

Developing an Export-Oriented Competitiveness Model for Iranian Hybrid Maize Seed in International Markets Using a Mixed-Methods Approach

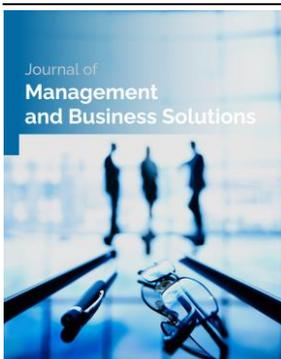
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ABSTRACT

The export competitiveness of agricultural inputs, particularly hybrid seeds, plays a decisive role in strengthening countries' positions in international markets and achieving sustainable agricultural development. The objective of this study is to develop an export-oriented competitiveness model for hybrid maize seed in international markets. This study employed a mixed-methods research design incorporating both qualitative and quantitative approaches. In terms of purpose, the research is applied, and regarding data collection procedures, it is classified as non-experimental research. Data collection instruments in the qualitative phase included library research, review of scholarly articles, and semi-structured interviews conducted with 20 experts and experienced specialists in maize seed production and breeding, agricultural marketing and export, agricultural and international policymaking, and seed enterprise and value chain management. Participants were selected using the snowball sampling method during the period from June to December 2025. Qualitative data analysis was based on Grounded Theory methodology (Strauss & Corbin, 2014) and conducted through systematic coding procedures using ATLAS.ti software. In the quantitative phase, purposive sampling was applied with the participation of 35 experts and specialists, and data were collected through a structured questionnaire. Following extraction of qualitative findings, Kendall's coefficient of concordance was used to evaluate agreement and consistency levels, assess consensus among interviewees and experts, and validate the research model. The data analysis process was conducted through open, axial, and selective coding procedures. The analytical results led to the identification of five principal causal categories, including technical–production factors, economic–commercial factors, managerial–strategic factors, institutional–policy factors, and marketing–branding factors. Intervening conditions were identified in the form of macroeconomic conditions, economic sanctions, fluctuations in the global seed market, technological constraints, and logistical risks. Export-oriented competitiveness of hybrid maize seed emerged as the core category, influenced by contextual conditions such as the seed industry structure, organizational capacity, national technological capability, and regulatory frameworks. Accordingly, strategic actions were extracted, including technological innovation, development of target markets, brand strengthening, reduction of production and export costs, institutional collaboration, human capital development, risk management, and digitalization. The outcomes of implementing these strategies can be interpreted across short-, medium-, and long-term horizons, respectively encompassing increased profitability and export stability, enhanced market share and credibility of Iranian brands, and ultimately strengthened sustainable development and resilience of the country's agricultural exports. The findings of this study can serve as a strategic decision-making foundation for seed production companies, agricultural policymakers, and export development institutions.

Keywords: Hybrid seed; Export; International market; Competitiveness



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Introduction

Global agricultural markets have become increasingly sensitive to the competitiveness of upstream inputs, especially seeds, because input quality, reliability, and price-performance ratios directly shape farm productivity and downstream value creation. In this context, hybrid maize seed has emerged as a strategic agricultural input that links innovation, productivity, and trade outcomes, particularly for countries seeking to diversify exports beyond traditional commodities and to secure more resilient positions in international markets. International organizations emphasize that escaping “commodity dependence” requires upgrading through technology, innovation, and movement toward higher-value activities, which includes strengthening input industries such as seeds and related agro-technologies (1). Policy guidance on seed sector development likewise highlights the importance of regulatory quality, market systems, and institutional coordination to enable seed industries to deliver both domestic productivity and trade-oriented performance (2). As a result, the competitiveness of agricultural inputs is now increasingly treated as a core component of export performance, not merely a domestic production concern.

Competitiveness, however, remains a contested and multi-dimensional construct in management and international business. Classical trade theory operationalized competitiveness through comparative advantage, and the influential concept of revealed comparative advantage (RCA) framed competitiveness as a pattern observable in trade flows rather than only in factor endowments (3). Yet, modern competitiveness thinking goes beyond trade indices and emphasizes how firms and industries assemble resources, capabilities, and governance arrangements to generate sustained performance. Early strategic management perspectives argued that corporate success stems from distinctive capabilities that are difficult to imitate, and that competitive positioning is ultimately grounded in how firms configure resources and commitments over time (4). Complementing this, corporate strategy frameworks stress that performance depends on aligning the organization with its environment through coherent choices about scope, positioning, and implementation (5). In technology-intensive sectors, competitiveness is also evaluated through indicators capturing innovation, productivity, and the ability to absorb and diffuse technology within and across value chains (6). Collectively, these perspectives imply that export-oriented competitiveness in hybrid seed markets cannot be reduced to price alone; it is a function of technological capability, strategic orientation, market access, and institutional fit.

