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Identification and prioritization of factors affecting the saffron supply chain and selection strategies during the pandemic crisis based on the ANP-SWOT method

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Purpose: Iran is the world's leading producer of saffron. This study aimed to investigate the challenges and provide some approaches to developing the supply chain of saffron, especially saffron exports during the coronavirus disease 2019 (COVID-19) pandemic.

Design/methodology/approach: In this study, the strengths, weaknesses, opportunities, and threats (SWOT) of saffron exports were identified during the COVID-19 pandemic. Subsequently, the weights of the criteria, sub-criteria, and priorities of the presented strategies are computed using the AHP-SWOT and ANP-SWOT methods. Finally, data were acquired through the systematic collection of expert opinions using the Delphi method.

Findings: According to the prioritization of saffron export development strategies during the COVID-19 pandemic based on the AHP-SWOT method, "Performing marketing research in universities" and "Creating international associations and using anti-COVID-19 tools" were identified as the most important strategies. Moreover, in the prioritization of saffron export development strategies during the COVID-19 pandemic based on the ANP-SWOT method, "Encouraging investors to attract investments and develop infrastructures" and "Performing marketing research in universities" are determined to be the most significant strategies.

Originality/value: Because of the COVID-19 pandemic, many economic problems have arisen for saffron-producing companies, highlighting the importance of implementing the best strategies to deal with these conditions. However, given the importance of saffron exports in Iran due to their high price and the occurrence of the COVID-19 pandemic crisis, it is imperative to conduct this research.

KEYWORDS

saffron export, saffron supply chain, AHP-SWOT, ANP-SWOT, COVID 19 pandemics

1 Introduction

Due to Iran's dependence on oil, the development of non-oil exports is considered one of the most important issues in the country's economy. In this case, the share of the agricultural sector in Iran, with 10.82% of non-oil exports in 2021, is of great importance (Ministry of Agriculture-Jihad, 2022). Saffron export is one of the most important parts of the saffron supply chain, and its analysis can help better manage the saffron supply chain. Moreover, saffron, which is the most valuable medicinal food product, is of special importance for countries that export industrial products (Noorulhaq and Maulavizada, 2018). Currently, Iran is the world's leading producer of saffron (Food and Agriculture Organization of the United Nations [FAO], 2023). The many and extensive uses of saffron and the special properties of this valuable medicine, as well as its high value-added, on the one hand, and the government's emphasis on the development of non-oil exports, on the other hand, clarify the need for special attention to the saffron supply chain. Iran exported 151.6 million dollars of saffron in 2021, accounting for roughly 2.92% of whole exports compared with the agriculture sector exports (5201.29 million dollars) (Central Bank of the Islamic Republic of Iran, 2022). Given Iran's unique capacity for saffron production and exports, this product has emerged as an axis for the development of non-oil exports.

Although Iran produces a large amount of the world's saffron, some countries, such as Spain, receive value added resulting from its re-exports. In addition, this product faces problems, including packing, lack of a valid brand, marketing, and lack of access to markets. Therefore, it is essential to promote Iranian saffron in global markets (Golmohammadi, 2014). It is necessary to investigate the factors affecting the exports of Iranian saffron. Therefore, it is very important to identify the factors that affect selection strategies for entering the international saffron market. During the past years, despite the special position of its production in Iran and its many strengths, due to infrastructural, marketing, and distribution problems, saffron products have not been able to gain a high position among the exports of agricultural products. Therefore, the purpose of our study was to identify and prioritize factors affecting saffron supply and selection strategies.

The world has been affected by COVID-19 since 2019, and during this period, different mutations of this virus have spread worldwide. The last mutation of COVID-19 (the Omicron variant) led to shutdowns and quarantines in many countries of the world despite vaccination (World Health Organization, 2022). Companies are forced to develop and prepare the best strategies to address this situation as effectively as possible. Agricultural production companies suffered significantly during this period. In particular, companies with a special focus on exports suffered irreparable losses in this era because of the quarantine of countries and ban on importing products from other countries. However, in addition to many threats, the pandemic can create opportunities for companies to utilize it as a lever for their progress (Riahi Dorcheh et al., 2021). Consequently, in the present research, the COVID-19 pandemic was considered the main subject, and the best strategies were presented and prioritized accordingly for the company under study. This crisis is not the first in history and will certainly not be the last. Therefore, it is essential for companies engaged in agriculture to apply the best strategies to cope with these conditions. The main novelties of this study are as follows:

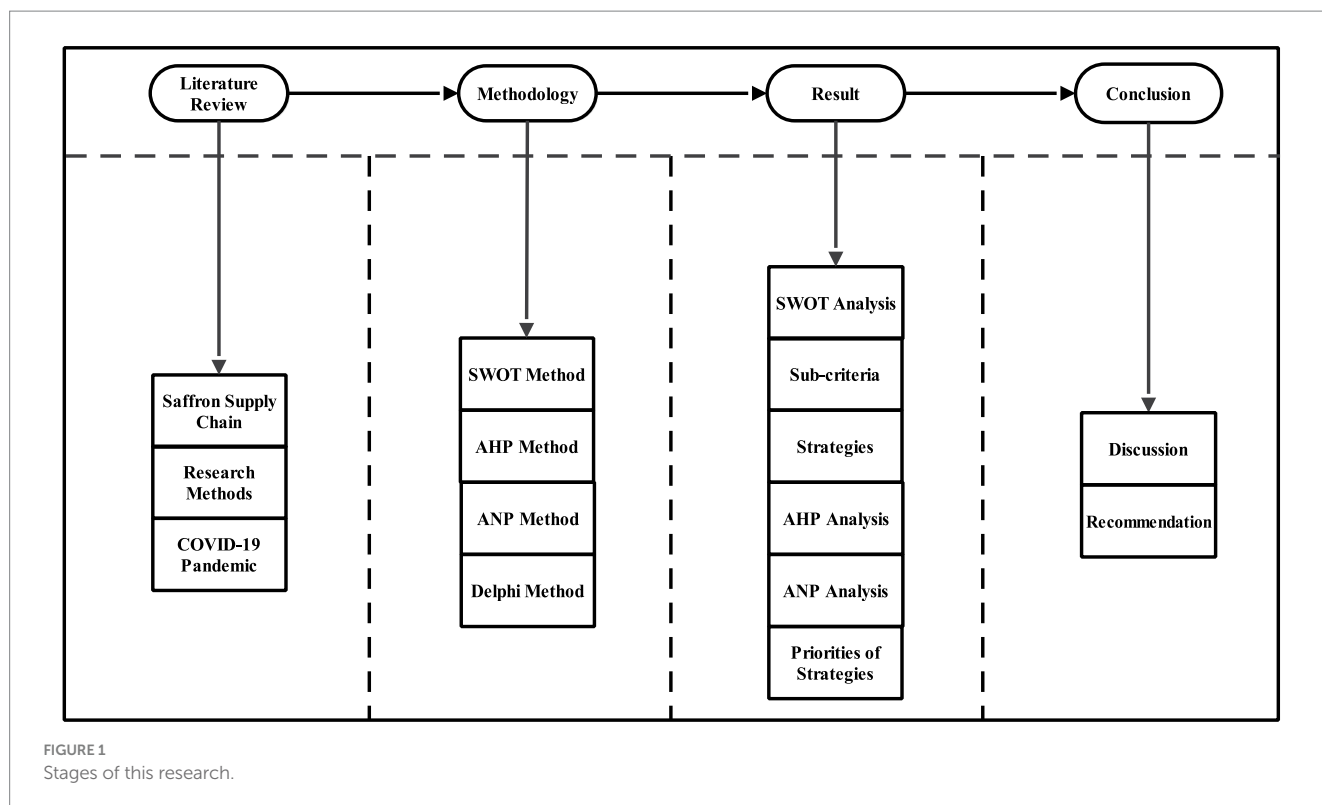
- Analysis of saffron exports during the COVID-19 pandemic, which is one of the most important components of the saffron supply chain, and development of the best strategy for it.
- Using the Analytic Network Process (ANP)—Strengths, Weaknesses, Opportunities, and Threats (SWOT) analysis to identify and prioritize saffron export strategies during the COVID-19 pandemic to enter the international saffron market.
- Comparing the performance of ANP-SWOT and Analytic Hierarchy Process (AHP)-SWOT methods and presenting the related results.

