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Identification and Prioritization of Factors Affecting the Success of the Agricultural Supply Chain in Iraq

Hasan. Al-Zaidi [1], Omid Ali. Adeli[2*], Mohammad Hasan. Maleki[3]

[1] Ph.D. student, Department of Economics, Faculty of Economic and Administrative Sciences, University of Qom, Qom, Iran
[2] Associate Professor, Department of Economics, Faculty of Economic and Administrative Sciences, University of Qom, Qom, Iran
[3] Professor, Department of Management, Faculty of Economic and Administrative Sciences, University of Qom, Qom, Iran

* **Corresponding author email address**: oa.adeli@qom.ac.ir

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ABSTRACT

Iraq, due to its multiple potentials, has considerable capacity for the growth of the agricultural sector. However, this sector in Iraq faces numerous challenges and difficulties. One of these challenges is the absence of an efficient agricultural supply chain. The present study seeks to identify the factors affecting the success of the agricultural supply chain in Iraq. In terms of orientation, this research is an applied study, and methodologically, it is a mixed-method study. The theoretical population of the study consisted of experts in the field of supply chain and agriculture in both Iran and Iraq. Sampling was conducted based on the expertise of specialists and through judgmental selection. The data collection tools in this study included interviews, expert validation questionnaires, and prioritization questionnaires. The methods employed in this research were thematic analysis, fuzzy Delphi, and CoCoSo. This study was carried out in three stages. In the first step, 21 factors were extracted through expert interviews and thematic analysis. In the second step, these factors were screened using the fuzzy Delphi method. Eleven factors were found to have desirable defuzzified values and were selected for final prioritization. The screened factors were then evaluated using the CoCoSo method. The prioritized factors included: strengthening agricultural and food-related startups and knowledge-based companies in Iraq, the decision-making system in the agricultural supply chain, and the linkage of Iraqi universities with the agricultural sector.

Keywords: *Agricultural products, Supply chain, Success, Prioritization*

1. Introduction

Agriculture has historically played a central role in the development, stability, and sustainability of societies, particularly in countries such as Iraq where fertile lands and strategic geographic positioning provide the potential for significant agricultural productivity. Yet, despite this potential, Iraq's agricultural sector has faced longstanding challenges, including war-related destruction, inadequate infrastructure, water scarcity, and limited modernization (Abd-El-Mooty et al., 2016; Maher, 2017). These structural and systemic issues have weakened agricultural supply chains, reduced productivity, and hindered food security in the country (Husain & Al-Heali, 2020). Understanding the factors that influence the success of agricultural supply chains, particularly in contexts characterized by fragility and transition such as Iraq, is thus essential for developing strategies that support sustainable agricultural growth and national food security.

Globally, the management of agricultural supply chains has evolved into a multidisciplinary research area, combining insights from operations management, logistics, sustainability, and information technology (Boyabatlı et al., 2022). Modern agricultural supply chains are not only responsible for efficiently moving goods from producers to consumers but are also expected to address issues of sustainability, transparency, resilience, and social welfare (Chkanikova, 2016; Yadav et al., 2022). The complexity of agricultural supply chains arises from the involvement of multiple actors—including farmers, distributors, processors, retailers, and regulators—as well as the perishable nature of agricultural products, the sensitivity of production to climatic conditions, and the growing influence of consumer expectations (Ge et al., 2015).

In the case of Iraq, sustainable agricultural development has been identified as both a challenge and an opportunity. Studies highlight that Iraq possesses fertile lands and abundant water resources through the Tigris and Euphrates rivers, yet mismanagement, salinity, and lack of infrastructure investment have severely undermined productivity (Mahmud, 2021; Salih & Al-Qaesi, 2018). This situation has created a paradox where Iraq, once known as the "breadbasket of the Middle East," has become a major food importer (Maher, 2017). Addressing this paradox requires not only the enhancement of agricultural production systems but also the establishment of efficient supply chain frameworks that can reduce losses, improve distribution, and integrate modern technological and governance mechanisms (Nosratabadi, 2022).

The concept of **Agri-food 4.0** has emerged as a transformative framework for addressing the shortcomings of traditional agricultural supply chains (Lezoche et al., 2020). This paradigm emphasizes the integration of digital technologies such as the Internet of Things (IoT), blockchain, artificial intelligence, and big data analytics into agricultural processes. The adoption of these technologies facilitates real-time monitoring, predictive analysis, and improved coordination across the supply chain, leading to reduced waste, better decision-making, and enhanced consumer trust (Song et al., 2022; Xu et al., 2025). For Iraq, where inefficiencies, corruption, and lack of transparency have historically plagued agricultural management, the integration of Agri-food 4.0 principles offers a pathway toward greater resilience and sustainability.