The international seed market illustrates this multi-dimensionality clearly. Hybrid maize seeds compete in global markets on yield potential, genetic stability, stress tolerance, and adaptation to diverse agro-ecologies, alongside pricing, certification, and branding. Empirical work on hybrid maize seed competitiveness underscores that performance in international markets is strongly connected to product characteristics, innovation cycles, and the capacity to respond to differentiated agronomic conditions across importing regions (7). In emerging markets, the competitiveness of agricultural inputs often hinges on a combination of production technology, quality assurance, and the ability to meet trade and phytosanitary requirements, all of which interact with market structures dominated by multinational firms (8). Therefore, for Iranian hybrid maize seed, export-oriented competitiveness must be understood as a capability to deliver reliable agronomic value and compliance, while also managing the commercial and institutional constraints that shape entry and survival in international markets.

A value chain lens is useful for understanding how seed firms translate innovation and production capacity into export performance. Value chain research highlights that competitiveness arises not only within the firm but across coordinated activities—from R&D and breeding to seed multiplication, processing, certification, logistics, marketing,

and after-sales services (9). For seed products, coordination across the chain is particularly critical because seed quality depends on genetics and on process integrity, while export success depends on the chain's ability to document quality, ensure traceability, and deliver reliably. This implies that export-oriented competitiveness is partly a governance problem: actors must coordinate standards, information flows, and investments across organizational boundaries. Consequently, competitiveness models in this sector should incorporate chain-level dynamics, including collaboration with research institutions, regulatory bodies, distributors, and farmers in target markets.

Export competitiveness also depends on how firms enter and manage foreign markets. Internalization theory and foreign market entry strategy analysis emphasize that firms choose entry modes and governance structures to manage uncertainty, protect proprietary assets, and reduce transaction costs (10). For seed firms, proprietary assets may include breeding know-how, parent lines, and quality systems. At the same time, market entry involves compliance costs, distribution design, and trust-building with intermediaries and farmers. These challenges are intensified when firms face institutional barriers, fluctuating exchange rates, and information asymmetries in foreign markets. Therefore, any export-oriented competitiveness framework for Iranian hybrid maize seed must address not only product and production factors but also internationalization choices and the managerial mechanisms that reduce risk and improve control across borders.

A growing body of management research has moved from "static" competitiveness measures toward capability-based explanations of export outcomes. In export marketing, responsiveness to export customers—understood as the ability to sense, interpret, and react to customer needs—has been shown to contribute to export market competitive advantage under certain conditions, reflecting the strategic value of customer-linked capabilities in international competition (11). Similarly, research on proactive market orientation indicates that export performance in SMEs improves when firms anticipate market changes and proactively align offerings and processes with export market requirements (12). Studies in the Iranian context also support capability-centric explanations. For example, market responsiveness has been linked to export performance through the mediating role of competitive advantage in SMEs, suggesting that responsiveness is not only an operational behavior but a pathway to sustained advantage (13). Marketing capabilities and communications can also influence "risky export performance" through competitive strategy mechanisms, indicating that managerial choices in positioning and communication shape outcomes under uncertainty (14). These streams imply that for hybrid seed exports, competitiveness is built through sensing and responding to foreign farmers' preferences, designing credible value propositions, and using communication and branding to reduce perceived risk.

Digitalization and competitive intelligence are increasingly central to competitiveness in dynamic export settings. Digital tools enable firms to monitor competitor activity, track market signals, and adapt strategies more rapidly. Evidence from digital startups indicates that competitive intelligence supports strategic pivots—timely changes in products, markets, or business models—particularly under uncertainty (15). Although seed firms differ from startups, the export environment for agricultural inputs can be turbulent due to exchange-rate volatility, climatic disruptions, and shifting regulations. Thus, digital competitive intelligence can support timely decisions about target markets, pricing, inventory, and customer engagement. In addition, the globalization of digital governance frameworks has created new compliance and data-handling expectations that can influence cross-border service and trade practices; research on regulatory regimes such as GDPR illustrates how digital compliance can reshape export conditions and competitive dynamics, even for firms outside the EU (16). For seed exporters, this broader shift

signals the need to strengthen digital capabilities in traceability, documentation, customer relationship management, and market analytics to enhance credibility and responsiveness.

