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Designing a Model for Intelligent Management of Agri-Businesses Supply Chain

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ABSTRACT

Ensuring food safety, preventing market imbalances of supply and demand, avoiding market inflation, and improving production efficiency and productivity, along with increasing transparency and traceability in distribution networks and supply chains of active agri-businesses, particularly in the field of basic and strategic products such as rice, tea, olives, and citrus, all rely on intelligent supply chain management (SCM). Therefore, the purpose of this applied research was to present a model based on the effective factors of intelligent SCM in agri-businesses and to identify SCM strategies and effective actions. In this regard, in addition to library studies, field studies were conducted through in-depth interviews with 33 experts from both public and private sectors in Guilan, Mazandaran, and Zanjan provinces, selected through theoretical and non-probabilistic sampling. To analyze the data, qualitative data-based and coding methods were employed. The validity and reliability of the data collection tool were confirmed. The research findings identified 1,556 open codes, 75 axial codes, and 9 selective codes, which included economic and financial factors, marketing and sales, production and operations, institutional, infrastructure and logistics, communication and information, technological and innovative, climatic, environmental, biological, and political factors. The initial model based on these effective factors was designed using qualitative analysis methods and Maxqda2020 software. After removing 29 sub-factors with a repetition rate of less than 7, the final model was presented based on 46 sub-factors. Finally, 8 supply chain strategies and 34 effective actions for successful intelligent SCM were proposed.

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Introduction

Today, achieving optimal performance has become a central focus for business managers, who seek to attain superior outcomes through various strategies. One such strategy is paying attention to the supply chains of agricultural businesses, as sustainable food supply chains have emerged as a key concern for businesses, government organizations, and consumers (Dwivedi et al., 2020). Moreover, due to the rapid industrialization of agriculture, the growing global demand for food, and increasing concerns about food quality and safety, the concepts of sustainability and supply chain transparency have gained significant importance in the agricultural and agri-food sectors (KumarMangla et al., 2018). What sets the supply chain of these products apart from other industries is the critical role of factors such as product quality, food security, and climatic conditions, as well as the risk of contamination from unsanitary and unsafe conditions, which can jeopardize the health of these products (Rajabzadeh et al., 2021).

Despite the significance of agricultural and food supply chains, these chains face a range of challenges and barriers. For example, Salehi et al. (2021) identified issues such as the lack of proper planning and strategic orientation, an inadequate performance appraisal system, limited knowledge of IT-based approaches, insufficient managerial support and participation, lack of financial support, incompatibility between supply chain structures and information systems, the high number of intermediaries at different supply chain levels, lack of IT infrastructure, high investment costs, resistance to change, insufficient knowledge and skills, underdeveloped qualitative performance, low labor productivity, poor marketing management, and a lack of teamwork in marketing as obstacles to agricultural supply chains.

Similarly, Rajabzadeh et al. (2021) highlighted issues such as farmers' lack of knowledge about product demand, improper planning of harvest time, managerial and technical limitations in storage, and the failure to adopt new technologies. The widespread use of traditional methods, particularly in product storage, also leads to significant agricultural product losses in developing countries. Sepahian et al. (2021) identified shortcomings in the market and marketing systems, improper and unplanned product imports, superficial market analysis, a failure to understand market structures, and weaknesses in identifying the behavioral interactions of market participants as reasons for the failure of agricultural supply chain networks. Khodabakhshi and Nemati (2020) pointed to issues related to pricing, innovation, packaging, raw material quality, marketing, and competition. Zarei et al. (2019) classified barriers into technical-infrastructural, social and service, policy-making, economic, educational and extension, and environmental categories, all of which hinder the development of agricultural product supply chains. Baniasad & Bagheri (2018) mentioned problems such as the lack of a proper structure, numerous intermediaries, and high consumer prices as challenges in the agricultural product distribution chain, exacerbated by the absence of a comprehensive business model.

Alkahtani et al. (2020) highlighted that the lack of development in supply chain management, particularly in alignment with technological and innovation advancements, is a key issue. Additionally, there is a lack of information and product sharing between supply chain partners due to inadequate technology, which results in a disconnection from customers and the continued use of traditional supply chain management approaches. Sharma et al. (2020) also mentioned several challenges, including the difficulty of production operations, seasonality of production, low product standards and quality, trade constraints, inventory storage and traceability issues, inadequate infrastructure, environmental concerns, climate change, unclear rules and regulations, poor management decisions, financial problems, and political instability.

Gazi (2020) identified several challenges

faced by the agricultural supply chain, including inadequate marketing, lack of transportation facilities, high transaction costs, multiple intermediaries, lack of awareness, and other social and economic issues. Ganesh Kumar et al. (2017) noted challenges such as smallholder ownership, high cultivation and marketing costs, scattered agricultural supply chains, poor marketing infrastructure, significant product losses (ranging from 30% to 60%) due to inadequate warehousing and storage, lack of effective packaging and branding, absence of standard certifications, insufficient market information, poor guaranteed purchase prices, low returns and productivity, limited access to financial resources and working capital, and a lack of knowledge regarding the use of fertilizers and pesticides. Additionally, they highlighted farmers' lack of proficiency in asset management, inability to implement appropriate portfolio improvements, and the absence of new technology, all of which contribute to poor product quality.

