tab. 14 according to the priority (from the most significance to the lowest significance).

Table 14 Prioritizing the supplier risks in the production projects based on the Fuzzy TOPSIS

Question	Sub group	C_i
12. in time delivery	delivery	0.140
23. the product lower cost compared to competitors	cost	0.158
14. delivery reliability (no interruption in product delivery)	delivery	0.169
5. the authorized certificates and GMP	quality	0.185
1. Higher return rate of product/raw material from supplier	quality	0.207
25. reducing additional costs compared to competitors	cost	0.215
27. the record of positive performance	record	0.227
21. mutual trust	Information and communication systems	0.237
18. Easiness in relationship	Information and communication systems	0.248
2. Higher return rate of product/raw material from supplier	quality	0.248
24. Lower transition cost compared to competitors	cost	0.262
13. Suppliers' distribution network quality	delivery	0.284
10. Customization	Flexibility	0.306
29. skilled human resource	record	0.329
3. quality and continuous improvement systems	quality	0.339
4. the sense and mentality of mutual participation and collaboration	quality	0.344

Table 14 Prioritizing the supplier risks in the production projects based on the Fuzzy TOPSIS (continuation)

Question	Sub group	C_i
11. service flexibility	Flexibility	0.362
26. no record of bankruptcy	record	0.367
15. the product development technology level in the supplier factory	Technology	0.374
20. long term relationships	Flexibility	0.391
8. volume flexibility	Information and communication systems	0.397
17. ability to reduce production costs using the top technologies	Technology	0.399
19. close relationships	Flexibility	0.414
9. flexibility in received product and raw material diversity	Information and communication systems	0.452
22. E-commerce (IT) maturity level	Information and communication systems	0.490
6. observing environmental terms in the supplier factory	Environmental	0.498
28. having plans to control environmental factors	record	0.515
16. the ability to develop the production technology in near future in supplier factory	Technology	0.533
7. waste management in the supplier factory	Environmental	0.567
30. number of agreement of supplier with the multi-national companies	record	0.597

Table 15 Prioritizing the environmental risks based on the Fuzzy TOPSIS

Question	Sub-group	C_i
31. change in exchange rate	environmental risks	0.156
36. sanctions	environmental risks	0.207
33. change in customs policies and tariffs	environmental risks	0.254
32. change in interest rate	environmental risks	0.326
35. country's political transformation	environmental risks	0.329
37. war and terrorism	environmental risks	0.385
34. change in paid tax	environmental risks	0.402
38. natural disasters	environmental risks	0.493
39. change in consumer's taste	environmental risks	0.680

The second method of classification: Friedman Test

The second method of classification is Friedman test [33] in which, the significance level is also lower than 0.05.

Table 16 Friedman Test for components

No. of questionnaires	61
Chi-square	436.569
DoF	38
sig	0.000

Since the significance level is also lower than 0.05 in this test (0.000), the test is confirmed for the questionnaire components. The components 12 and 23 and the components 30 and 7 are the components with highest and lowest significance in this test, respectively (similar to the Fuzzy TOPSIS technique).

There is a partial difference between two methods; however, the components have relatively the same significance in both methods. Regarding the environmental risks, the question 31 is determined as the most important risk by respondents in both methods and the question 39 has the lowest importance among the environmental components. This test was also used in order to study the group importance.

Table 17 Prioritizing the supplier risks in the production projects based on Friedman Test

Question	Mean Rank	Priority
1	22.89	8
2	21.65	11
3	18.13	20
4	18.32	19
5	26.73	3
6	15.67	25
7	13.73	29
8	16.88	23
9	17.47	21
10	20.59	13
11	17.42	22
12	27.75	1
13	21.22	12
14	26.22	4
15	20.09	15
16	14.36	27
17	19.77	16
18	22.30	10
19	15.80	24
20	18.58	18
21	23.52	7
22	14.93	26
23	27.62	2
24	22.80	9
25	24.84	5
26	19.54	17
27	23.80	6
28	14.21	28
29	20.26	14
30	12.51	30

Table 18 Prioritizing the environmental risks based on Friedman Test

Question	Mean Rank	Priority
1	26.66	1
2	20.80	2
3	23.72	3
4	18.99	4
5	20.12	5
6	24.07	6
7	19.22	7
8	15.50	8
9	11.32	9

Table 19 Friedman test for groups

No. of questionnaires	61
Chi-square	111.913
DoF	8
Sig	0.000

As the significance level is lower than .05 in this test (0.000), this test is also confirmed for groups.

Table 20 Prioritizing based on Friedman test

Group	Mean Rank	Priority
Quality	5.50	3
Environmental factors	3.30	7
Flexibility	4.25	6
Delivery	7.03	1
Technology	4.39	5
Information and communication systems	4.65	4
Cost	6.93	2

As can be seen, the most important group for the supplier selection is the delivery factors group (including the in time delivery, distribution network quality, and delivery reliability) and the least important group is the environmental issues in the supplier factory.

4 CONCLUSION

The present study aimed to provide a supplier selection model emphasizing the project risk management in drug production in the country's pharmaceutical industry utilizing the Fuzzy TOPSIS technique as well as the Friedman Test to prioritize groups. According to the priorities obtained in the Fuzzy TOPSIS technique and the Friedman Test, the data in 20% top of the means were eliminated (due to elimination of the least important data).