Export competitiveness is also shaped by macro-level constraints and the ability to remain resilient under shocks. In many contexts, export firms face environmental turbulence—policy changes, sanctions, logistics disruptions, and demand volatility. Recent research shows that organizational resilience can improve the survival prospects of SME exporters, with effects conditioned by entrepreneurial resilience and environmental turmoil (17). For Iranian seed exporters, resilience is particularly relevant because external shocks can affect access to finance, trade routes, and foreign partners' confidence. Resilience, in this sense, is not only a defensive posture; it is an enabling capability that supports sustained participation in export markets, the continuity of relationships, and the ability to recover from disruptions.

Competitiveness studies in agricultural export sectors provide additional insights into determinants and measurement approaches. Research on the competitiveness and determinants of cocoa exports illustrates how export performance is influenced by production capacity, policy conditions, and market access factors, reinforcing the argument that competitiveness emerges from an interaction of firm-level and environment-level drivers (18). While cocoa differs from hybrid seed, both are embedded in global value chains and exposed to price dynamics, compliance demands, and reputation effects. Furthermore, competitiveness in export companies can be strengthened through organizational ambidexterity—balancing exploitation and exploration—and absorptive capacity, which enables firms to acquire and apply external knowledge for advantage (19). In the seed sector, ambidexterity may manifest as the ability to commercialize existing varieties efficiently while simultaneously investing in R&D and breeding for new market segments; absorptive capacity supports learning from international trials, partner feedback, and emerging technologies.

From a national development standpoint, export-oriented competitiveness in hybrid seed can contribute to upgrading toward a knowledge-based economy. Knowledge-based and creative economy perspectives emphasize that economic performance increasingly depends on intangible assets such as knowledge, innovation, and learning systems rather than only physical capital (20). Seed industries embody these characteristics because genetic improvement, quality control, and commercialization depend on scientific knowledge, experimentation, and institutional networks. For Iran, strengthening the export competitiveness of hybrid maize seed can therefore be framed as both an export development agenda and an innovation-led industrial upgrading agenda. This perspective aligns with strategic thinking on the transnational presence of Iranian knowledge-based firms, where successful foreign market presence requires coherent strategic models that combine capability development, market knowledge, and institutional navigation (21).

Despite these conceptual advances, there remains a practical gap in integrating the diverse determinants of export-oriented competitiveness—technical, economic, managerial, institutional, and marketing—into a single coherent model tailored to a specific product-industry context. Hybrid seed exports are shaped by scientific, regulatory, and market factors simultaneously, and the interactions among these factors can vary across target markets and time. Recent work on export diversification and “product space” logic suggests that countries can reshape their sustainable and innovative growth by identifying adjacent export opportunities and building capabilities that support diversification and branding at a national level (22). This indicates that competitiveness is not merely about selling more of the same product; it also involves building pathways for capability expansion,

market upgrading, and portfolio diversification—issues that are relevant for seed firms seeking to move from regional markets to broader international penetration.

Moreover, export potential and market selection involve both opportunities and constraints. Research assessing export potential to demanding markets highlights that firms must simultaneously manage opportunities (market size, demand growth) and challenges (standards, competition, logistics) when designing export strategies (23). For Iranian hybrid maize seed, identifying and prioritizing target markets requires an explicit evaluation of institutional distance, entry barriers such as variety registration and phytosanitary rules, and the structure of competition. This reinforces the need for an export-oriented competitiveness framework that incorporates systematic market selection, risk assessment, and capability alignment.