The rest of this study is structured as follows. Section 2 presents a literature review. Section 3 introduces the SWOT, AHP, and ANP methods. In Section 4, analyses are performed on saffron exports during the COVID-19 pandemic, and strategies are prioritized using the developed methods. Finally, in Section 5, conclusions are presented. Figure 1 schematically shows the stages of this study.

2 Literature review

Without appropriate programming, non-oil exports cannot have a higher position (Hitt et al., 2012; Onoh et al., 2018). The process of strategic programming in supply chain management is a managerial process involving coordination of the organization's capabilities with available opportunities determined during the time and investigated for investment or lack of investment in the organization's resources (Rahbari et al., 2023a; Rigby and Bilodeau, 2007; Rahbari et al., 2023b).

Several studies have investigated the environmental impacts and economic aspects of saffron production as well as the challenges and opportunities for promoting saffron marketing (Abolhassani et al., 2020; Shahnoushi et al., 2020; Mohammadi and Reed, 2020). Similar to our study, Noorulhaq and Maulavizada (2018) investigated production performance and saffron exports in Afghanistan and found that saffron production increased from 3390.3 kg during 2014–2015 to 6081.2 kg during 2016–2017 in Afghanistan. In 2014, Afghanistan accounted for 1.36% of the global saffron production. Tantry and Dar (2017), using an economic analysis of saffron production and marketing in Kashmir and Jammu, found that this product was exposed to extinction, and it was necessary for researchers, farmers, and policymakers to pay attention to creating a high demand in international markets and developing a scientific approach to expand genetic technology after harvesting. Karbasi and Rastegaripour (2016) evaluated the advantages of saffron production and exports and showed that saffron production had relative advantages in Torbat Heydarieh. In addition, government interventions had positive effects on the production of this product. They also found that Iran, Spain, and Greece had relative global export advantages during 2004–2012, while the value-added of Iran's saffron exports was not considerable. Golmohammadi (2014) investigated the economic importance, exports, pharmaceutical features, and different applications of saffron production in South Khorasan Province, demonstrating that paying attention to this product could result in improving the position of this product in global markets, and the economic value of its exports was directly achieved by Iran (but not other countries). Aghdaie et al. (2012) identified barriers to Iran's exports using Porter's diamond and showed that the most important barriers to Iran's saffron export included demand conditions, related



industries and supporters, the firm's strategy, the structure, competition, and the role of government.

The SWOT method has several limitations, such as the impossibility of strategies and evaluation criteria (Pahl and Richter, 2009). Hence, in terms of searching for SWOT improvement, the best techniques that can be used are multi-criteria decision-making (MCDM) methods. Kurttila et al. (2000) developed a combined method of analysis and MCDM method to solve the weaknesses in terms of the measurement and the evaluation of SWOT analysis. They used this method based on AHP in SWOT analysis, known as AHP, in their subsequent studies. Moreover, many researchers, including Stewart et al. (2002), Shrestha et al. (2004), Vidal et al. (2011), Kajanus et al. (2012), and Kalatpour (2017), utilized this approach. It should be mentioned that this approach was solely used to prioritize SWOT factors in all above-mentioned studies, and this technique was not expanded to the strategy selection step. The fuzzy ANP method and SWOT analysis were used to identify the best strategies for tile manufacturing companies (Babaesmailli et al., 2012). Shahabi et al. (2014) proposed an ANP–SWOT analysis to prioritize Iran's steel scrap industry strategies. Zhao et al. (2016) used the ANP–SWOT analysis in terms of the rare earth industry of China, and they also developed the five short-term strategies and four long-term strategies to determine the optimal strategy of the rare earth industry. Starr et al. (2019) used an ANP–SWOT approach for analysis of the cross timbers forest resources of Texas, Oklahoma, and Kansas. Shahanipour et al. (2020) investigated human resources management using the ANP–SWOT analysis. In their studies, they identified and prioritized strategies using an approach based on creativity among employees in administrative organizations.

In recent years, considerable research has been conducted on the effects of the COVID-19 pandemic. Nayak et al. (2022) investigated

the effects of the COVID-19 pandemic on different industries, including the agricultural industry in India. In this study, the energy and power industries, transportation and tourism, automotive, education, publications, and electricity were analyzed in addition to the agricultural industry. The authors first investigated the parts of the agricultural industry affected by the pandemic and then analyzed the demand, supply, and security of food products. In the following, the pandemic's impact on the health of farmers and the price of agricultural products was discussed, and finally, some preventive measures were presented in order to deal with the pandemic. Ben Hassen et al. (2020) studied the effects of the COVID-19 pandemic on the behavior and consumption of food products in Qatar. In this study, using statistical analysis, food characteristics and habits during the pandemic and their changes were analyzed. According to the research findings, the method of consumption and preparation of food products, and, in general, the relationship between consumers and food products has changed. Aday and Aday (2020) evaluated the effects of the COVID-19 pandemic on the supply chain of food products and the agricultural sector. In addition to investigating the supply chain of food products, they analyzed the behavior of consumers and the global trade of food products during the pandemic. Finally, they made recommendations for controlling and minimizing the effect of the pandemic on the supply chain of food products, small farms, global trade, businesses, and governments. Poudel et al. (2020) studied the impacts of the COVID-19 pandemic on food products and the agricultural sector. In this study, the impact of the pandemic on the production, distribution, and safety of food products, as well as the demand for food products, was analyzed. They found that the pandemic affected all activities in the supply chain of food products. The most important activity is the transportation and distribution of food products. Purkait et al. (2020) investigated the impacts of the

COVID-19 pandemic on the fisheries sector and economic shocks to it in India. In this study, the situation of the fisheries sector before the pandemic in India was analyzed, the pandemic effects on the different components of this sector were evaluated, and some policies were presented to improve the shocks resulting from the pandemic.