Technological innovations, however, cannot succeed in isolation. Research shows that supply chain effectiveness requires strong governance and collaborative approaches among diverse stakeholders (Cao & Tao, 2025). The use of evolutionary game theory in analyzing agricultural supply chain coordination highlights the importance of multi-party collaboration, where farmers, government agencies, distributors, and technology providers must align their incentives to ensure overall system performance (Yan et al., 2020). In contexts such as Iraq, where institutions are in transition and trust between actors may be fragile, collaborative governance models can help balance conflicting interests and create accountability mechanisms.

Another major dimension of agricultural supply chain success lies in **risk management and resilience**. Agricultural production and distribution are inherently vulnerable to climate change, water scarcity, and global disruptions such as the COVID-19 pandemic (Sharma et al., 2020). The pandemic, for example, exposed significant weaknesses in global agricultural supply chains, leading to disruptions in labor, transportation, and market access. It also highlighted the need for more resilient supply chain designs capable of withstanding shocks (Shukla et al., 2023). In Iraq, the combined pressures of climate variability, conflict-related disruptions, and dependency on imports further amplify these risks, making resilience-building strategies indispensable (Abd-El-Mooty et al., 2016; Husain & Al-Heali, 2020).

Blockchain technology has been widely recognized as a powerful tool for addressing transparency and traceability challenges in agricultural supply chains (Alkahtani et al., 2021; Song et al., 2022). By providing immutable records of transactions, blockchain enhances trust between supply chain actors, prevents fraud, and ensures quality standards. In Iraq, where corruption and weak institutional oversight have undermined agricultural development, blockchain adoption can restore confidence and encourage investment. Complementing blockchain, live-streaming and platform-based solutions are being explored to improve the efficiency and accessibility of agricultural markets, allowing farmers to connect directly with consumers and reduce intermediary exploitation (Xu et al., 2025).

Beyond technology, the design and optimization of agricultural supply chains remain central to ensuring efficiency. Optimization models, particularly those considering multi-echelon structures and regulatory frameworks such as cap-and-trade, provide insights into how supply chains can balance cost efficiency, environmental sustainability, and product freshness (Ma et al., 2020). Such models are critical in countries like Iraq where cold-chain infrastructure is underdeveloped and post-harvest losses are alarmingly high (Ge et al., 2015). Strategic optimization therefore not only minimizes waste but also enhances competitiveness in both domestic and international markets.

Human and institutional capacity also play a crucial role. Research emphasizes the challenge of human resource development in Iraq, particularly in sectors such as agriculture where technical expertise and managerial skills are urgently needed (Birks & Sinclair, 2021). The lack of qualified professionals, combined with outdated educational programs, limits the ability of the agricultural sector to adapt to modern supply chain practices. Strengthening educational institutions, promoting agricultural disciplines, and creating linkages between universities and the private sector can therefore significantly improve supply chain performance (Mahmud, 2021; Salih & Al-Qaesi, 2018).

Furthermore, agricultural supply chains must incorporate sustainability and green purchasing principles, particularly given the global shift toward environmentally responsible consumption (Chkanikova, 2016). Food retailers and large agribusinesses increasingly demand sustainable practices from their suppliers, creating pressure for producers and supply chain managers to adopt greener processes. For Iraq, aligning agricultural practices with sustainability standards not only improves export potential but also ensures the long-term viability of natural resources, particularly water and soil (Abd-El-Mooty et al., 2016).

Regional studies on the Middle East emphasize that the future of food supply will depend on balancing local self-sufficiency with international trade integration (Nosratabadi, 2022). Iraq, due to its geopolitical importance and agricultural potential, can play a pivotal role in regional food systems. However, achieving this requires overcoming entrenched inefficiencies, fostering cross-border collaborations, and adopting modern supply chain governance frameworks. Scenario planning approaches, as applied in other sectors such as social security revenue management, provide a useful tool for exploring potential futures and preparing for uncertainties (Arabi et al., 2024). In the context of agricultural supply chains, scenario-based foresight can guide policymakers in Iraq to anticipate risks, identify opportunities, and design adaptive strategies.