Within Iran's context, practical efforts to build export competitiveness require coherent strategy and governance at both firm and policy levels. Strategic management perspectives stress fit and coherence: firms need to align product development, cost structures, branding, and distribution with environmental conditions and institutional rules (5). At the same time, the seed sector requires supportive policy guidelines and effective institutions to reduce transaction costs and to improve compliance and quality assurance systems (2). Because export competitiveness is shaped by macroeconomic volatility and international constraints, it also requires technological upgrading and innovation-oriented development pathways to reduce dependence on commodity exports and create sustainable competitiveness (1). This mix of micro-level capability building and macro-level enabling conditions suggests that a mixed-method approach is particularly suitable for modeling export-oriented competitiveness in this context, because it allows the discovery of context-specific categories and their relationships while also validating the model through expert consensus.

Finally, the conceptualization of competitiveness in this study is grounded in the idea that export success is not only a function of comparative advantage but also the result of strategic resource deployment and capability building. Revealed comparative advantage can indicate whether a country has a competitive position in trade, but it does not fully explain how firms develop and sustain competitiveness in technologically complex markets such as hybrid seeds (3). Therefore, an integrative model should connect trade competitiveness logic with strategic management and value chain perspectives, incorporating firm capabilities (innovation, market responsiveness, competitive intelligence), institutional and policy factors, and environmental turbulence. In addition, such a model should reflect how export-oriented competitiveness translates into performance outcomes—market penetration, brand credibility, economic returns, and resilience—consistent with contemporary export management research (11, 12, 17).

Accordingly, the aim of this study is to develop and validate a mixed-methods model of the export-oriented competitiveness of Iranian hybrid maize seed in international markets by identifying its causal conditions, contextual and intervening factors, strategic responses, and resulting outcomes.

Methods and Materials

This study adopts a mixed-methods research design integrating qualitative and quantitative approaches. In terms of purpose, the research is applied, and regarding the method of data collection, it is categorized as a descriptive, non-experimental study. In order to interpret and develop an export-oriented competitiveness model for Iranian hybrid maize seed in international markets, the personal perspectives of a group of experts and experienced specialists were examined. These participants were active in the fields of maize seed production and breeding,

agricultural marketing and export, agricultural and international policymaking, and seed enterprise and value chain management, each possessing at least ten years of professional experience and demonstrated achievements in the relevant domain. Data were collected through in-depth semi-structured interviews with 20 members of the identified statistical population using the snowball sampling technique. It should be noted that theoretical saturation was achieved after the fifteenth interview, and thereafter most information and data began to repeat; however, interviews continued until the twentieth participant to ensure robustness and the possibility of identifying additional insights. Interviews were conducted in a semi-structured format, beginning with core questions concerning the export-oriented competitiveness of Iranian hybrid maize seed in international markets, while subsequent questions were designed dynamically based on respondents' answers during the interview sessions. Interviews continued until theoretical saturation was fully confirmed. The study sought to employ the Grounded Theory research strategy to provide a clear conceptual representation of key factors, strategic actions, and consequences associated with export-oriented competitiveness of Iranian hybrid maize seed in international markets within a comprehensive model. Accordingly, the following questions were posed to interviewees: (1) What causal and contextual factors contribute to the formation and strengthening of export-oriented competitiveness of Iranian hybrid maize seed in international markets? (2) How can the central phenomenon of export-oriented competitiveness of Iranian hybrid maize seed in international markets be explained, and what dimensions characterize it? (3) In response to causal, contextual, and intervening conditions, what strategies and actions should be adopted to enhance export competitiveness of maize seed? (4) What consequences does the implementation of export-oriented competitiveness strategies for hybrid maize seed generate for exporting firms, target markets, and the national seed industry? Following the interviews, transcripts were carefully prepared, and alongside interview data, secondary documents were used to strengthen theoretical interpretation. Prior to conducting interviews, structured conceptual frameworks were established. Each interview lasted approximately 40 minutes to one hour. After data collection, information was systematically analyzed and organized into tabular formats based on coding principles.