Despite the significance of saffron in the studies conducted, especially in Iran, the supply chain of this product in Iranian companies has not yet been analyzed. On the other hand, considering the importance of saffron exports in Iran because of its high price and the occurrence of the COVID-19 pandemic crisis, this study can be considered innovative. According to the Iran Customs Administration, saffron exports in the first 3 months of 2022 faced a 63% reduction compared to the first 3 months of 2021, mainly because of the lack of proper strategic planning during the COVID-19 crisis (The Islamic Republic of Iran Customs Administration, 2022). Consequently, because of the COVID-19 pandemic, many economic problems have arisen for saffron-producing companies, which shows the need to implement the best strategies to address these conditions.

3 Methodology

The SWOT analysis is a powerful strategic tool for analyzing environmental conditions and can be effective in detecting external and internal strategic factors (Rahbari et al., 2024a; Babaesmailli et al., 2012). It identifies the best combination of strategies that are important for maximizing strengths and opportunities and minimizing the effects of weaknesses and threats. After developing a SWOT matrix based on the identified factors, four groups of WT, WO, ST, and SO approaches are identified based on their combination (Hill and Westbrook, 1997). The following steps were defined in the process of using the AHP method in SWOT:

Step 1: A SWOT matrix was created; that is, the factors in each SWOT group are identified.

Step 2: Pairwise comparisons were performed between the identified SWOT factors.

Step 3: Pairwise comparisons were performed between the four groups of SWOT analysis, including strengths, weaknesses, opportunities, and threats. After performing pairwise comparisons and determining the relative weight of each group, the final weights were determined by multiplying the relative weights of the factors by the relative weight of the groups using the eigenvalue. In addition, the sum of the final weights must be equal to 1.

Step 4: The results were used to evaluate the strategy. In the process of strategic programming using numerical values, the importance of each factor was determined.

Because the weights assigned by the AHP method to the factors are based on the assumption of non-dependence, they may be different from the weights calculated by accepting the assumption of dependence (Shrestha et al., 2004). Therefore, it is essential to consider the dependency among the factors and their intervention in the measurement (Yüksel and Dagdeviren, 2007). By considering the

limitations mentioned for the AHP method and the inability of this approach to apply dependency between criteria and factors, Saaty (1996) developed another approach known as ANP. In contrast to the AHP method, the ANP method has a network structure. The hierarchical formation of AHP is a top-down linear structure, while the network structure of ANP is a non-linear structure developed in all orientations (Sevкли et al., 2012). Because there is a mutual dependency between the available components, it can be concluded that SWOT analysis using ANP is essential for ranking the strategies, criteria, and sub-criteria.

In general, the ANP and AHP methods proposed for SWOT analysis involve four levels. The purpose (best strategy) is at the first level. The second level is SWOT. The third level is the factors of each SWOT group, and the fourth level is the substituted strategy (Yüksel and Dagdeviren, 2007). The ANP method often involves two ranking strategies. The first method is to create a supermatrix. The second method is based on matrix operations and performs a pairwise comparison of the criteria for each criterion (Tzeng and Huang, 2011). In this study, the second method was used for ranking. The following steps are defined in the process of using the ANP method in SWOT:

Step 1: Identifying the SWOT factors of and substituted strategies.

Step 2: Determining the importance degree of the SWOT group by performing pairwise comparisons and the scale of 1–6 (W_1 computation).

Step 3: Computing the internal dependency matrix of groups (the level of the two models) by performing pairwise comparisons (W_2 computation).

Step 4: Determining the priority importance of each SWOT group by multiplying W_2 with W_1 (W_f computation).

Step 5: Determining the relative importance of each SWOT factor by performing pairwise comparisons (W_{sub-f} [local]).

Step 6: Determining the final importance of each SWOT factor by multiplying the fourth step with the fifth step (W_{sub-f} [global]).

Step 7: Determining the importance of substitution strategies in comparison to each SWOT factor with a scale of 1–9 by pairwise comparisons.

Step 8: Determining the final priorities of each strategic alternative (by multiplying the sixth step with the seventh step).

The SWOT-ANP method is a combination of SWOT analysis and the network analysis process (ANP), which helps identify and prioritize internal and external factors in an organization. One of the advantages of this method is its ability to analyze the complexities and dependencies between different factors, which makes decisions more accurate and effective. In addition, this method allows managers to simultaneously examine strengths, weaknesses, opportunities, and threats at the same time. However, its limitations include the complexity of implementation and the need for accurate and valid data for evaluation. In addition, the results may be affected by the

subjective biases of the decision-makers, which may reduce the accuracy of the analysis.

In order to collect data through the field method, various questionnaires were used at different stages of the research method. The Delphi technique has been used to identify strengths, weaknesses, opportunities, and threats (Joshi et al., 2011; Spina et al., 2023; Fathi et al., 2024). The questions in the questionnaire were first prepared, and then a pre-test was performed in terms of the appropriateness of the words and questions to determine the questions without ambiguous questions. Subsequently, the questionnaire was given to experts from the Agricultural Jihad Organization in Khorasan province, saffron farmers, and research centers in Khorasan. The participants were asked to answer four questions:

- 1) What are the strengths of saffron exports during the COVID-19 pandemic?
- 2) What are the internal weaknesses of saffron exports during the COVID-19 pandemic?
- 3) What are the external threats to saffron exports during the COVID-19 pandemic?
- 4) What are the opportunities for saffron exports during the COVID-19 pandemic?

First, experts from the Agricultural Jihad Organization in Khorasan province were selected to fill out the questionnaire due to the high production of saffron in this province. The answers received by the experts were then summarized, and similar items were deleted. At this stage, answers were received through semi-structured interviews with 18 experts. To determine sample size, a targeted sampling method was used for all eligible individuals.

Subsequently, the second questionnaire was given to the experts, who were asked to identify the importance of the comments with respect to the Likert scale. Here, agreement and disagreement items were identified, and the study population was questioned whether they agreed with the comments' priority in the second questionnaire, and opponents were asked to state the reason for their disagreement. Finally, comments were considered to determine the agreement. In this step, the participants were asked to review the answers and read their own comments and judgments so that they could reach a common agreement and the final result with regard to the above-mentioned steps.

The first questionnaire was prepared to gather the strengths, weaknesses, opportunities, and threats using the Delphi technique and experts' comments from the Agricultural Jihad Organization in Khorasan province ($n = 5$), experts from research centers ($n = 5$), and saffron farmers ($n = 8$). Another questionnaire was completed to perform pairwise comparisons to determine the weight of the criteria and sub-criteria by experts of the Agricultural Jihad Organization and saffron farmers owing to their familiarity with this product. In this stage, face-to-face interviews and structured questionnaires were used to perform pairwise comparisons, and the target sample was the same group of experts as in the first stage (in this stage, four farmers participated). It should be mentioned that another questionnaire was used to perform each step of the research, such as creating the matrix of W1, W2, and Wf and strategy scoring with regard to the sub-criteria. The weighted mean, Likert scale, and geometric mean were used to collect the comments.