Finally, the literature highlights the importance of integrating cooperative strategies into supply chain management. Cooperative approaches, combined with digital technologies, can significantly improve coordination and reduce costs (Alkahtani et al., 2021). For Iraq, where fragmented supply chains and lack of coordination remain serious barriers, cooperative strategies involving farmer cooperatives, financial institutions, and technology providers could drive systemic improvements.

In summary, the success of agricultural supply chains in Iraq depends on a combination of technological innovation, collaborative governance, optimization models, human resource development, sustainability practices, and resilience to risks. The current study builds upon these perspectives to identify and prioritize the key factors influencing the success of Iraq's agricultural supply chain.

2. Methods and Materials

The present study, from the perspective of philosophical foundations, is based on pragmatism; in terms of purpose, it is exploratory; and in terms of orientation, it is applied. Moreover, from the perspective of data collection, it is a field study, and its methodology is mixed-method. In this study, thematic analysis, fuzzy Delphi, and CoCoSo techniques were employed. The fuzzy Delphi and CoCoSo techniques are quantitative in nature, whereas thematic analysis has a qualitative nature.

The theoretical population of the study consisted of faculty members of universities in Iraq and Iran in the field of agriculture and agricultural supply chain (with an academic rank of associate professor or higher), as well as managers and consultants of the agricultural sector in Iraq. Sampling was conducted based on the expertise of specialists in the agricultural supply chain domain, and 10 individuals were selected as the sample. The criterion for determining the sample size in the current study was theoretical saturation. The data collection tools in the study included interviews and questionnaires. Thematic analysis was conducted based on interviews, while the fuzzy Delphi and CoCoSo methods focused on questionnaire-based data collection.

The steps of this research were as follows:

Interviewing experts regarding the factors affecting the success of the agricultural supply chain in Iraq.

Screening the factors affecting the success of the agricultural supply chain in Iraq using the fuzzy Delphi method and distributing expert validation questionnaires.

Prioritizing the factors affecting the success of the agricultural supply chain in Iraq by applying the CoCoSo method.

Providing recommendations for improving the agricultural supply chain in Iraq.

In this study, thematic analysis was used to examine the expert interviews with the aim of extracting the factors influencing the success of the agricultural supply chain in Iraq. Thematic analysis is a qualitative method employed to extract primary and secondary factors from interviews. The steps of thematic analysis are as follows (Braun & Clarke, 2006; Arabi et al., 2024):

Step 1: Familiarization with the data. To enable the researcher to become acquainted with the depth and breadth of the data content, it is necessary to immerse themselves in it. Immersion in the data primarily involves repeated reading of the data and active reading (i.e., searching for meanings and patterns).

Step 2: Generating initial codes. This step begins once the researcher has read the data and become familiar with it. This stage includes generating initial codes from the data. Codes represent a feature of the data that appears interesting to the analyst. The coded data are distinct from themes.

Step 3: Searching for themes. This step involves categorizing different codes into potential themes and organizing all coded data extracts within the identified themes. Essentially, the researcher begins to analyze their codes and considers how various codes can be combined to form an overarching theme. At this stage, some initial codes form main themes, while others form sub-themes, and some are discarded.

Step 4: Reviewing themes. This stage begins when the researcher has created a set of themes and proceeds to review them. This includes two phases of revision and refinement. The first involves reviewing at the level of coded extracts. The second involves considering the validity of themes in relation to the dataset as a whole. If the thematic map works well, one can proceed; if not, the researcher must return to recoding until a satisfactory thematic map is produced.

Step 5: Defining and naming themes. This step begins once a satisfactory thematic map exists. The researcher defines and further refines the themes selected for analysis, then analyzes the data within them. Through this process, the essence of what each theme addresses is identified, and it is determined which aspect of the data each theme captures.

Step 6: Producing the report. This stage begins once the researcher has a set of fully polished themes. It includes the final analysis and writing of the report.

In the present study, the fuzzy Delphi method was used to screen the factors influencing the success of the agricultural supply chain. In the fuzzy Delphi algorithm for screening, it is first necessary to develop a suitable fuzzy scale to fuzzify the linguistic expressions of experts. In this regard, common fuzzy scales can be used. In the current study, a five-point Likert fuzzy scale was employed, which is presented in Table 1.