In this study, the pathology conducted by the researchers revealed that the supply chain for key agricultural and food products—specifically rice, tea, citrus, and olive—from the provinces of Zanjan, Guilan, and Mazandaran, as detailed in Table 1, faces numerous challenges.

Table 1
Supply Chain Challenges of Selected Agricultural Products.

Rice	**Tea**	**Olive**	**Citrus**
• Lack of capital for packaging and modernization (shortage of processing industries) • High costs of packaging, bulk sales and low profit • Violations such as mixing rice by some factories • Lack of financial capacity for standardization in paddy units • Weak supervision of production units • Elimination of the enactment of the national standard • Traditional production and trade practices • Existence of intermediaries and brokers • Small paddy lands • Rising prices of inputs and fertilizers • Rice imports during the harvest season • High product demand and the possibility of imbalance between supply and demand • Low water stress and irregular rainfall	• High cost of tea production • Farmers do not enjoy the benefits of dry tea • Lack of necessary infrastructure in gardens and factories • Lack of factories with new technologies • Low capacity in necessary financial support • High prices of packaging machines and labor costs, small and small tea factories • Consecutive changes in tea industry laws or instability in the tea industry, • Lack of supervision of responsible and monitoring devices on the supply and sale of tea in the market • Weak distribution network of product supply in large and chain stores • Traditional thinking in the manufacturing industry • Low mechanization coefficient and traditional production process from the garden to the factory, • Weakness in packaging, unattractive and without added value • Improper import of low quality tea and supply in elegant and attractive packages	• High production costs • Lack of proper packaging • Improper import and smuggling • Lack of export system • Lack of attention to customer tastes • Lack of industrial units for olive production and processing • Low productivity and yield per hectare • Water shortage problem • Expensive labor • Agricultural pests and frost • Lack of standard warehouse • Improper condition of roads and infrastructure • The presence of brokers and their role in decision-making and decision-making in the field of buying and offering prices • Product quality produced • Product distribution problems in the market	• High production costs • Cut subsidies and lack of support • Lack of proper transport car and container • Weakness in the production and export chain • Lack of large and important sorting units in the province • Lack of liquidity and lack of economic stability • Reduction of investment for conversion factories • Shortage processing industries • Shortage of warehouses and cold storages with high capacity(traditional storage) • The presence of brokers throughout the chain • Weak market monitoring • Lack of guaranteed purchase, gardeners' insurance, lack of purity and incentives for production • Credit problems of manufacturers • Insufficient familiarity of gardeners with modern scientific gardening, use of non-specialists and untrained people • Insufficient knowledge of marketing methods, • Decision-makers' inattention to private sector criticism

According to Table 1, the supply chain of active businesses in the studied agricultural products faces challenges such as issues related to supply and demand, infrastructure and logistics, government, policy and legal concerns, economic and financial constraints, climatic, environmental, and biological factors, political instability, distribution, marketing and sales, technological limitations, and production and operational difficulties. These challenges negatively affect the effectiveness, efficiency, transparency, and traceability of the agricultural business supply chain, leading to minimal market responsiveness and threatening food security. Researchers such as Kumar et al. (2020), Ghazinoori et al. (2020), Kwamega et al. (2018), Ganesh Kumar et al. (2017), Zecca and Rastorgueva (2014), Bavarsad et al. (2019), Babayi Meybodi and Roustapisheh (2017), Sepahpanah et al. (2020), Rajabipoor Meybodi et al. (2021), Baniasad and Bagheri (2018), and Khosravipour and Shoaybi (2020) have emphasized that one of the necessary measures to overcome these problems and improve the performance of agricultural businesses is the adoption of smart supply chain management, which represents a modern approach to agricultural sector management.

Given the importance of managing the supply chain of agricultural businesses and the need for a comprehensive strategy to enhance the efficiency of the supply chains for five key horticultural and agricultural products—rice, olives, tea, and citrus (kiwi and orange)—this study aims to present a model based on factors affecting the intelligent management of agri-business supply chains. This study specifically focuses on the provinces of Guilan, Mazandaran, and Zanjan, which are the main producers of these essential and strategic agricultural products. The model is particularly relevant in light of global challenges such as the Covid-19 pandemic, rising food prices, wars, geopolitical tensions, international sanctions, and the difficulties Iran faces in global trade exchanges, especially with countries exporting agricultural products.

Liturature review

Agri-food Supply Chain (ASC)

The concept of the supply chain was introduced in the 1980s and gained widespread use in the 1990s. This was a period during which, alongside advancements in production capabilities and the application of reengineering models, many business executives realized that improving internal processes and flexibility within a company's capabilities was not sufficient to maintain market presence. Instead, they recognized that materials and services from various suppliers significantly impacted the organization's ability to meet customer needs. As a result, suppliers of parts and materials were required to produce and distribute goods with the best quality and lowest cost. Additionally, product suppliers needed to be closely aligned with producer market development policies. Managers also realized that simply producing a quality product was not enough. It became essential to provide products that met customer criteria (i.e., when, where, and how the customer wanted them) with the desired quality and cost, creating new challenges (Gazi, 2020; Esfahani Zanjani et al., 2020).