4 Results and discussion

The SWOT sub-factors are shown in Table 1. Then, by creating the SWOT matrix, combination strategies for WO, ST, SO, and WO were configured based on the experts' comments. In this model, five strategic factors are considered for each factor: strengths, weaknesses, opportunities, and threats.

Based on the experts' comments, combination strategies were determined according to sub-criteria priorities. The main combination strategies for saffron export development are shown in Figure 2. Therefore, all the extracted strategies can be observed in the SWOT matrix.

SO1: performing marketing research in universities

One of the strengths of Iran's saffron exports and production is the presence of universities and research facilities in the country that improve saffron production, processing, and marketing. In addition, protecting knowledge enterprises from establishing R&D units for processing and extracting effective saffron materials, preventing crude sales, creating higher value-added, and using marketing research to know customers and external competitors based on the destination country provides the field to conduct marketing research at universities because there are some facilities at universities, and the market is performed as well as possible. During the COVID-19 pandemic, because exports decreased at one point in time and transportation systems were also limited, opportunities for saffron processing with the support of knowledge enterprises to set up research and development units, extract effective saffron substances, prevent raw sales, and create higher added value.

SO2: introduction and supply by the fairs and sales offices

Introducing different products in Iran, such as saffron, is easily possible, especially after the COVID-19 pandemic, using various technologies in the country. In addition, saffron exports face opportunities, such as sales offices and different virtualized and specialized fairs in other countries. One way to improve and develop Iran's saffron exports during the COVID-19 pandemic is to introduce and supply this product through fairs and sales offices.

WO1: encouraging investors to attract investments and develop infrastructures

One of the problems in the field of saffron export development during the COVID-19 pandemic is the lack of required infrastructure and its potential in terms of resources. One of the main reasons for this is financial and economic problems. In addition, one of the weaknesses of exporting this product is the lack of financial resources and economic problems during the COVID-19 pandemic. Therefore, by encouraging investors, necessary financial facilities must be provided to create the necessary infrastructure, especially the transportation infrastructure required for this product.

ST1: creating international associations and using anti-COVID-19 tools

Because of the high quality of Iran's saffron in the world, producing 90% of saffron in Iran, the presence of research facilities, and easy introduction of products with the help of information technology and world networks, creating interactional associations and unions results in facilitating the introduction of brands to different

TABLE 1 Description of SWOT sub-factors.

Strengths		Weakness	
S1	The presence of university and research facilities inside the country to improve the production, processing, and marketing of saffron	W1	Lack of necessary infrastructure during the COVID-19 pandemic for suitable transportation for product export
S2	Producing 90% of the world's saffron, Iran is the largest producer of saffron in the world	W2	Lack of having a strategic perspective and management for presence in global markets
S3	Facilitating the introduction of products and the process of global supply with the help of information technology and the wireless networks, especially after the COVID-19 pandemic	W3	Bulk export of Iran's saffron
S4	Familiarity with international regulations and limitations in terms of exporting agricultural crops, especially saffron	W4	Failure to provide the required financial resources and economic problems during the COVID-19 pandemic
S5	High quality of Iran's saffron in the world	W5	Lack of familiarity with the customers' interests in different areas of the words

Opportunities		Threats	
O1	Preventing loss of saffron fragrance and increasing stability by using packing technology	T1	COVID-19 pandemic limitations and health protocols
O2	Using marketing research to detect the customers and foreign competitors on the basis of destination country	T2	Instability of economic and uneconomic parameters affecting saffron production and supply, especially during the COVID-19 pandemic
O3	Establishing an officious pricing policy in markets of export with higher priority	T3	Lack of having an appropriate good brand in global markets
O4	Supporting knowledge enterprises to set up research and development units for processing and extracting effective saffron materials, preventing crude sales, and creating the lighter value added	T4	Lack of an electronic money transfer system due to economic and political issues
O5	Virtualized and specialized fairs in different entries to be familiar with saffron consumption during the COVID-19 pandemic	T5	Misuse and duplication of successful names

countries. Moreover, it is necessary to execute this strategy because of the lack of a good brand in global markets and the lack of an electronic money transfer system because of economic and political problems. In addition, due to the COVID-19 restrictions imposed on saffron-producing companies, as well as global restrictions due to the pandemic, health protocols should be followed as much as possible using anti-COVID-19 tools. Therefore, the brands of companies in this field will be known more than before in global markets and will increase exports.

WT1: supporting the private sector in exports

The private sector of experts must be supported because of the bulk exports of Iran's saffron, lack of familiarity with customers' interest in various areas of the world, lack of necessary infrastructure during the COVID-19 pandemic for suitable transportation for product export, lack of strategic perspective and strategic management for the presence in global markets, lack of motivation for investors, and duplication of successful names, and lack of good brands in global markets. In fact, these supports result in decreasing internal weaknesses, and, finally, threats can be decreased.

WT2: guaranteed price and shopping

One of the problems proposed in the field of Iran's saffron production is the instability of economic and non-economic

parameters during the COVID-19 pandemic, and producers are highly concerned. Another problem with saffron export and production is the lack of financial resources and economic problems during the COVID-19 pandemic. Hence, in order to reduce concerns about the economic instability in Iran, this instability can be controlled by shopping and determining the guaranteed price.

4.1 AHP analysis

The SWOT factors, SWOT sub-factors, and strategies considered as criteria, sub-criteria, and alternatives, respectively, are placed in descending order of hierarchy structure. A pairwise comparison matrix is derived at each level between the criteria, sub-criteria, and alternatives. Participants could focus on each part of the problem using pairwise comparisons. Every time, the simplification of the two attributes or criteria should be considered. Criteria and alternatives were ranked using the AHP scale, with absolute values of 1–9. Geometric mean values were used to calculate pairwise comparison matrices of the forms filled by expert team members. Finally, AHP analysis was performed using Expert Choice software (Expert Choice LLC, FL, US) and the eigenvector technique. First, a pairwise comparison of the SWOT factors was applied with regard to the goal.