Table 1

Five-point fuzzy scale in the fuzzy Delphi method

Linguistic variable	Fuzzy value	Triangular fuzzy number
Very low	1~	(0, 0, 0.25)
Low	2~	(0, 0.25, 0.5)
Medium	3~	(0.25, 0.5, 0.75)
High	4~	(0.5, 0.75, 1)
Very high	5~	(0.75, 1, 1)

After screening the factors influencing the success of the agricultural supply chain in Iraq, the next step was prioritizing these factors. In the current research, the CoCoSo technique was used to determine the priorities of the factors influencing the success of the agricultural supply chain. This method, by integrating the information from both the fuzzy Best-Worst method and the fuzzy WASPAS method, ranks the factors with high accuracy and is recognized as one of the most recent and reliable ranking techniques.

The steps of the CoCoSo method are as follows:

Step 1: In this stage, experts' opinions about the importance of each factor influencing the success of the agricultural supply chain are collected using a 10-point scale.

Step 2: The decision matrix data are normalized using the fuzzy method.

Step 3: At this step, based on the following relations, the weighted sum (S) and weighted product (P) values are calculated for each alternative. In the two relations below, Wj represents the weight of the criteria, which is provided as input to the CoCoSo method. The values of Si are obtained using the SAW method, and the values of Pi are obtained using the WASPAS method.

$$S_i = \Sigma (w_j r_{ij}),$$
$$P_i = \Sigma (r_{ij})^{(w_j)},$$

Step 4: In this part, the score of alternatives is derived based on three strategies using the following relations. The first relation describes the arithmetic mean of the WSM and WPM scores, while the second expresses the relative scores of WSM and WPM in comparison with the best options. The third relation is a compromise between the WSM and WPM models. In this relation, λ is determined by the decision-maker, although a value of 0.5 provides significant flexibility.

$$k_{ia} = (P_i + S_i) / \Sigma (P_i + S_i),$$
$$k_{ib} = S_i / \min(S_i) + P_i / \min(P_i),$$
$$k_{ic} = (\lambda(S_i) + (1-\lambda)(P_i)) / (\lambda \max(S_i) + (1-\lambda) \max(P_i)),\ 0 \le \lambda \le 1.$$

Step 5: In this stage, the final score is obtained using the following relation. This relation represents the sum of the geometric mean and the arithmetic mean of the three strategies from the previous step. A higher score (k) for each alternative indicates its superiority.

$$k_i = (k_{ia} k_{ib} k_{ic})^{(1/3)} + 1/3 (k_{ia} + k_{ib} + k_{ic}).$$

3. Findings and Results

The factors influencing the success of the agricultural supply chain were obtained through interviews with experts. The interviews were analyzed using the thematic analysis method. After conducting the interviews with experts, the researchers proceeded with their conceptual analysis. A detailed evaluation of these interviews led to the extraction of the research themes. To clarify and identify the themes, the researcher applied coding. Each interviewee was represented by the letter E, and before the capital letter E, the number referred to the sentence of the respective interviewee. For example, the code 2E5 refers to the second sentence of interviewee number five. The themes of the study are presented below.

Table 2

Factors influencing the success of the agricultural supply chain

Codes related to each factor	Research themes
4E5, 5E9, 3E4	Utilization of specialized managers and consultants
2E2, 2E5	Educational policies in the supply chain
6E2	Technological infrastructure in the supply chain network
8E4, 6E1	Use of Internet of Things technology for supply chain digitalization
9E6, 4E10	Use of blockchain technology for supply chain transparency and product traceability
4E1, 5E8	Use of big data technology for trend identification and risk analysis in the supply chain
10E4	Macro-level agricultural policies in Iraq
1E4, 3E5	Collaboration with leading international agricultural companies
2E7	Strengthening agricultural and food-related startups and knowledge-based companies in Iraq
9E9, 3E6	Banking sector support for agriculture
6E3	Diversification of financing methods in Iraq
4E2	Taxation policies in Iraq
3E1, 3E7	Customs policies in Iraq
1E10	Innovation policies in the agricultural sector
8E9, 7E7	Linkage of Iraqi universities with the agricultural sector
7E6, 1E8	Development of agricultural academic disciplines in Iraq
1E7	Existence of foresight committees in the agricultural supply chain
3E10	Use of global experiences in the agricultural supply chain
6E10, 7E8	Decision-making system in the agricultural supply chain
1E6	Maintenance and repair policies in the agricultural supply chain
5E5, 5E7	Productivity programs in the agricultural supply chain in Iraq

The 21 factors extracted from thematic analysis were screened using the fuzzy Delphi method. At this stage, 10 factors were eliminated, and 11 factors were selected for final evaluation and ranking. Factors with a defuzzified number greater than 0.7 were considered for final evaluation and prioritization using the CoCoSo method. In the current study, 11 factors had a defuzzified number greater than 0.7. The value of 0.7 was taken as the threshold for evaluating and screening the factors influencing the success of the agricultural supply chain. In most studies, the numerical threshold ranges between 0.5 and 0.7; in the present research, the value of 0.7 was selected as the threshold. Table 3 presents the list of factors influencing the success of the agricultural supply chain along with their defuzzified values.