In general, a supply chain is a network of information and materials that facilitates the flow of goods and services among supply chain member organizations, transforming raw materials into products and distributing those products to end customers (Gazi, 2020). More specifically, the supply chain consists of activities such as: (1) ordering and purchasing raw materials, (2) converting raw materials into semi-finished and final products, and (3) delivering the final products, ensuring high quality through an effective distribution system (Makinde et al., 2020).

In the context of agriculture and agri-food products, agricultural supply chains encompass development activities from "farm to fork," including agricultural operations such as land cultivation, crop production, processing, production, testing, packaging, warehousing, transportation, distribution, and marketing (Sharma et al., 2020). Agricultural supply chains can also be defined as a network of actors

involved in agriculture, distribution, processing, and marketing of agricultural and horticultural products, from "farm to fork" (Mirabelli and Solina, 2020), or as a set of suppliers of agricultural raw materials and inputs, processing companies, and various retailers (Alkahtani et al., 2020).

Agri-food supply chain management (ASCM)

Supply chain management (SCM) is a broad concept that has emerged from multiple disciplines, including procurement, logistics, transportation, industrial organizations, marketing, strategic management, and more (Sayyadi et al., 2016). Wei et al. (2021), following the perspective of Mentzer (2001), defined SCM as the systematic and strategic coordination of traditional business functions and tactics across the supply chain to enhance the long-term performance of individual companies and the entire supply chain. Makinde et al. (2020) viewed SCM as the coordination and integration of various activities to ensure the optimal flow of raw materials through production and distribution, ultimately satisfying customer demands. According to Weerabahu & Nanayakkara (2019), citing the World Supply Chain Forum, SCM is an approach to integrating key business processes from suppliers that provide value-added products, services, and information to customers and other stakeholders, all aimed at delivering value to the end consumer.

In the context of agriculture, SCM was initially defined by a group of Dutch researchers, primarily from Wageningen University in the Netherlands. In agricultural businesses, SCM focuses on ensuring the timely arrival of agricultural products in the market (Gazi, 2020). From another perspective, agricultural SCM is seen as the management of the relationship between the supply of raw materials for agricultural production, the processing of these materials, logistics, and the distribution of products (Luo et al., 2018). SCM in agribusiness involves managing relationships between businesses responsible for the efficient production and supply of agricultural products, from the farm gate to the consumer, with the aim of meeting consumer requirements in terms of quantity, quality, and price. SCM provides an integrated approach to planning improvements in agricultural production and marketing systems to address future challenges (Chojar, 2009).

Research backgrounds

After reviewing the articles from valid indexes, a total of 56 articles (published between 2005 and 2021) related to supply chain management were collected. After examining the abstracts and findings, 38 articles that were directly or indirectly related to the supply chain management of agricultural products were selected as research references. Due to space limitations, only a few of these articles are presented in Table 2.

Table 2
Research Backgrounds.

Source	Title	Total Info.	Purpose and findings
Chitrakara et al. (2021: 1)	Improvement strategies of food supply chain through novel food processing technologies	Product: Supply chain in food industry	Findings: They concluded that these technologies would make food processing activities smarter, which would ultimately help to run the FSC smoothly during COVID-19 pandemic.
Yang et al. (2021: 54)	Improving vegetable supply chain collaboration: a case study in Vietnam.	Method of analysis: descriptive and analytical	Findings: The study found that cooperative SCs are the most appropriate for Vietnamese farmers. It also identified the key activities needed to engage farmers with cooperative SCs and the mechanisms that the cooperative needs to develop. Cooperative SCs can be e nhanced only when farmers are motivated to engage in SC activities and when the cooperative implements a robust management mechanism.

Soleymani taklimi et al. (2020: 98)	Strategic Planning for Developing Supply Chain of Olive in Roudbar County, Guilan Province	Product: Vegetable supply chain	Findings: To implement supply chain development strategies, practices such as: "promote the planting of high-yielding and customer-friendly varieties", "promote modern irrigation practices such as drip irrigation", "construction of seedling nursery for ease of access to seedlings of high yielding varieties", "the assignment of public land with supportive facilities to increase the area of under cultivation", "encouraging agricultural university graduates to build mechanized orchard through especial support schemes", "organizing olive festivals to promote regional brand and increase sales" were introduced.
Kumar et al. (2020: 1003)	Exploring the relationship between ICT, SCM practices and organizational performance in agri-food supply chain	Country: Vietnam	Findings: The results indicate that ICT and SCM practices (logistics integration and supplier relationships) have a significant relationship. Furthermore, SCM practices (information sharing, supplier relationship and logistics integration) have a significant and positive impact on performance of the organization.
Saetta & Caldarelli (2020: 333)	How to increase the sustainability of the agri-food supply chain through innovations in 4.0 perspective: a first case study analysis.	Method: In-depth study	Findings: The paper identifies technological innovations that can improve distribution logistics and management of the entire supply chains. The paper presents a first survey of companies in the agri-food sector and a preliminary assessment of possible solutions for identifying logistic improvement measured through specific parameters.
Weerabahu& Nanayakkar (2019: 865)	A Best Practice Reference Model for Agricultural Supply Chain for Rice	Product: Olive Supply Chain	Findings: Mechanization, Knowledge and Skills Development, Quality Improvement, Risk Management, Information Availability, Branding, Marketing Network, Market Information Production, Effective Storage Facilities/ Methods, Government Policy Implementation, Cost Reduction, Chain Flexibility, Education and knowledge, prior planning, information technology, infrastructure development, communications development, water management practices and types of rice were identified as key factors in the success of the rice supply chain.
Miri et al. (2018: 89)	Strawberry Supply Chain Analysis in Ramiyan County, Golestan Province	Spatial scope: Roudbar County, Guilan Province	Findings: The development of the strawberry chain is possible by holding local festivals in the harvest season, creating local markets and roadside sales, processing and producing strawberry by-products along with regional brand development. It was also found that communication between farmers and input suppliers in the city eliminates outside brokers and farmers make more profit from production.
Ganeshkumar et al. (2017: 68, 88-89)	Agri-food Supply Chain Management: Literature Review	Analysis Method: SWOT Analytical Framework and Strategic Action Planning Matrix	Findings: Encourage farmers to form associations, consortia, cooperatives and self-help groups to increase resource efficiency; Contract farming; Granting marketing facilities; Efficiency of processing centers; Develop and implement effective agricultural policies in order to create a favorable environment for the rapid development of agriculture and minimize the waste of agricultural products; Creating warehouses with effective facilities; Development of transport fleet, especially in rural areas and development of infrastructure; Encouraging banks and financial institutions to support farmers financially through incentives to invest in rural infrastructure have been introduced as agri-food supply chain management actions.