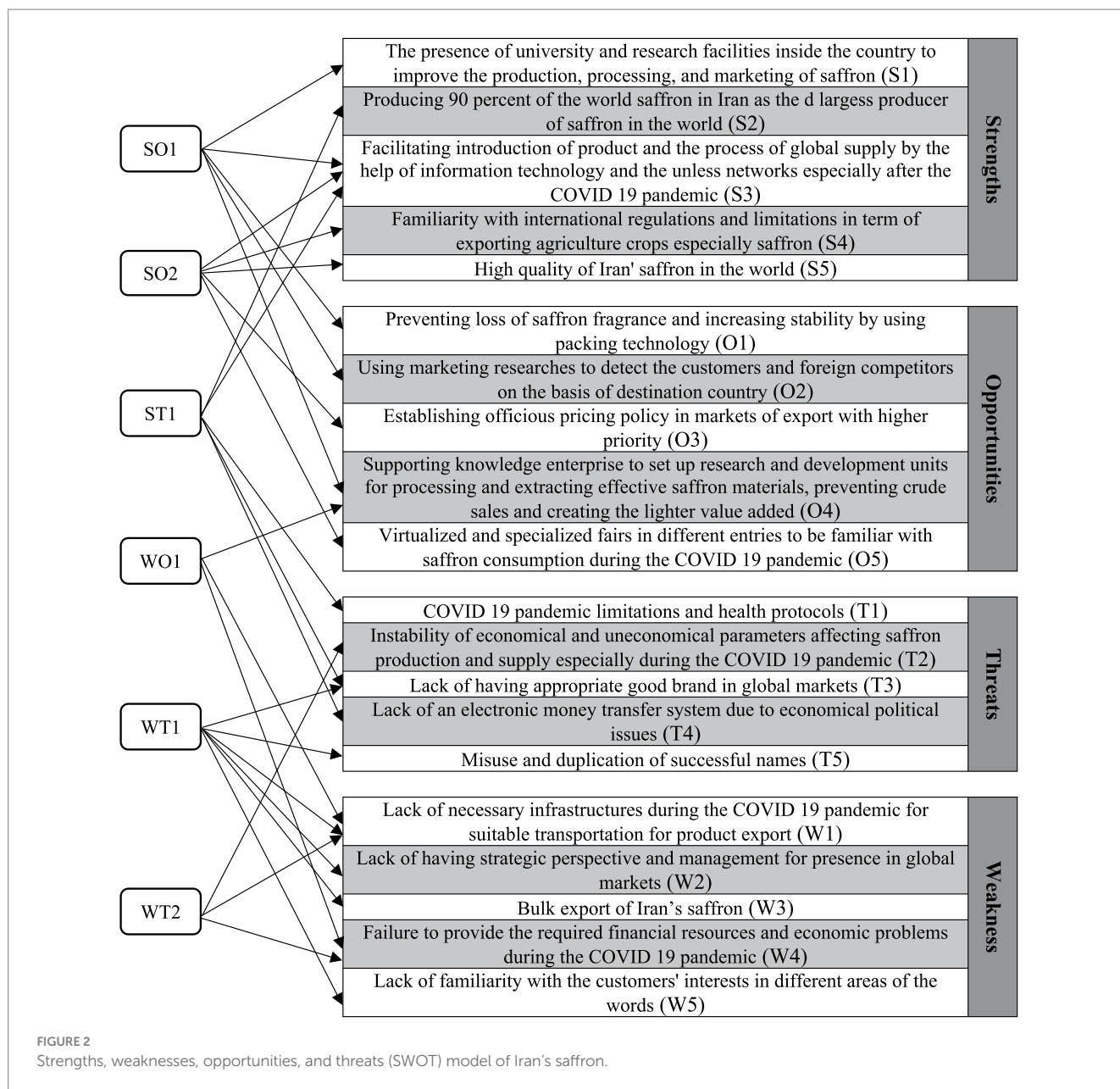


TABLE 2 Relative importance of each SWOT factor.

	Opportunities	Threats	Strengths	Weaknesses	Relative importance
Opportunities	1	1.2	3	1.3	0.284
Threats	2	1	4	1.2	0.170
Strengths	1.3	1.4	1	1.5	0.073
Weaknesses	3	2	5	1	0.473

IR = 0.07.

In the following, by considering different comments and views, the criteria and sub-criteria of the strategies used and saffron export development were presented. First, the method for obtaining each sub-criteria weight using the AHP method was explained. Pairwise comparison was performed for these criteria. The results of pairwise

comparisons and their relative importance are presented in Table 2. The scores provided by all experts are shown in this table. The results showed that, according to the views of all experts, the importance of strengths is 1.5, 1.3, and 1.4 times more than that of weaknesses, opportunities, and threats. Therefore, based on the general results of

pairwise comparisons and the relative importance of each factor, it should be mentioned that weaknesses had the highest importance and ranked first with a weight of 0.47. Also, it can be said that the selected experts assign 54% of the factors affecting saffron export development to internal factors, including strengths and weaknesses, and external factors that are out of their control constitute 46% of these factors. In this way, to develop saffron exports during the COVID-19 pandemic, weaknesses and threats should be considered by experts, and strategies based on weaknesses should be more effective. Therefore, it is desirable to develop defensive tactics directed at reducing weaknesses. The IR coefficient had an acceptable value for incompatibility.

In the next step, for each sub-criterion, a pairwise comparison was implemented separately for each expert and criterion. In addition, for each sub-criterion, the relative priority was determined. The results obtained from pairwise comparisons of sub-criteria for each factor of

strengths, weaknesses, opportunities, and threats are presented in Table 3. For instance, we explained the pairwise comparison matrix of weakness (W3 and W5 in comparison to other weakness factors) as the most important factor in determining the strategies of saffron export development.

According to the experts, the importance of W3 was 3, 4, 5, and 1.2 times more than that of W5, W1, W4, and W2, respectively. In addition, the importance of W5 was three times higher than that of W1, and it was five times more important than W4. In addition, it was 1.4 times more important than W2. In this regard, according to the results and the last column of the table showing the weight of the sub-criteria in the related criterion group, it can be stated that answering the criteria of strength, sub-criteria of S2 with a weight of 0.507, had priority over other sub-criteria. This means that among the sub-criteria of strength factors, the sub-criteria of S2 was the most important factor in terms of developing Iran's saffron exports during the COVID-19 pandemic, and more than half of the importance of the mentioned sub-criteria belonged to this factor. S1 had a lower score or importance than the other factors. Factors S5, S3, and S4 with weights of 0.261, 0.111, and 0.084 ranked second, third, and fourth, respectively.

The results obtained from pairwise comparisons of sub-criteria, including weakness, showed that the highest importance was devoted to W2 sub-criteria, at over 40%. This factor is managerial, and according to experts' views, it is expected to have higher importance. In other words, according to the ranking obtained from pairwise comparisons, it can be said that this factor with a score above 1 had higher importance in comparison to other factors. Hence, experts believe that it is the most important factor in saffron export development during the COVID-19 pandemic. The second highest rank belonged to the W3 factor. The weight related to this factor was approximately 30%, which was close to that of the previous factor. The third rank belonged to W5, with a weight of approximately 16%; the fourth rank was devoted to W4, and the least important sub-criterion was W1. Among five factors considered as sub-factors, it can be said that sub-factors of W2, W3, and W5 were related to technical managerial issues, and they allocated approximately 26% of the weight of these factors to themselves. W4 was related to economic issues, and W1 was related to executive issues with the least weight and importance. Therefore, managerial and technical issues are considered to be the most important factors in developing Iran's saffron exports during the COVID-19 pandemic.