Table 3

Defuzzified Numbers of Research Factors

Research factors	Lower bound of experts' average opinions	Median of experts' average opinions	Upper bound of experts' average opinions	Defuzzified number
Utilization of specialized managers and consultants	0.40	0.46	0.52	0.46
Educational policies in the supply chain	0.55	0.57	0.63	0.58
Technological infrastructure in the supply chain network	0.38	0.46	0.52	0.45
Use of Internet of Things technology for supply chain digitalization	0.78	0.85	0.93	0.85
Use of blockchain technology for supply chain transparency and product traceability	0.74	0.80	0.86	0.80
Use of big data technology for trend identification and risk analysis in the supply chain	0.79	0.86	0.93	0.86
Macro-level agricultural policies in Iraq	0.50	0.56	0.64	0.57
Collaboration with leading international agricultural companies	0.32	0.40	0.48	0.40
Strengthening agricultural and food-related startups and knowledge-based companies in Iraq	0.73	0.80	0.88	0.80
Banking sector support for agriculture	0.76	0.84	0.90	0.83
Diversification of financing methods in Iraq	0.53	0.66	0.71	0.63
Taxation policies in Iraq	0.39	0.44	0.50	0.44
Customs policies in Iraq	0.28	0.35	0.46	0.36
Innovation policies in the agricultural sector	0.68	0.77	0.85	0.77
Linkage of Iraqi universities with the agricultural sector	0.71	0.84	0.92	0.82
Development of agricultural academic disciplines in Iraq	0.74	0.86	0.95	0.85
Existence of foresight committees in the agricultural supply chain	0.78	0.85	0.91	0.85
Use of global experiences in the agricultural supply chain	0.41	0.50	0.55	0.49
Decision-making system in the agricultural supply chain	0.78	0.85	0.90	0.84
Maintenance and repair policies in the agricultural supply chain	0.29	0.36	0.43	0.36
Productivity programs in the agricultural supply chain in Iraq	0.72	0.80	0.86	0.79

Considering the defuzzified numbers of the factors affecting the success of the agricultural supply chain in Iraq, the screened factors are as follows: use of Internet of Things technology for supply chain digitalization (A), use of blockchain technology for supply chain transparency and product traceability (B), use of big data technology for trend identification and risk analysis in the supply chain (C), strengthening agricultural and food-related startups and knowledge-based companies in Iraq (D), banking sector support for agriculture (E), innovation policies in the agricultural sector (F), linkage of Iraqi universities with the agricultural sector (G), development of agricultural academic disciplines in Iraq (H), existence of foresight committees in the agricultural supply chain (I), decision-making system in the agricultural supply chain (J), and productivity programs in the agricultural supply chain in Iraq (K).

Then, the screened factors are prioritized using the CoCoSo method. At first, experts must state their opinions regarding the degree of importance of each factor on a 10-point scale. The decision matrix was formed based on the opinions of 10 experts. These data were normalized using the fuzzy method according to the second step of the CoCoSo technique.

Based on the normalized matrix values, the weighted sum matrix (S) and weighted product matrix (P) were calculated according to the formulas of step three in the CoCoSo method. Table 4 presents the weighted sum matrix values for the factors influencing the success of the agricultural supply chain. The values of the weighted sum matrix were obtained by multiplying the normalized matrix data by the weight of experts' opinions. The weights of all experts' opinions were considered equal to 0.1. This weight was obtained by dividing the number one by ten. Finally, the data of this matrix must be aggregated using the S index. The S index equals the row-wise sum of the weighted sum matrix data. This index is obtained in the same way as the utility of each option in the SAW technique.