After reviewing the articles from valid indexes, a total of 56 articles (published between 2005 and 2021) related to supply chain management were collected. After examining the abstracts and findings, 38 articles that were directly or indirectly related to the supply chain management of agricultural products were selected as research references. Due to space limitations, only a few of these articles are presented in Table 2.

Methodology

The present study aligns with the principles of interpretive paradigms and follows the approach of social interpretivism. It is applied in purpose and exploratory in nature. The research employs a qualitative method,

utilizing interviews and data analysis through Maxqda2020 software.

The study adopts grounded theory as its primary strategy, a widely used approach in qualitative research. Data collection involved both library and field methods, with a qualitative approach and semi-structured interview tools applied specifically to the agricultural sector.

Population and sampling

Three provinces—Guilan, Mazandaran, and Zanjan—were chosen for the study due to their comparative advantages and their roles as production and supply centers for selected agricultural products (rice, tea, olives, and citrus). As shown in Table 3, the statistical population comprised public and private sector experts from these provinces. For this study, 33 experts were selected through theoretical sampling using non-probabilistic judgment and snowball methods. Initially, specific experts were interviewed based on the researcher's knowledge and the study's objectives. These experts then recommended others, continuing the sampling process until 33 experts had participated. Sampling ceased upon reaching saturation, where no new information or perspectives emerged. In terms of sample size adequacy, qualitative methods typically require input from a minimum of 15 to a maximum of 60 experts with relevant expertise and interest in the research topic (Grisham, 2009).

Table 3

Population and sampling.

Statistical population and participating units			**Sampling method**
Guilan	Public sector experts	• Agriculture-Jihad Organization in Guilan Province • Rice Research Institute of Iran • Tea Organization of Iran • Tea Research Center of Iran • Fund to support the development of the country's tea industry • Rudbar Olive Research Station • 100 units for olive processing and pakaging	Theoretical sampling (Targeted and snowballing method) Sample size: 33 experts
	Private sector experts	• 156 tea processing units and 35 brands • 100 brands and 1425 rice paddy units • 40 units for citrus sorting and processing • Northern Golden Buds Tea Growers Association • Guilan Tea Traders and Exporters Union • Syndicate of Northern Tea Factories	
Mazandaran	Public sector experts	• Agriculture-Jihad Organization in Mazandaran Province • Syndicate of Northern Tea Factories • Tea offices of Ramsar and Tonekabon counties • Citrus and Subtropical Fruits Research Center	
	Private sector experts	• 12 tea processing units and 35 brands • 500 units for citrus sorting and processing • 950 rice paddy units	
Zanjan	Public sector experts	• Agriculture-Jihad Organization in Zanjan Province • Tarom Olive Research Station	
	Private sector experts	• 32 units for olive processing and pakaging • 16 rice paddy units	

Data collection tool

Data were collected using semi-structured interview tools comprising two sections: demographic information and factors influencing agricultural supply chain management. The demographic section included six questions about the participants' age, gender, education level, sector representation (public or private), professional experience, and province.

The second section focused on nine key factors impacting agricultural supply chain management: Economic and financial factors, Marketing and sales, Production and operational issues, Institutional considerations, Infrastructure and logistics,Technological and innovative aspects, Information and communication,Climatic, biological, and environmental challenges, Political factors.These structured yet flexible interviews provided detailed insights into the effective factors shaping the management of agricultural supply chains in the selected provinces.

Validity and reliability

To confirm the preliminary validity of the instrument, the feedback of university professors was sought. Following minor revisions, the instrument was validated for its content and form. Additionally, the validity criteria proposed by Dolani et al. (2012) were applied to qualitative research, which included aspects such as result analysis, evaluation based on experience and evidence, and apparent outcomes. These checks ensured robust validity. In the library study phase, 58 influencing factors were identified from 38 domestic and foreign studies, while 76 factors were uncovered through interviews, demonstrating the tool's effectiveness with more than 90% success in identifying relevant factors.