The next group included five sub-factors. According to rankings obtained from pairwise comparisons, it can be mentioned that the O4 sub-factor with a score above 1 had higher importance than other factors. Therefore, experts believe that this is the most important opportunity factor in terms of saffron expert development during the COVID-19 pandemic. The second rank was related to the O5 sub-factor. The weight allocated to this factor was approximately 24%. The third rank belonged to O3 and weighed approximately 23%, which was close to the weight of the previous factor. The fourth rank belonged to O2, while the least important sub-factor was O1, with a weight of 6%. It can be said that, in this group, the issues of interactions with other countries, such as the sales office, virtualized and specialized fairs, and protection of knowledge enterprises, are very important during the COVID-19 pandemic. The next group involved sub-factors of threats. The T3 sub-factor was more important than the other factors. Therefore, experts believed that it was the most

TABLE 3 Relative importance of SWOT subgroups.

Opportunities	O1	O2	O3	O4	O5	Relative priority
O1	1	1.3	1.3	1.4	1.4	0.063
O2	3	1	1.3	1.3	1.3	0.111
O3	3	3	1	1.2	1	0.226
O4	4	3	2	1	2	0.362
O5	4	3	1	1.2	1	0.228
IR = 0.04						

Threats	T1	T2	T3	T4	T5	Relative priority
T1	1	1.4	1.5	1.2	5	0.099
T2	4	1	1.2	4	6	0.309
T3	5	2	1	4	7	0.435
T4	2	1.4	1.4	1	3	0.118
T5	1.5	1.6	1.7	1.3	1	0.040
IR = 0.07						

Strengths	S1	S2	S3	S4	S5	Relative priority
S1	1	1.8	3	1.3	7	0.038
S2	8	1	5	6	3	0.507
S3	3	1.5	1	7	1.3	0.111
S4	3	1.6	1.7	1	4	0.084
S5	1.7	1.3	3	1.4	1	0.261
IR = 0.05						

Weaknesses	W1	W2	W3	W4	W5	Relative priority
W1	1	1.7	1.5	1.3	1.3	0.045
W2	7	1	2	6	4	0.445
W3	5	1.2	1	4	3	0.287
W4	3	1.6	1.4	1	1.5	0.071
W5	3	1.4	1.3	5	1	0.160
IR = 0.08						

TABLE 4 Final and relative weights of each SWOT factor and its sub-factors.

Factor	Factor's priority	Sub-factor's	Relative priority	Sub-factor's overall priority
Opportunities	0.284	O1	0.063	0.018
		O2	0.111	0.032
		O3	0.226	0.064
		O4	0.362	0.103
		O5	0.228	0.065
Threats	0.170	T1	0.099	0.017
		T2	0.309	0.053
		T3	0.435	0.074
		T4	0.118	0.020
		T5	0.040	0.007
Strengths	0.073	S1	0.038	0.002
		S2	0.507	0.037
		S3	0.111	0.008
		S4	0.084	0.006
		S5	0.261	0.019
Weaknesses	0.473	W1	0.045	0.021
		W2	0.445	0.210
		W3	0.287	0.136
		W4	0.071	0.034
		W5	0.160	0.076

important threat to saffron expert development during the COVID-19 pandemic, with a weight of approximately 43%. The T2 sub-factor ranked second. The weight of this factor was approximately 31%. The sub-factors of T4, T5, and T1 with weights of 0.118, 0.099, and 0.04 ranked third, fourth, and fifth, respectively.

In the next step, the final importance of factors included within each SWOT group (sub-criteria) was obtained separately. The fifth column of Table 4 shows the weight of the sub-criteria with regard to all criteria, which is obtained by multiplying the criteria weight by the column of the relative weight. The least important sub-criterion was the S1 factor with a weight of 0.3%. The most important sub-criterion was W2 with a weight of 21%. This factor had the highest weight in the related group. The sub-factors of W3 and O4 ranked second and third, respectively. Sub-factors S4 and S1, with weights of approximately 0.6 and 0.2%, respectively, had the least importance. It can be said that the sub-factors included in weaknesses are the most important factors and the most effective sub-factors in the evaluation of strategies because approximately 47% of the weight was related to this sub-factor. It should be mentioned that weaknesses were the first priority in comparison to other factors and criteria. The sub-criteria of opportunity, with a weight of approximately 28%, were placed in the next priority. The least important sub-criterion was strength, with a weight of approximately 7.2%. The other priorities were S2, S5, S3, and S4. Sub-factors included in threats with a weight of approximately 95% constituted the final weight. Therefore, to determine the strategy

during the COVID-19 pandemic, it is first necessary to consider factors included in opportunities and weaknesses and to implement strategies that decrease the effect of factors included in weaknesses, in addition to using opportunities or applying them.

In general, the abovementioned sub-criteria can be divided into three groups: economic, structural, and technical. The first group involved technical managerial issues with a weight of approximately 55%. The other group was related to structural issues, with a weight of approximately 34%. The other group was related to economic factors with a weight of 11%. It can be said that factors included within weakness were considered by the experts, and the sub-factors of opportunity should be considered to execute the strategies of Iran's saffron development during the COVID-19 pandemic. The sub-factors of strength had very low potential, and their strategies might have had the least influence. Hence, it is desirable to apply strategies that provide some opportunities following the factors selected for them. By multiplying the last columns of Table 2 with those in Table 3, the overall priority of each sub-factor is calculated. The prioritizing strategies were similar to those used in this procedure. By considering the average of the pairwise comparisons recommended by the expert team, the relative priority of alternative strategies was calculated with respect to each sub-factor included in each SWOT.

Finally, Expert Choice software was used to calculate the overall priority of each alternative. As shown in Table 5, according to priorities of strategies in terms of saffron export development during the COVID-19 pandemic based on the AHP-SWOT method, "Performing marketing research in universities" and "Creating international associations and using anti-COVID-19 tools" were the most important approaches to developing Iran's saffron position during the COVID-19 pandemic in global markets, and "Supporting the private sector in export" had minimum weight. With regard to the four priorities of factors and their sub-factors by considering the final weight, it is expected that the WO strategy was considered as the first priority, and with regard to the relative weight of WT strategies, they were given higher priority, but such results were not obtained. First, the strategies are scored according to the views and comments of experts, and scoring is performed mentally. The second reason is that it is better to use the ANP model to evaluate the results again, as this model measures the dependency between the factors and sub-factors.

4.2 ANP analysis

The ANP method was used to identify the ranks of the six strategies in the second proposed approach. This method also uses specific results from the AHP method. A pairwise comparison of SWOT factors based on the AHP analysis (Table 2) was used in this regard. In addition, a dependency analysis was conducted between the SWOT factors for the external and internal environments based on the dominant proposal in the expert interview forms. The dependencies among SWOT factors are shown schematically in Figure 3. Moreover, expert opinions were used to investigate the interaction effects between the factors. The results of the dependence matrix (W2) were obtained for this phase. The interdependent priorities of the SWOT factors (Wf) are shown in Equation 1, which

TABLE 5 Relative importance of AHP.