Table 4

Weighted Sum Matrix (S) for Research Factors

Research factors	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5	Expert 6	Expert 7	Expert 8	Expert 9	Expert 10	S index
A	0	0.017	0.014	0	0	0	0.029	0.013	0	0.05	0.123
B	0.014	0	0.029	0.038	0.014	0.013	0.029	0.05	0.05	0.05	0.287
C	0.043	0.05	0.071	0.038	0.029	0.05	0.071	0.025	0.067	0.10	0.544
D	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	1.000
E	0.029	0.067	0.057	0.026	0.014	0.013	0.029	0	0.033	0.05	0.318
F	0.029	0.05	0.043	0.038	0.043	0.063	0.086	0.063	0.05	0.083	0.548
G	0.029	0.05	0.057	0.063	0.029	0.075	0.086	0.10	0.033	0.067	0.589
H	0.014	0	0.043	0.026	0	0	0	0.025	0.017	0.05	0.175
I	0.014	0	0.029	0.038	0.029	0.05	0.029	0.025	0.033	0.067	0.314
J	0.071	0.067	0.086	0.075	0.043	0.05	0.071	0.063	0.083	0.083	0.692
			0	0.014	0.014	0.038	0.029	0.013	0	0	0.122

Along with the calculation of the weighted sum matrix data, the weighted product matrix (P) must also be calculated. The formula for calculating this matrix and the P index is similar to the computations of the WASPAS method. To calculate the weighted product matrix, each value of the normalized matrix must be raised to the power of the weight of experts' opinions. The weight of all experts' opinions was equal to 0.1. The values of the weighted product matrix are presented in Table 5.

Table 5

Weighted Product Matrix (P) for Research Factors

Research factors	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5	Expert 6	Expert 7	Expert 8	Expert 9	Expert 10	P index
A	0	0.836	0.823	0	0	0	0.882	0.812	0	0.933	4.286
B	0.823	0	0.882	0.908	0.823	0.812	0.882	0.933	0.933	0.933	7.929
C	0.919	0.933	0.967	0.908	0.882	0.933	0.967	0.871	0.960	1	9.340
D	1	1	1	1	1	1	1	1	1	1	10.000
E	0.882	0.960	0.946	0.874	0.823	0.812	0.882	0	0.896	0.933	8.008
F	0.882	0.933	0.919	0.908	0.919	0.954	0.985	0.954	0.933	0.982	9.369
G	0.882	0.933	0.946	0.955	0.882	0.972	0.985	1	0.896	0.960	9.411
H	0.823	0	0.919	0.874	0	0	0	0.871	0.836	0.933	5.256
I	0.823	0	0.882	0.908	0.882	0.933	0.882	0.871	0.896	0.960	8.037
J	0.967	0.960	0.985	0.972	0.919	0.933	0.967	0.954	0.982	0.982	9.621
			0	0.819	0.823	0.907	0.882	0.812	0	0	5.066

The final score of the factors affecting the success of the agricultural supply chain in the CoCoSo method is obtained using the K index. The calculation of the K index requires computing three indices: Ka, Kb, and Kc. The Kc index is derived from the combination of Ka and Kb. The value of λ in this study was set at 0.5, which is very common in previous research. Finally, the K index is calculated as the sum of the arithmetic mean and geometric mean of the three indices Ka, Kb, and Kc. The values of the four indices for evaluating the factors influencing the success of the agricultural supply chain in Iraq under the CoCoSo method, along with the final ranking of each factor, are presented in Table 6.

Table 6

Four Indices for Evaluating Factors in CoCoSo

Research factors	Ka	Kb	Kc	K	Rank
Use of Internet of Things technology for supply chain digitalization	0.048	2.008	0.4008	1.156	11
Use of blockchain technology for supply chain transparency and product traceability	0.090	4.202	0.746	2.335	8
Use of big data technology for trend identification and risk analysis in the supply chain	0.109	6.638	0.898	3.414	5
Strengthening agricultural and food-related startups and knowledge-based companies in Iraq	0.121	10.530	1.000	4.967	1
Banking sector support for agriculture	0.091	4.475	0.756	2.449	6
Innovation policies in the agricultural sector	0.109	6.678	0.901	3.431	4
Linkage of Iraqi universities with the agricultural sector	0.110	7.024	0.909	3.569	3
Development of agricultural disciplines in Iraq	0.060	2.661	0.493	1.5003	9
Existence of foresight committees in the agricultural supply chain	0.092	4.449	0.759	2.444	7
Decision-making system in the agricultural supply chain	0.113	7.917	0.937	3.932	2
Productivity programs in the agricultural supply chain in Iraq	0.057	2.182	0.471	1.292	10

According to the K index, the prioritized factors are: strengthening agricultural and food-related startups and knowledge-based companies in Iraq, the decision-making system in the agricultural supply chain, and the linkage of Iraqi universities with the agricultural sector. The higher the value of this index for a factor, the more important that factor is assessed. Practical recommendations of the research were developed based on the most important factors influencing the success of the agricultural supply chain in Iraq.