Table 1. Characteristics of Interview Participants

No.	Position Title	Area of Expertise	Organization/Institution
1	R&D Manager, Pars National Agro-Industry Company	Maize seed breeding and production	Pars National Agro-Industry Company
2	Export and Marketing Manager	International marketing	Pars National Agro-Industry Company
3	Technical Manager, Seed Division	Technical production and operations	Seed Production Unit
4	Head of Seed Science and Technology Research Center	Seed research and technology	Specialized Seed Research Institute, Ministry of Agriculture
5	Faculty Member, Plant Breeding	Plant breeding and biotechnology	Tarbiat Modares University
6	Head of Quality Assurance Unit	Standards and quality control	Reputable Domestic Seed Company
7	CEO, Private Seed Export Company	Export management	International Private Seed Company
8	Senior Expert, International Affairs	Policy and foreign trade	International Affairs Office, Ministry of Agriculture
9	President, Iran National Seed Association	Seed industry development	Iran Seed Association
10	Senior Expert, Iran Chamber of Commerce	Agricultural exports	Iran Chamber of Commerce, Industries and Mines
11	Brand and Marketing Manager	Branding and advertising	Pars National Agro-Industry Company
12	Agricultural Export Development Consultant	Marketing and market development	Export Consulting Firms
13	Head of Specialized Seed Quality Control Laboratory	Quality control	Reference Laboratory, Ministry of Agriculture
14	Legal Affairs Expert	Commercial law and policymaking	Company Legal Department

15	Leading Large-Scale Maize Farmer	Practical production and market experience	Large Private Agricultural Sector
16	Successful Regional Seed Exporter	International trade	Seed Export Companies
17	IT Manager	Value chain digitalization	Pars National Agro-Industry Company
18	Representative of Export Institution/Export Guarantee Fund	Export finance and insurance	Export Guarantee Fund
19	Head of Agricultural Planning and Budget Organization	Policy and institutional support	Agricultural Planning and Budget Organization
20	University Professor in International Agricultural Trade	International trade and marketing	University of Agricultural Sciences and Natural Resources

Member-checking strategies were also implemented to ensure the credibility of findings. The obtained results were reviewed and analyzed with six subject-matter experts, and both the findings and their interpretations were approved. For interview data analysis, all interviews were audio-recorded to enable precise review and interpretation of participants' viewpoints. After confirmation of theoretical saturation, interview data were analyzed using ATLAS.ti software through systematic coding procedures based on the Grounded Theory approach following Strauss and Corbin (2014), leading to development of the research model.

In the quantitative phase of the study, following extraction of qualitative findings, Kendall's coefficient of concordance was employed to evaluate the level of agreement, consistency, and consensus among interviewees and experts, as well as to validate the proposed model.

The validity instrument included a back-and-forth iterative process. The most appropriate judges of data validity and conceptual confirmation during interviews were the interview participants themselves. Accordingly, through detailed analysis of each interview and iterative comparison prior to conducting subsequent interviews, continuous data refinement and correction served as the most significant criterion for ensuring data validity. The developed model was evaluated using the criteria of applicability and fitness, which are commonly employed in Grounded Theory studies for assessing validity. Test–retest reliability was applied to assess reliability, referring to the consistency of data classification over time. This index is used when a coder performs coding of the same text at different time intervals. Accordingly, selected interviews were re-coded after 30-day intervals. High agreement between coding results at two different time points confirmed research reliability. For inter-coder reliability calculation, several interviews were selected and re-coded within specified time intervals, and identified codes were compared across the two periods.

$$\text{Reliability Percentage} = (\text{Number of Agreements} \times 2) / \text{Total Number of Codes} \times 100$$

Table 2. Coding Results

No.	Interview Code	Total Codes	Agreements	Disagreements	Inter-Coder Reliability
1	M15	14	5	3	71%
2	M16	13	5	2	76%
	Total	27	10	5	74%

Based on the table above, the total number of codes recorded by researchers was 27, with 10 agreements and 5 disagreements across the two time periods. Inter-coder reliability for interviews conducted in this study was calculated as 74%. Since this value exceeds the accepted threshold of 60%, coding reliability is confirmed.

In this study, a researcher-developed questionnaire was designed based on the identified factors. Validity and reliability concepts were employed to assess the credibility of the questionnaire. To evaluate content validity, the questionnaire was initially provided to six experts specializing in maize seed production and breeding, agricultural marketing and export, agricultural and international policymaking, and seed enterprise and value chain

management. After incorporating expert feedback and implementing necessary revisions, 46 items were retained from the initial 50-item questionnaire. Questionnaire reliability was assessed using SPSS software and Cronbach's alpha test. The criterion for reliability confirmation was obtaining a Cronbach's alpha value greater than 0.70. All items achieved values above 0.70; therefore, no questions were removed. Following confirmation of validity and reliability, questionnaires were purposively distributed among 35 experts and specialists, and ultimately 31 completed questionnaires were collected and analyzed.