For reliability, the Holstie method was employed. This method involves coding the data in two steps to evaluate consistency. The formula used for calculating reliability, expressed as the Percentage Agreement Observed (PAO), is as follows:

PAO=2MN1+N2PAO = \frac{2M}{N1 + N2} PAO=N1+N22MWhere:

M is the number of common coding cases between the two coders,N1 and N2 are the total items coded by the first and second coders, respectively.The PAO value ranges from 0 (complete disagreement) to 1 (complete agreement). A value greater than 0.7 is considered acceptable. This method confirmed the reliability of the data collection tool.

PAO = 2M / (N1+N2)= 2× 69 / (69+78)= 138/ 147 = 0.938

In this study, the interview content was coded by two researchers: the first coder, a university faculty member, and the second coder, a lecturer from Payame Noor University and Jihad University of Guilan. The total coding quantities performed were as follows:

N1 (codes by the first coder): 78N2 (codes by the second coder): 69M (common codes): 69Using the formula for the Percentage Agreement Observed (PAO):

he threshold of 0.7, the reliability of the data collection tool for the qualitative portion of the study is deemed acceptable.

Data analysis

Initially, descriptive statistical methods were employed to explain the demographic information of the interviewees. Subsequently, as depicted in Figure 1, the grounded theory approach, incorporating open, axial, and selective coding, was utilized to develop the initial model (Goldkuhl & Cronholm, 2010).

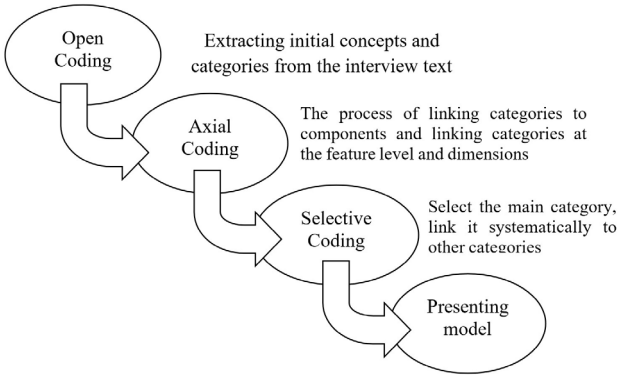

Figure 1. Steps to Perform Coding and Presenting Model.

After identifying the initial factors influencing intelligent supply chain management, a qualitative analysis was conducted using the content analysis method and MAXQDA2020 software. MAXQDA is advanced software designed for qualitative data analysis, particularly useful for researchers employing qualitative research methods such as grounded theory or content analysis. In this study, one objective of the content analysis was to capture insights provided by public and private stakeholders regarding factors influencing the intelligent management of supply chains in active agricultural businesses. First, all interview data were entered into the software. Subsequently, effective dimensions and corresponding indicators were identified, and the relevant content was systematically coded.

Results

Table 4, shows the demographic information of the interviewees.

Table 4
Demographic Information of the Interviewees.

Frequency	Province	Frequency	experience	Frequency	Section	Frequency	Sex	Frequency	Age	Frequency	Level of education
14	Guilan	6	Under 10 years	19	Public	3	Female	1	Under 35 years	6	B.A.
11	Mazan-daran	12	10-20	14	Private	30	Male	16	35-45	17	M.A.
8	Zanjan	10	20-30	-	-	-	-	10	45-55	9	Ph.D
-	-	5	At least 30 years	-	-	-	-	6	At least 55 years	1	Other
33	Total	33	Total	33	Total	33	Total	33	Total	33	Total

According to Table 4, most of the interviewees, with a share of more than 51%, had a master's degree; Most of the interviewees, with a share of more than 48%, were in the age group of 35 to 45 years, and the age groups of 45 to 55 years and 55 years and more were in the next categories with about 30 and 18%, respectively; Most of the interviewees were men with a share of more than 90%. Most of the interviewees accounted for more than 57% of the public sector. Most of the interviewees with a share of about 36% have a history of 10 to 20 years; after that, the interviewees with a history of between 20 and 30 years and a share of more than 30% were in the second place and the interviewees with a share of 42%, 33% and 24% were from Guilan, Mazandaran and Zanjan provinces, respectively; which seems logical considering the establishment of more national organizations and units in these two provinces.

As noted, 33 interviews were conducted using the aforementioned methods with public and private sector experts. A total of 1,556 open codes were extracted from the interview texts and classified into 75 axial codes as sub-categories. In the final step, these 75 sub-categories were consolidated into 9 main categories using the selective coding method. Table 5 presents only the selective and axial codes derived from the 33 interviews.

Table 5
Summary of Axial and Selective Coding Results.