4. Discussion and Conclusion

The findings of this study identified and prioritized the factors influencing the success of agricultural supply chains in Iraq using a mixed-method approach. The results showed that among the screened factors, the three most critical elements were: strengthening agricultural and food-related startups and knowledge-based companies in Iraq, the development of an effective decision-making system within the agricultural supply chain, and the establishment of strong linkages between Iraqi universities and the agricultural sector. These three factors stood out with the highest K indices in the CoCoSo analysis, demonstrating that institutional innovation, systemic governance, and knowledge transfer are central pillars of supply chain success in Iraq. Other important but lower-ranked factors included the use of blockchain and IoT technologies, big data analytics, supportive banking systems, and innovation policies.

These results reflect a broader understanding of agricultural supply chain dynamics in fragile and developing economies, where structural inefficiencies, weak institutions, and capacity gaps limit productivity. The prioritization of startups and knowledge-based companies indicates a recognition that traditional agricultural practices alone are insufficient to meet contemporary food security and sustainability challenges (Maher, 2017; Salih & Al-Qaesi, 2018). Startups bring innovation, agility, and digital integration into the agricultural sector, enabling more efficient production and distribution. This finding is consistent with recent global studies which argue that entrepreneurship and innovation ecosystems are key to advancing agricultural supply chains in the era of Agri-food 4.0 (Lezoche et al., 2020).

The prominence of the decision-making system factor highlights the need for systemic governance and structured coordination among stakeholders. In Iraq, the agricultural sector has historically suffered from fragmented policies, poor institutional oversight, and corruption (Abd-El-Mooty et al., 2016; Mahmud, 2021). An integrated decision-making system ensures that supply chain actors—from farmers to distributors and regulators—can align strategies, share data, and coordinate effectively. This finding resonates with evolutionary game models that emphasize collaborative governance as a mechanism for achieving sustainability in agricultural supply chains (Cao & Tao, 2025). It also supports prior work showing that supply chain coordination, when grounded in consumer behavior and supported by institutional mechanisms, enhances efficiency and reduces systemic risks (Yan et al., 2020).

The third prioritized factor—linkages between universities and the agricultural sector—emphasizes the importance of knowledge transfer, research, and human resource development. Iraq has long faced human capital shortages in agriculture, both in technical expertise and managerial skills (Birks & Sinclair, 2021). Strengthening academic-industry partnerships can facilitate applied research, disseminate technological innovations, and train the next generation of agricultural professionals. Such linkages also support the adoption of sustainability practices, as universities can provide both theoretical frameworks and practical innovations (Nosratabadi, 2022). This finding aligns with broader evidence that capacity building and education are crucial enablers of agricultural supply chain resilience (Mahmud, 2021; Salih & Al-Qaesi, 2018).

The ranking of blockchain, IoT, and big data technologies in the middle tiers of importance suggests that while technological integration is valued, it is seen as secondary to governance and institutional reforms. Blockchain offers immutable transaction records, enabling transparency and traceability (Alkahtani et al., 2021; Song et al., 2022). IoT enables real-time monitoring of agricultural inputs, outputs, and logistics (Lezoche et al., 2020), while big data analytics allow for predictive modeling and risk assessment (Ge et al., 2015). These technologies have been shown to increase supply chain efficiency, but their effectiveness in Iraq depends heavily on the availability of infrastructure, supportive policies, and the willingness of actors to adopt them. The study's results confirm that without strong institutional support and human capital, technological solutions alone cannot transform agricultural supply chains in fragile contexts (Sharma et al., 2020).

The findings also reinforce the importance of risk management and resilience in agricultural supply chains. The COVID-19 pandemic revealed the vulnerabilities of global agricultural systems, particularly in emerging economies (Shukla et al., 2023). In Iraq, disruptions to logistics and market access highlighted the need for resilient systems that can adapt to shocks. Blockchain, IoT, and big data can contribute to resilience by enabling rapid response and flexible adjustments, but their adoption requires systemic readiness (Xu et al., 2025). This confirms that resilience-building must be embedded in both policy frameworks and technological adoption strategies.