Strategy	Overall priority
SO1	0.214
ST1	0.202
WO1	0.160
SO2	0.146
WT2	0.143
WT1	0.134

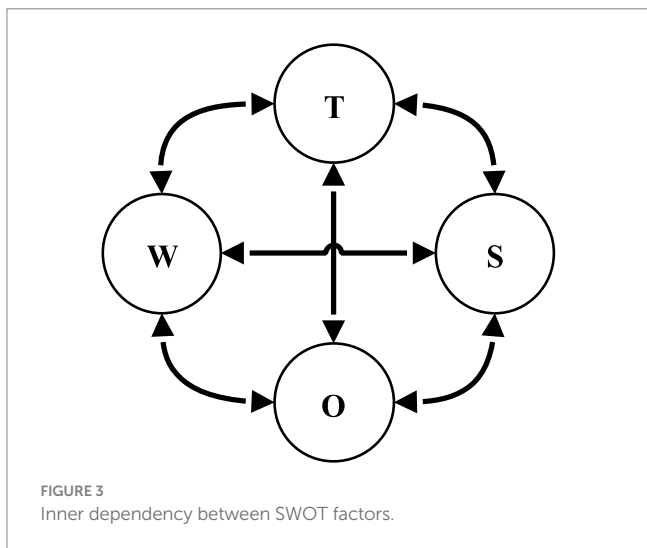


FIGURE 3 Inner dependency between SWOT factors.

is calculated by multiplying W2 by the vector of the importance degree of the SWOT factors (W1).

$$\begin{aligned}
 Wf = W2 \times W1 &= \begin{pmatrix} S & W & O & T \\ S & 0 & 0.591 & 0.563 & 0.316 \\ W & 0.413 & 0 & 0.178 & 0.154 \\ O & 0.331 & 0.294 & 0 & 0.532 \\ T & 0.272 & 0.119 & 0.254 & 0 \end{pmatrix} \\
 \times \begin{pmatrix} S & 0.073 \\ W & 0.473 \\ O & 0.284 \\ T & 0.170 \end{pmatrix} &= \begin{pmatrix} S & 0.493 \\ W & 0.107 \\ O & 0.254 \\ T & 0.148 \end{pmatrix} \tag{1}
 \end{aligned}$$

As shown in Table 6, the weight of each SWOT dimension in the ANP method was different from that in the AHP method. With regard to the second column of the table, strengths had the highest weight in the ANP method, and weaknesses had the lowest weight. The factors included in threats and opportunities ranked second and third, respectively, with weights of 0.245 and 0.148, respectively. Approximately half of the weight of these factors' (50%) belonged to strength. The weakness constitutes approximately 14% of the total weight. Therefore, it can be said that in the internal environment of Iran's saffron, strengths had a higher rank, and strategies based on strengths were more effective and influential. In an external environment, factors included within opportunities can overcome

factors included within threats in terms of weight according to the view of experts. Hence, strategies using available strengths and opportunities must be applied during the COVID-19 pandemic. In the AHP method, weaknesses and threats had the highest importance, while the factors included within opportunities and strengths had the highest importance in the ANP method, and with regard to Iran's saffron conditions and the COVID-19 pandemic, it is expected that strengths and opportunities can be used more than threats and weaknesses. Hence, it seems that the ANP method is more efficient because it measures the dependency between factors and sub-factors.

The third column of the table demonstrates the sub-factors of a related group, and the fourth column shows the relative weight of each sub-factor in the related group. In the strength factor group, S2 had the highest weight, while S5 and S3, with the weights of 0.261 and 0.111, ranked second and third, respectively. S1, with a weight of 0.038, is the least important. The ranks of the sub-factors were the same in terms of priority compared to the AHP method. Another group comprises the sub-factors included in the weaknesses. W2, W3, W1, and W4 had the highest and lowest importance values, respectively. The technical managerial issue had the highest weight in both methods. The ranks of W3 and W5 were the same for the two methods, and only W1 and W4 had different priorities. In terms of opportunity sub-factors, it should be noted that O4 and O1 had the highest and lowest importance, respectively, and the priority of the other factors is observed in the table. It had the same ranking as that of the AHP method. T3, T2, T4, T5, and T1 had the highest and lowest importance values, respectively. These results are similar to those obtained using the AHP method.

In the next step, the final importance of the sub-criteria of the SWOT factors was obtained separately. The fifth column of the table shows the weight of the criterion with regard to all criteria, and it is obtained by multiplying the criteria weight by the relative weight, and it shows the final weight. The least important sub-criterion was related to W1 with a weight of 0.5%. S2, with a weight of 25%, was the most important sub-criterion. This factor had the highest weight among all the related groups. The sub-factors S5 and O4 ranked second and third, respectively. The sub-factors of W4 and T5, with weights of 0.8 and 0.6%, respectively, were placed in the least important priority. The other priorities and final weights of the sub-factors are presented in Table 6. It can be said that the sub-factors included within strengths were the most important sub-factors to evaluate the strategies during the COVID-19 pandemic because approximately 49% of the weight is related to these sub-factors. It should be mentioned that strengths were prioritized over other factors or criteria. The sub-criteria of opportunities with a weight of approximately 25% were placed as the next priority. The least important sub-criterion was the weakness criterion with a weight of approximately 11%. The other priorities were W2, W3, W5, W1, and W4. Sub-factors included in the threats with a weight of approximately 15% constituted the final weight. Therefore, to determine a strategy during the COVID-19 pandemic, it is necessary to consider the strength and opportunity factors and adopt strategies that maximize the use of opportunities while using their strengths.

In general conclusion, the mentioned sub-criteria can be divided into three groups, including economical, structural, and technical managerial groups. The first group included structural factors, with a weight of approximately 62.8%. Another group was related to technical

TABLE 6 Relative and final weights of each SWOT factor and its sub-factor by using ANP.

Factor	Factor's priority	Sub-factor's	Relative priority	Sub-factor's overall priority
Opportunities	0.254	O1	0.063	0.016
		O2	0.111	0.028
		O3	0.226	0.057
		O4	0.362	0.092
		O5	0.238	0.060
Threats	0.148	T1	0.099	0.015
		T2	0.309	0.046
		T3	0.435	0.064
		T4	0.118	0.017
		T5	0.04	0.006
Strengths	0.493	S1	0.038	0.019
		S2	0.507	0.250
		S3	0.111	0.055
		S4	0.084	0.041
		S5	0.261	0.129
Weaknesses	0.107	W1	0.045	0.005
		W2	0.445	0.048
		W3	0.278	0.030
		W4	0.071	0.008
		W5	0.16	0.017

TABLE 7 Relative importance of ANP.

Strategy	Overall priority
WO1	0.202
SO1	0.177
SO2	0.174
ST1	0.152
WT2	0.148
WT1	0.146

managerial factors with a weight of approximately 30.1%. The last group was related to economic factors with a weight of approximately 7.1%. It can be said that the weight of factors related to technical managerial factors was higher than that of structural factors in the AHP method, and it is necessary to implement the strategies during the COVID-19 pandemic to improve technical managerial processes. In the ANP method, the weight of factors related to the structure was higher than that of technical managers; therefore, strategies must be implemented to improve the structure of saffron exports during the COVID-19 pandemic.