Axial coding		Selective coding
1.	Economic stability and assurance of financial markets	Economic and Financial factors
2.	Effective facilities and financial support	
3.	Attracting and directing domestic and foreign investments	
4.	Economic conditions of supply chain activists	
5.	Connect to the world's financial channels	
6.	New methods of marketing and sales	Marketing and sales factors
7.	Being Quality, organic and standard products	
8.	Competitive price with reasonable profit margin	
9.	Branding and attractive packaging	
10.	Effective and hybrid advertising	
11.	Incentive and various sales plans	
12.	Transparent and cohesive distribution network	
13.	Import control and support of domestic products	
14.	Customer orientation and customer relationship management	
15.	Employing trained, specialized and experienced personnel	
16.	Cooperation with supply and export holdings	
17.	Target market research and identification of target market needs	
18.	Timely and cheap provision of high quality and standard inputs for farmers	Production and operational factors
19.	Utilization of new techniques and methods of planting, holding and harvesting	
20.	Equipping and optimizing production machines and raising the standard of factories	
21.	Access and supply of quality and standard raw materials	
22.	Continuous improvement, quality improvement and organizing of production processes	
23.	Coordinated and integrated production management	
24.	New attitude, expertise and managerial knowledge of manufacturers	
25.	Utilizing educated and specialized manpower and updating skills	
26.	Having strategic and operational production plans and programs	
27.	Integrated management of productivity and production costs	
28.	Construction of conversion industries in a suitable location	
29.	Approving the budget and timely allocation of credits	Institutional factors
30.	Ease of business environment	
31.	Management of import and export of products	
32.	Training, extension and counseling courses	
33.	Appointment of efficient and competent executives	
34.	Law on Organizing Agricultural Lands	
35.	Controlling imports and supervising the fair distribution of inputs	
36.	Governmental support in finance, taxation and insurance areas	
37.	Appropriate monetary and fiscal policies	
38.	Strict implementation of privatization policy	
39.	Alignment of national policies and strategies	
40.	Implementation market regulation policies	

41.	Suitable roads to access lands	Infrastructure and logistics factors
42.	Modern agricultural and irrigation operations infrastructure	
43.	Adequate and suitable space in factories	
44.	Logistics and infrastructure facilities of customs and terminals	
45.	Existence of a multimodal transport fleet	
46.	Standard and suitable warehouses and cold stores	
47.	Existence of permanent markets and exhibitions	
48.	Intra-group and inter-group interaction of supply chain actors (close relations with partners)	Informational and communicational Factors
49.	Interactions between the public and private sectors	
50.	Cooperation and coordination of government institutions	
51.	Communication with universities and research institutes	
52.	Knowledge sharing and transfer in the supply chain	
53.	Long-term contracts between different sectors	
54.	Existence of integrated information systems	
55.	Continuous monitoring	
56.	Agricultural hardware and software technologies	Technological and innovative factors
57.	New technologies for irrigation and resource utilization	
58.	Research and Development (R&D)	
59.	New Information and Communication Technologies in Education	
60.	Access to new scientific and specialized findings	
61.	Marketing and sales hardware and software technologies	
62.	New technologies in the field of processing and production	
63.	Suitable weather conditions	Climatic, biological and environmental factors
64.	Management of water consumption and productivity	
65.	Biological methods of controlling diseases and weeds	
66.	Preservation and restoration of abandoned lands	
67.	Cultivation of cultivars, seedlings and plants compatible with the region	
68.	Organic and environmentally friendly production methods	
69.	Rehabilitation and improvement of soil quality	
70.	Promoting environmental literacy of farmers	
71.	Managing conflicts of interest in policy making	Political factors
72.	Lack of politicking in selecting managers	
73.	Economic diplomacy	
74.	Political and social stability of the country	
75.	Resolving sanctions	

As shown in Table 5, 75 sub-factors were classified into 9 main factors affecting the intelligent management of the supply chain of agri-businesses in the northern provinces. Figure 2 presents the initial model based on these main factors.

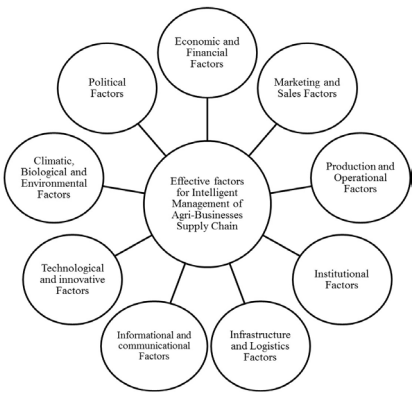

Figure 2. Initial Model for Intelligent SCM of Agri-Businesses.

By using Maxqda2020 software, 1,556 systematic codes were recorded. Each code represents the effect of one of the indicators on the intelligent management of the agri-business supply chain. As specified in the open, axial, and selective coding process, the 1,556 open codes (indicators) were classified into 75 axial codes (sub-factors) and 9 selective codes (main factors). After compiling the initial model, in the second step, to design a more reliable model of factors affecting intelligent supply chain management, it was decided to eliminate sub-factors that had a frequency of less than 7 items, as they were considered insignificant. According to the calculations, 29 sub-factors with a frequency of less than 7 were eliminated, and finally, 46 sub-factors are presented in Figure 3.