Findings and Results

Open coding is an analytical process through which codes, concepts, and categories are identified, and their characteristics and dimensions are discovered within the data. Open coding consists of three stages. In order to conduct an in-depth examination of research resources and information, initial codes are first identified. In subsequent stages, following analytical examination, these codes are first categorized into concepts and then organized into broader categories. The following table presents a sample of the open coding process.

Table 3. Sample of Open Coding

No.	Statement/Concept Extracted from Interview	Initial Code	Abstract Concept
1	"Domestic seeds perform well in some regions but are not recognized in foreign markets."	Weak brand recognition	Export branding deficiency
2	"Exchange rate fluctuations prevent us from offering fixed prices to foreign buyers."	Export price instability	Economic risk
3	"Variety registration in target countries is costly and time-consuming."	Difficulty of international variety registration	Institutional export barrier
4	"Our seeds have high compatibility with the climate of neighboring countries."	Climatic adaptability of seed	Technical competitive advantage
5	"There is no specific support for seed exports compared to other products."	Weak policy support	Policy gap

Following completion of open coding and identification of the characteristics and dimensions of subcategories, the categorization of concepts within the framework of axial coding was undertaken. In this study, "export-oriented competitiveness of Iranian hybrid maize seed in international markets" was identified as the central category representing all categories. In most interviews, participants directly or indirectly referred to different dimensions of export-oriented competitiveness of Iranian hybrid maize seed in international markets. At this stage, the main objective was to identify relationships among classifications derived from open coding, which was conducted based on the paradigmatic model and played a crucial role in the theory development process.

In the third phase of qualitative data analysis, selective coding was employed to refine categories and organize them into a coherent and integrated theoretical framework. During this stage, categories and concepts requiring revision or improvement were refined. The following sections explain the rationale for identifying and selecting the central category within the designed model.

During the processes of data collection and analysis, and with the objective of identifying the central phenomenon of export-oriented competitiveness of Iranian hybrid maize seed in international markets, various driving, enabling, and influential factors were identified. This dimension of the model focuses on events and factors that lead to the emergence and development of the central phenomenon.

Table 4. Extracted Codes and Causal Concepts of the Study

No.	Main Category	Subcategories	Initial Codes
1	Technical– Technological Factors	Seed quality and purity	High genetic purity – uniform growth and performance – resistance to environmental stresses
		Production technology and plant breeding	Use of modern plant breeding technologies – application of biotechnology in variety improvement – automation-based mass production
		Innovation and product development	Development of new varieties aligned with target markets – improvement of performance indicators – genetic diversity among varieties
2	Economic Factors	Cost and pricing	Competitive production cost – flexible export pricing – reduction of logistics costs
		Economies of scale and investment	Mass production and reduction of unit cost – investment in modern production lines – access to low-cost financial resources
		Profitability and return on investment	High return on investment – potential for long-term sustainable profitability – reduction of financial risks caused by market fluctuations
3	Managerial Factors	Export planning	Targeting regional markets – formulation of export operational plans – monitoring competitors and market trends
		Supply chain management	Coordination among production, packaging, and distribution – inventory optimization – reduction of transportation losses
		Strategic decision-making	Long-term export orientation – evaluation of risks and opportunities – flexibility in responding to market changes
4	Institutional and Policy Factors	Government support	Export financial and tax incentives – production and export subsidies – export insurance and guarantees
		Laws and regulations	Facilitation of licensing processes – stability of commercial and customs regulations – compliance with international technical and quarantine standards
		Trade diplomacy	Membership in regional and international organizations – facilitation of political relations to access markets
5	Marketing Factors	Target market identification	Assessment of farmers' needs in destination countries – analysis of consumer purchasing behavior and decision-making – understanding seed cultivation and consumption patterns
		Branding and product promotion	Development of a national Iranian seed brand – advertising campaigns in specialized media – participation in international exhibitions
		Distribution networks and after-sales services	Development of local and international distribution channels – provision of technical services and farmer consultancy – quality assurance and after-sales support

Intervening conditions refer to a set of general circumstances that influence how strategies exert their effects and may facilitate, moderate, or modify their implementation within a specific context. These conditions function either as enabling or constraining factors for strategies developed within a defined environment. The following table illustrates how these categories were identified in the research model.