Table 21 The means based on group priority in supplier selection in pharmaceutical industry

Group	Component	Mean C_i %
delivery	12. in time delivery	40.96
	13. suppliers' distribution network quality	83.09
	14. delivery reliability (no interruption in product delivery)	49.44
cost	23. the product lower cost compared to competitors	46.23
	24. lower transition cost compared to competitors	76.65
	25. reducing additional costs compared to competitors	62.90
quality	1. Higher return rate of product/raw material from supplier	60.56
	2. proper quality of the supplier support system	72.56
	3. quality and continuous improvement systems	99.18
	4. the sense and mentality of mutual participation and collaboration	100.64
	5. the authorized certificates and GMP	54.13
Information and communication systems	18. easiness in relationships	72.56
	19. close relationships	132.24
	20. long term relationships	116.15
	21. mutual trust	69.34
	22. e-commerce maturity level	143.36
Flexibility	10. Customization	89.53
	11. service flexibility	105.91
	8. volume flexibility	114.39
	9. flexibility in received product and raw material diversity	121.12
record	26. no record of bankruptcy	107.37
	27. the record of positive performance	66.41
	28. having plans to control environmental factors	150.67
	29. skilled human resource	96.26
	30. number of agreement of supplier with the multi-national companies	174.66
technology	15. the product development technology level in the supplier factory	109.42
	16. the ability to develop the production technology in near future in supplier	155.94
	17. ability to reduce production costs using the top technologies	116.73
Environmental	6. observing environmental terms in the supplier factory	145.70
	7. waste management in the supplier factory	165.89

As can be seen in the table of C_i means, the e-commerce maturity level, having plans to control the environmental factors, the agreements of the intended supplier with the multi-national company, the ability to develop the technology for supplier factory are the importance factors in suppler selection in pharmaceutical industry. It is better to eliminate them from the top supplier selection indicators in the country's pharmaceutical industry. Based on the table of the C_i means in the environmental risks, "change in the consumers' tastes" has no effect on the country's pharmaceutical industry or in other words, it has a low value in managing the environmental risks in the country's pharmaceutical industry in terms of the experts. The following points should be considered in order to reduce the supplier risk in the drug production projects.

The change in the consumer's taste is not an evaluable factor in the pharmaceutical industry.

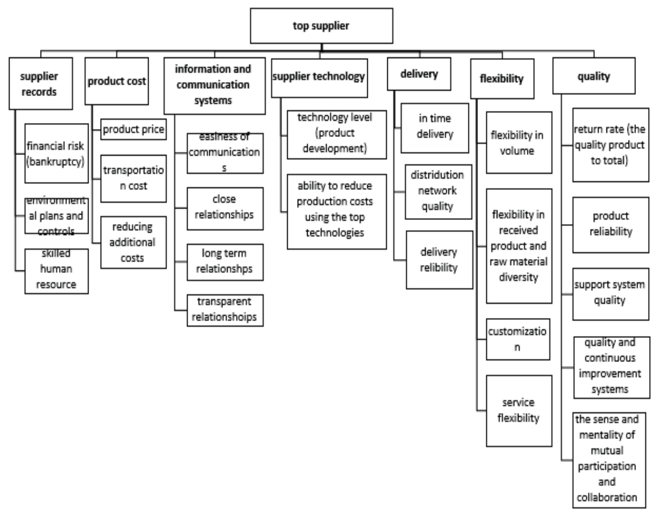

Figure 6 The final model of top supplier selection in the pharmaceutical industry

The priority in the supplier selection is related to ones who meet the delivery and cost indicators to the best possible way.

For this purpose, they should have in-time delivery, a distribution network with proper quality, and not interrupt the supply of the raw material/product suddenly.

On the other hand, their prime price should be lower than the competitors' of the same quality. Having the authorized certificates, including the Ministry of Health certificates and GMP etc., is in priority of decisions; however, the Ministry of Health permission is needed with regard to procuring the pharmaceutical raw material.

Flexibility in volume and services as well as the product diversity do not matter in the pharmaceutical industry because the pharmaceutical raw materials follow special standards and terms that changing them is not desirable for the buyer.

In line with the supplier's selection desirable terms, the environmental risks should not be ignored. Accordingly, the supplier with a plan for economical-political risks is in priority.

The change in the interest rate, sanctions, change in the customs tariff, etc., can result in the supplier failure and consequently, product supply interruption if these measures are unplanned.

The following suggestions can be considered in this regard for the future research:

The present research perspective to define the risk events is a project risk management and a customer-oriented view and it also considers the events resulting in the customer dissatisfaction – the producer's view in this research – to the supplier's activities as the risk events.

However, it should not be ignored that the customers' expectations and views are not the only important issue but the other groups' views including shareholders, employees, suppliers, and even society is important.

Hence, the more holistic view can consider these views in defining the risk events and build a model to incorporate these views.

For example, the risk drivers should also be defined and measured in this regard considering the shareholders' and company owners' views.

The statistical population in this study consisted of the pharmaceutical industry supply chain including Tamin pharmaceutical investment, Alborz investment, and Shafadarou Company.

The use of a broader statistical population like the whole pharmaceutical industry or incorporating other main holdings can provide a bigger sample and hence, more generalizable results.

The risks identified in this research can be ranked utilizing the project management methods based on the PMBOK standard.

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