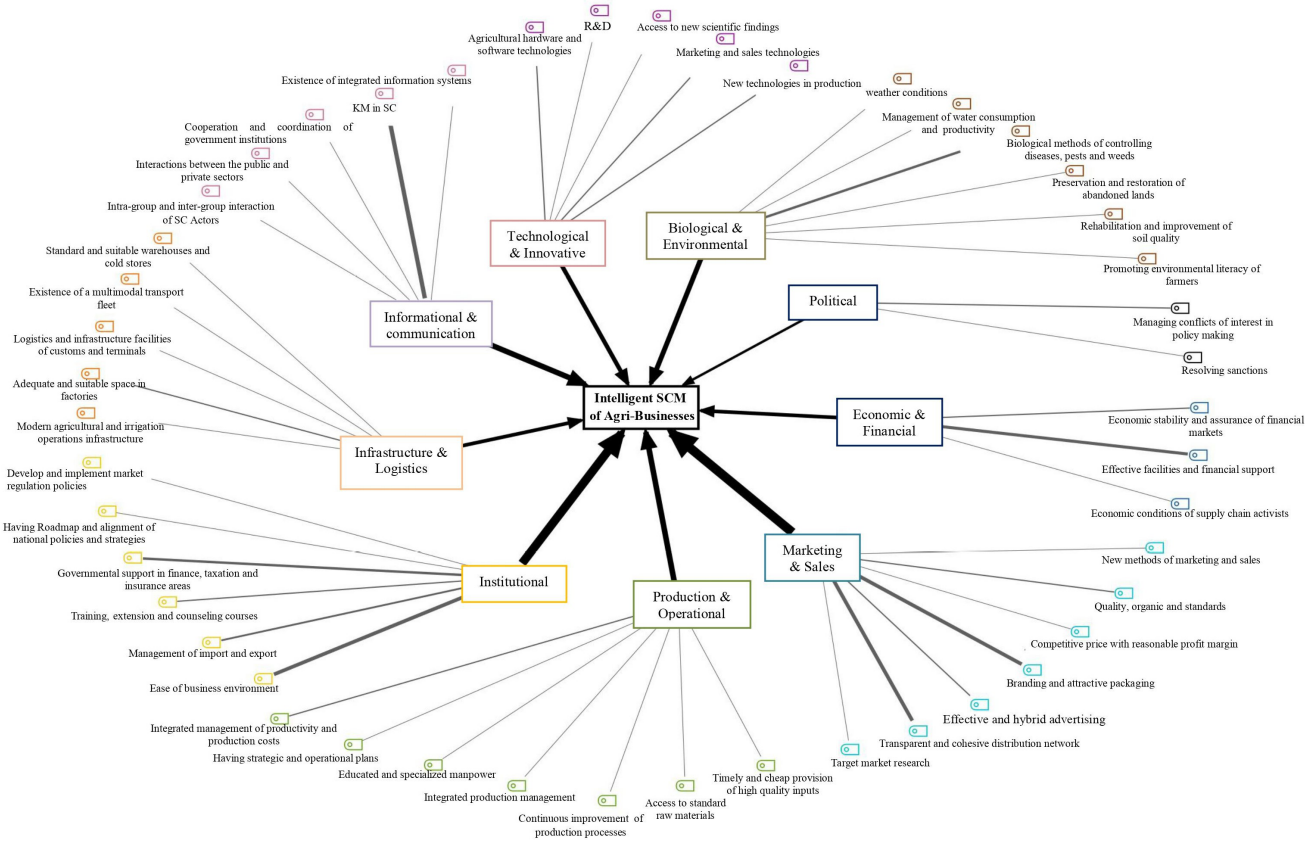

Figure 3. Final Model for Intelligent SCM of Agri-Businesses.

Based on the model in Figure 3, out of 5 economic and financial factors in the initial model, only 3 factors included in the final model and among the final 3 factors, the most frequent repetitions belonged to the factor of effective facilities and financial support; out of 5 political factors in the initial model, only 2 factors included in the final model, and among the final 2 factors, the highest frequency of repetition belonged to the Managing conflicts of interest in policy making factor; out of 12 marketing and sales factors in the initial model, only 7 factors included in the final model, and among the final 7 factors, the highest frequency of repetition belonged to the 2 factors of branding and attractive packaging and a transparent and coherent distribution network; out of 11 production and operational factors in the initial model, only 7 factors included in the final model, and among the final 7 factors, the highest frequency of repetition belonged to the management of productivity and production costs; out of 12 institutional factors in the initial model, only 6 factors included in the final model, and among the final 6 factors, the highest frequency of repetition belongs to the 2 factors: ease of business environment and governmental support in finance, taxation and insurance areas; out of 7 infrastructural and logistic factors in the initial model, only 5 factors included in the final model, and

among the final 5 factors, the most frequent repetitions belonged to the adequate and appropriate space of factories and the condition of their equipment and machinery; and out of 8 communication and information (interactive) factors in the initial model, only 5 factors included in the final model and among the final 5 factors, the most repetition belonged to knowledge management in the supply chain (Knowledge sharing and transfer in the supply chain).

- Out of 7 technological and innovative factors in the initial model, only 5 factors included in the final model, and among the final 5 factors, the highest frequency of repetition belonged to the 2 factors: of application of new technologies in production and marketing-sales.
- Out of 8 climatic, environmental and biological factors of the initial model, only 6 factors were included in the final model and among the final 6 factors, the most frequent repetitions belonged to the biological and new methods of controlling diseases, pests and weeds.

Also, based on the analytical results, it was found that marketing and sales, institutional, communication and information and operational production factors have a higher impact on intelligent supply chain management than other factors.

Discussion

According to the pathology of the selected agricultural business supply chains, it was determined that these chains face challenges such as supply and demand, infrastructure and logistics, government, policy and legal issues, economic and financial factors, climatic, environmental and biological concerns, political factors, distribution, marketing and sales, technological issues, and production and operational difficulties. These challenges lead to market inflation, food security threats, and an imbalance between supply and demand.