Table 5. Extracted Codes of Intervening Factors

No.	Main Category	Subcategories	Initial Codes
1	Macroeconomic Factors	Exchange rate fluctuations	Exchange rate instability, unpredictability of export prices, increased risk in foreign contracts
		Inflation and economic instability	Rising input costs, reduced long-term planning capability, instability of production costs
		International financial constraints	Difficulties in money transfers, banking restrictions, increased financial transaction costs
2	Political and Sanctions Factors	International sanctions	Restricted market access, increased export costs, reduced confidence of foreign partners
		Regional political risks	Instability of political relations, sudden trade policy changes, risk of contract termination
		Trade diplomacy limitations	Weak commercial negotiations, lack of preferential agreements, limited presence in target markets
3	Logistical and Infrastructure Factors	Transportation and transit	High international transportation costs, shipment delays, limited export routes
		Export infrastructure	Weak cold storage infrastructure, shortage of specialized seed warehouses, absence of specialized export terminals

		Customs procedures	Lengthy customs formalities, multiplicity of supervisory agencies, increased clearance time
4	Climatic and Environmental Factors	Climate change	Temperature and precipitation variability, increased seed production risk, reduced performance stability
		Environmental hazards	Drought, pest and disease outbreaks, decline in seed quality
		Natural resource limitations	Agricultural water scarcity, declining soil fertility, pressure on production systems
5	External Technological and Information Factors	Limited access to global technology	Restrictions on technology transfer, technological lag, dependence on domestic technology
		Access to global market information	Weak competitive intelligence, lack of up-to-date market data, limited transparency of global demand
		Speed of technological change	Shortening variety life cycles, continuous need for updating, increasing innovation pressure

Contextual conditions refer to factors beyond the direct control of organizations; however, awareness of these conditions enables organizations to respond appropriately. The following table demonstrates the identification of these categories within the research model.

Table 6. Extracted Codes of Contextual Factors

Main Contextual Category	Subcategory	Initial Codes
Political–Legal Environment	International laws and regulations	Customs and tariff regulations in target countries – phytosanitary regulations – intellectual property and seed registration laws
	Diplomatic relations and agreements	Bilateral/multilateral trade agreements – membership in international organizations – level of political relations with target countries
	Domestic and international political stability	Government stability and macro agricultural policies – regional geopolitical risks – impact of sanctions on global market access
Economic–Market Environment	Structure and competition in the global seed market	Market share of multinational companies – market concentration and monopoly levels – competitors' pricing behavior
	Demand and consumption patterns	Trends in maize consumption (livestock feed, food industries, biofuel) – farmers' technological and quality preferences – buyer price sensitivity
Technological–Ecological Environment	Technological advances in seed production	Breeding technologies – seed production and processing systems – packaging and storage technologies
	Environmental requirements and climate change	Sustainable agriculture standards and carbon reduction – drought resistance and global warming adaptation – regulations related to genetically modified crops
	Logistics and digital infrastructure	Quality of transportation networks and digital customs systems – access to international e-commerce platforms – seed tracking and identification systems

The central category represents a conceptual abstraction of the phenomenon forming the foundation of the research process. Since none of the categories were more abstract than the others, a central phenomenon aligned with the research topic was selected. The following table presents the structure of the central category identified in this study.

Table 7. Core Concepts of the Study

Main Central Category	Subcategories	Initial Codes
Export-Oriented Competitiveness of Iranian Hybrid Maize Seed	Creation of competitive value based on quality and performance	High yield per unit area – genetic stability of varieties – adaptability to diverse climatic conditions
	Market penetration and sustainability in international markets	Sustainable entry into regional markets – maintaining market share against competitors – repeat purchases by foreign farmers
	Cost and economic advantage in exports	Competitive pricing relative to foreign brands – reduction of seed production costs – management of logistics and export expenses
	Brand credibility and target market trust	Recognition of Iranian seed brands in target markets – trust in seed quality and authenticity – satisfaction and loyalty of foreign customers

Strategic alignment of the seed value chain	Coordination among breeding, production, and marketing – integration between research and market – institutional and cross-sectoral collaboration
Long-term competitive sustainability and export development	Continuity of exports in the long term – adaptation to market and climate changes – diversification of export product portfolio

Strategies refer to plans or actions adopted by policymakers, stakeholders, and implementers to achieve export-oriented competitiveness of Iranian hybrid maize seed in international markets. In this study, actions represent operational solutions required for implementing export-oriented competitiveness. The following table presents the strategies identified within the research model.