Finally, Expert Choice software was used to calculate the overall priority of each alternative. As shown in Table 7, according to priorities of strategies in terms of saffron export development during

the COVID-19 pandemic based on the ANP-SWOT method, “Encouraging investors to attract investments and develop infrastructures” and “Performing marketing researches in universities” were the most important approaches to developing Iran’s saffron position during the COVID-19 pandemic in global markets, and “Supporting the private sector in export.” had minimum weight. It is observed that the strategies used in the factors included in opportunities and strengths had a higher priority. This result was expected, and the WT strategies had a lower priority with respect to the low weight of factors included in threats and weaknesses. In addition, the WO strategy was the first priority. As can be seen from Table 6, structural factors are the most important in terms of Iran’s saffron export development during the COVID-19 pandemic; therefore, the execution of this strategy is necessary.

4.3 Comparing AHP and ANP method

After performing ANP and AHP analyses, the results of the strategic priorities of the two methods were compared with each other, and the results are presented in Table 8. Differences were observed between the first four priorities, but no differences were observed between the last two priorities. In ANP methods, the first strategy gave importance to using opportunities to reduce the effects of weaknesses. In the second, third, and fourth strategies, using strengths was very important. These strategies must be considered for future studies. Given the high weight of the factors included in opportunities and strengths, in both methods, defensive strategies (performing the strategy to reduce the effects of weaknesses and threats) had the least importance.

5 Conclusion

Saffron is a highly valued medicinal food product that is of significant importance to countries involved in its export and industrial production. Currently, Iran is the world’s leading producer of saffron, while countries such as Spain capitalize on its value through expert processing. This study examines the saffron supply chain to identify and rank the factors influencing the strategy of entering the international saffron market during the COVID-19 pandemic.

We analyzed the strengths, weaknesses, opportunities, and threats using both the Analytic Hierarchy Process (AHP) and Analytic Network Process (ANP) methods and compared the results. In the AHP approach, the sub-factors categorized as weaknesses were found to be the most critical, accounting for approximately 47% of the total weight in the strategy evaluation. This indicates that weaknesses had a higher priority than other factors. The sub-criteria related to opportunities, with a weight of approximately 28%, ranked next in importance. The least significant sub-criteria were those related to strengths, which accounted for approximately 7.2%. The most important sub-criterion was W2, with a weight of 21%. Consequently, to formulate a strategy during the COVID-19 pandemic, it is essential to focus on addressing weaknesses while leveraging the available opportunities.

In terms of the ANP method, the strength sub-factor emerged as the most crucial, representing 49% of the total weight in the strategy

TABLE 8 Comparing the priorities of AHP and ANP methods.

Strategy	Symbol	ANP	AHP	ANP	AHP
Performing marketing research in universities	SO1	0.177	0.214	2	1
Introduction and supply by the fairs and sales offices	SO2	0.174	0.146	3	4
Encouraging investors to attract investments and develop infrastructures	WO1	0.202	0.160	1	3
Creating international associations and using anti-COVID-19 tools	ST1	0.152	0.202	4	2
Supporting the private sector in export.	WT1	0.146	0.134	6	6
Guaranteed price and shopping	WT2	0.148	0.143	5	5

evaluation. Strengths were prioritized over other factors, followed by sub-criteria of opportunities, which accounted for approximately 25% of the weight. The least significant were weaknesses, contributing only 11%, while threats accounted for approximately 15%. Therefore, to develop a strategy during the COVID-19 pandemic, it is vital to focus on the strengths and opportunities to maximize their potential while minimizing their weaknesses.

The findings of our study differ significantly from those of Abolhassani et al. (2020), Aghdaie et al. (2012), Noorulhaq and Maulavizada (2018), and Shahnoushi et al. (2020), who primarily focus on the economic aspects of saffron production and trade. While these articles delve into economic analyses, production, and marketing challenges, our article examines strategic considerations during the COVID-19 pandemic using the Analytic Hierarchy Process (AHP) and Analytic Network Process (ANP). The submitted research uniquely identifies the criticality of weaknesses and opportunities for strategy development using AHP, while ANP reveals strengths as the most important factor. This comparative approach and emphasis on pandemic-related strategic considerations distinguish the submitted article from other literatures.

According to the priority of saffron export development strategies during the COVID-19 pandemic based on the AHP-SWOT method, “Performing marketing research in universities” and “Creating international associations and using anti-COVID-19 tools” were the most important approaches to developing Iran’s saffron position during the COVID-19 pandemic in global markets, and “Supporting the private sector in export” had minimum weight. Moreover, to the priority of saffron export development strategies during the COVID-19 pandemic based on the ANP-SWOT method, “Encouraging investors to attract investments and develop infrastructures” and “Performing marketing researches in universities” were the most important approaches to developing Iran’s saffron position during the COVID-19 pandemic in global markets, and “Supporting the private sector in export.” had minimum weight. A comparison of the results of strategy priority in ANP methods showed that it is important to use the opportunities in the first strategy in order to decrease the weakness effects. Using strengths is very important in the second to fourth strategies, and it is necessary to consider these strategies because of the high weight of factors included in strength and opportunity. Defensive strategies had the lowest importance for both methods. When solving a problem under dependency assumptions, the ANP

method considers possible dependencies among factors, sub-factors, and alternatives.

Therefore, it is recommended that future studies address the export of agricultural and non-agricultural products in addition to saffron. The supply chain of other products during the COVID-19 pandemic can also be examined, and the best strategies are identified and prioritized (Rahbari et al., 2024b; Zhao et al., 2024). Other important factors, such as environmental factors, can also be considered when examining such issues (Sadati-Keneti et al., 2023; Dorcheh and Rahbari, 2023; Pasandideh et al., 2023; Heidari et al., 2019). In addition, other methods can be used to examine the supply chain strategies for saffron and other products (Jafari et al., 2023; Di Vita et al., 2023; Pourahmadi et al., 2023). Among these methods, the QSPM-SWOT and fuzzy SWOT methods can be used and compared to the methods used in this study.

Although our study offers valuable insights into the saffron supply chain during the COVID-19 pandemic, we acknowledge several key limitations. The analysis relies on expert opinions and secondary data, which may introduce bias and limit the generalizability of the findings. Additionally, although robust, the ANP-SWOT model depends on specific assumptions regarding factor relationships and weightings, potentially influencing the results. The study’s focus on a specific geographical context and time period limits the extrapolation of the findings to other regions and future scenarios. Further research is needed to validate the findings with comprehensive empirical data, conduct a longitudinal analysis, and investigate the framework’s applicability in different contexts.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors without undue reservation.

Ethics statement

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. Written informed consent from the [patients/participants OR patients/participants legal guardian/next

of kin] was not required to participate in this study in accordance with the national legislation and the institutional requirements.

Author contributions

FR: Conceptualization, Data curation, Investigation, Methodology, Writing – original draft. MR: Software, Supervision, Validation, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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