The role of supportive financial systems, reflected in the prioritization of banking support and diverse financing methods, is also notable. Access to credit and financial services is a critical enabler for farmers and agribusinesses to invest in modern technologies, infrastructure, and risk mitigation strategies (Mahmud, 2021). The findings suggest that Iraq's financial institutions must play a more proactive role in supporting agricultural stakeholders, echoing evidence from regional studies emphasizing the link between financial access and sustainable agricultural growth (Nosratabadi, 2022; Salih & Al-Qaesi, 2018).

Innovation policies were also identified as relevant factors. In Iraq, where outdated agricultural policies have constrained development, supportive innovation policies can encourage the adoption of modern technologies and green practices (Maher, 2017). Previous research indicates that sustainability in food supply chains depends on both institutional support and inter-organizational relationships (Chkanikova, 2016). By embedding innovation policies, Iraq can create an enabling environment for sustainable agricultural supply chain transformation.

The lower-ranked factors such as customs and taxation policies, while not prioritized, remain important contextual variables. Inefficient customs processes and poorly designed taxation frameworks have long been barriers to agricultural trade in Iraq (Husain & Al-Heali, 2020). These structural challenges reduce competitiveness and hinder integration into regional and global supply chains. Although not considered critical in this study, they represent systemic issues that require policy attention in the long term.

Overall, the results of this study converge with global evidence that successful agricultural supply chains depend on a balanced integration of technology, governance, and capacity-building (Boyabatlı et al., 2022; Yadav et al., 2022). For Iraq, the prioritization of startups, decision-making systems, and university linkages suggests that institutional and human capacity gaps must be addressed before advanced digital technologies can yield their full benefits. The study provides a nuanced understanding that while Agri-food 4.0 technologies are essential for modernization, their adoption must be embedded within a supportive ecosystem of governance, finance, and education.

This study, while providing valuable insights into the prioritization of factors influencing agricultural supply chain success in Iraq, has several limitations. First, the sample size of experts was relatively small, with only ten participants involved in the fuzzy Delphi and CoCoSo evaluations. Although theoretical saturation was achieved, the limited number of respondents may not capture the full diversity of perspectives across different regions, supply chain stages, or institutional contexts in Iraq. Second, the study focused primarily on expert perceptions rather than empirical performance data from existing agricultural supply chains. This reliance on qualitative and judgment-based methods may introduce subjectivity. Third, while the study incorporated advanced decision-making methods such as fuzzy Delphi and CoCoSo, these methods inherently simplify complex realities, potentially overlooking interdependencies among factors. Finally, the study was conducted within a specific national context—namely Iraq—which may limit the generalizability of the findings to other countries with different institutional, cultural, or infrastructural conditions.

Future research should expand the scope of inquiry by incorporating larger and more diverse samples of stakeholders, including farmers, supply chain intermediaries, government officials, and consumers, to ensure a more comprehensive understanding of agricultural supply chain dynamics. Empirical studies measuring actual supply chain performance indicators such as efficiency, resilience, and sustainability would complement expert-based evaluations and strengthen the validity of findings. Moreover, future studies could adopt system dynamics or agent-based modeling approaches to capture the complex interactions between technology adoption, policy frameworks, and market dynamics. Comparative research across different countries in the Middle East could also highlight regional similarities and differences, offering lessons for cross-border collaboration. Finally, longitudinal studies could track the evolution of prioritized factors over time, providing insights into how interventions and reforms affect the agricultural supply chain landscape in Iraq.

For practitioners, the findings suggest several actionable strategies. Policymakers should prioritize the development of agricultural startups and knowledge-based companies by providing incubation programs, financial incentives, and infrastructure support. Establishing robust decision-making systems that enhance coordination and transparency across supply chain actors is essential, particularly through digital platforms and regulatory frameworks. Universities should be more actively engaged in applied agricultural research and partnerships with industry to strengthen human capital and knowledge transfer. Financial institutions should design tailored credit products for farmers and agribusinesses, while innovation policies should promote the adoption of IoT, blockchain, and big data technologies. By aligning these practical measures with the prioritized factors identified in this study, Iraq can significantly strengthen its agricultural supply chain and move toward sustainable food security.

Authors' Contributions

Authors contributed equally to this article.

Declaration

In order to correct and improve the academic writing of our paper, we have used the language model ChatGPT.

Transparency Statement

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Declaration of Interest

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Ethics Considerations

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