Therefore, the purpose of this study was to present a model based on factors affecting the intelligent management of agri-business supply chains in the Guilan, Mazandaran, and Zanjan Provinces. To achieve this objective, field studies were conducted, and semi-structured interviews were held with 33 public and private sector experts. Using the grounded theory method, 1,556 open codes were initially identified. Then, through axial and selective coding, 75 sub-factors were classified into 9 categories: economic and financial, marketing and sales, production and operational, institutional, infrastructure and logistics, communication and information (interactive), technological and innovative, climatic, environmental and biological, and political.

To qualitatively analyze the interview results, the qualitative analysis method and Maxqda2020 software were used. After eliminating sub-factors with a frequency of less than 7, a final model based on 46 factors was developed for the intelligent management of agri-business supply chains.

Conclusion

In conclusion, it is predicted that the successful implementation of intelligent management in the agricultural supply chain will lead to numerous positive outcomes, including: controlling intermediation and market regulation, providing easy access to products, ensuring transparency, tracking and monitoring, increasing efficiency, and facilitating marketing, supply, and sales. It will also improve distribution with reasonable pricing and quality, enhance brand credibility in both domestic and foreign markets, expand processing industries, and improve production processes. Additionally, it will support producers, align the interests of importers, create productive and sustainable employment, reduce rural migration, stabilize agricultural lands, increase competitiveness with foreign products, enhance food security, save resources and water, economize agricultural products, increase value-added output, and reduce foreign exchange outflows. Ultimately, these efforts will contribute to an increase in non-oil revenues and the profitability of all actors

in the agricultural supply chain.

Managerial implications

Based on the research findings, several strategies are necessary to intelligently manage the supply chain of agricultural businesses in the studied products. These include lean supply strategy, agile supply strategy, integration (internal, supplier, customer, and external based on international cooperation), and supporter and facilitator strategies, either separately or in combination.

To implement the lean supply strategy, the following operational actions are recommended:

Establish a strong and coordinated team of chain actors for pathology, troubleshooting, reorganizing the chain, and improving production, marketing, and sales processes. Strengthen transportation infrastructure and implement lean logistics to reduce waste and improve product handling, storage, and maintenance. Provide training, skills, and empowerment to production and industry actors to improve productivity, efficiency, and reduce production costs. Focus on producing export-oriented products, organic items, and customer-friendly products that comply with international standards. For the agile supply strategy, the following actions are suggested:

Continuously evaluate and update distribution networks to ensure timely customer response. Maximize flexibility and optimize production lines to create distinctive products and adjust to market changes (e.g., volume, variety, demand). Develop conversion industries, branding, and brand development to promote added value. To implement the internal integration strategy, the following actions are proposed:

Promote the use of integrated information systems for better management. Accelerate information sharing and ensure instant access to chain data.Organize regular meetings and working groups to address obstacles in the supply chain, with government support. For integrating with suppliers, the following measures are recommended:

Use smart technologies and digital solutions to accelerate communication and information exchange with suppliers. Support the improvement of production by ensuring the timely provision of quality and affordable raw materials.Establish farm-factory complexes (supplier participation in the production process) and select reliable, alternative suppliers. To ensure integration with customers, the following actions are advised:

Use applications and e-commerce to streamline orders, marketing, and sales. Maintain continuous communication with customers and gather feedback. Focus on understanding customer needs in both domestic and foreign target markets, and engage in culture-building, promotional activities, and targeted advertising. For international cooperation, the following steps are suggested:

Direct capital toward overseas cultivation (planting in other countries and importing to Iran). Form partnerships with international holdings and companies across various scientific, research, supply, production, and trade sectors. Attract international investors in agriculture, industry, logistics, infrastructure, and trade services. To implement the supporter and facilitator strategy, the following actions are proposed:

Develop e-government initiatives to eliminate bureaucracy and improve the business environment. Formulate comprehensive and transparent protection laws and regulations. Address corruption and rent-seeking in distribution networks and remove legal barriers for industry players. Identify and allocate potential lands for the development of agro-industrial activities. Optimize the tax system through adjusted corporate income tax rates and exemptions. Design an effective facility system for targeted financing of industry players. Offer targeted subsidies and other financial incentives in budget allocations. Create a development document that outlines a proper pattern for agriculture and industry. Ensure targeted management of exports and imports, combat

smuggling, and support domestic production. Guarantee the purchase of agricultural products. Lastly, for the implementation of the green supply strategy, it is recommended to:

Monitor and manage environmental risks. Optimize agricultural and production activities using applied and laboratory research. Promote green methods and environmentally friendly production resources, such as biological and non-chemical pest control and using native, regionally adapted cultivars

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Conflict of interests

The authors declare no conflict of interest and no financial support from any organizations.

Authors contributions

Sahar Asadzadeh Manjili: idea maker of the article, author of the abstract, introduction, the theoretical foundations and Literature review, conducting field studies and data collection, analysis of data, writing the section of discussion and conclusion, making final corrections.

Firoozeh Hajaliakbari: Corresponding author, Reading and revising the abstract, writing the methodology, designing the research conceptual model, participating in writing the discussion and conclusion, presenting suggestions, participating in the corrections and confirming the last version of manuscript.

Nabiollah Mohammadi: Reading, strengthening suggestions, contributing to corrections and confirming the last version of manuscript.

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