Table 8. Extracted Codes and Research Strategies

Main Strategic Category	Subcategories	Initial Codes
Competitive Product Development Strategies	Enhancement of seed genetic quality	Increased yield stability – improved resistance to drought and heat stress – genetic uniformity and varietal purity
	Localization of varieties for target markets	Adaptation of varieties to destination-country climates – field trials in target countries – customized breeding based on foreign farmers' needs
	Technological innovation in production	Use of advanced breeding technologies – improvement of seed multiplication and processing – enhancement of packaging and storage technologies
Marketing and International Market Penetration Strategies	Targeted selection of export markets	Focus on regional and neighboring markets – prioritization of markets with fewer barriers – market risk and attractiveness analysis
	Development of Iranian seed export brand	Creation of a reliable brand identity – emphasis on quality and competitive advantages – utilization of standards and certification labels
Cost Management and Pricing Strategies	Direct engagement with foreign customers	Interaction with farmers and distributors – provision of technical after-sales services – training and transfer of cultivation knowledge
	Reduction of production costs	Optimization of parental seed farms – improvement of labor productivity – reduction of seed losses
	Competitive export pricing	Lower pricing compared to multinational brands – flexible payment conditions – provision of export incentive packages
Institutional and Network Strategies	Logistics cost management	Selection of optimal transportation routes – consolidation of export shipments – reduction of clearance time and costs
	Cross-sector collaboration	Cooperation between seed companies and universities – interaction with governmental and support institutions – partnerships with foreign companies
	Strengthening the seed value chain	Coordination among breeding, production, and marketing – integration of value chain decisions – reduction of gaps between research and market
Learning and Competitive Sustainability Strategies	Utilization of agricultural diplomacy	Leveraging commercial attaché capacities – participation in international exhibitions
	Learning from export experiences	Analysis of past failures and successes – documentation of export knowledge – continuous refinement of strategies
	Human capital development	Specialized training of human resources – recruitment of breeding and international marketing experts – enhancement of managerial skills
	Focus on long-term sustainability	Development of sustainable exports – adaptation to climate and market changes – diversification of export product portfolio

The implementation of strategies leads to specific outcomes. The influence of contextual categories, intervening factors, and the application of executive strategies related to export-oriented competitiveness of Iranian hybrid maize seed in international markets can enhance the international competitiveness of Iranian seed and promote the sustainable development of seed exports. The following table presents the research outcomes.

Table 9. Outcomes

Main Outcome	Subcategories	Initial Codes
Enhancement of International Competitiveness of Iranian Seed	Improvement of competitive position in the global market	Increased capability to compete with foreign brands – improved image of Iranian products – reduced dependence on imports
	Increased trust in target markets	Satisfaction of foreign farmers – repeat purchases – customer loyalty
Sustainable Development of Seed Exports	Stability and continuity of exports	Reduced export fluctuations – sustained market presence – increased predictability
	Expansion of target markets	Increase in destination countries – penetration into new markets – expansion of distribution networks
Improvement of Economic Performance of Seed Companies	Increased profitability	Growth in foreign currency revenues – improved return on investment – reduction of overall costs
	Increased organizational productivity	Process optimization – effective utilization of resources – enhancement of operational efficiency
Strengthening the National Seed Value Chain	Institutional integration	Coordination between research and production – alignment of support policies – reduction of institutional conflicts
	Enhancement of innovation capacity	Development of seed technologies – increased plant breeding capability – transfer of technical knowledge
Increased Resilience Against Environmental Shocks	Coping with sanctions	Reduced external dependence – export flexibility – commercial risk management
	Adaptation to climate change	Development of resistant varieties – reduction of production risks – long-term production sustainability

After completing the stages of identifying the central category and establishing relationships with other categories based on the systematic paradigm of Grounded Theory, the designed model was further developed and finalized. The final model represents approaches whose application can increase managers' motivation to pursue export-oriented competitiveness of Iranian hybrid maize seed in international markets. This model is the result of examination, analysis, and interpretation of expert and specialist interviews within the Grounded Theory framework and is illustrated in Figure 1.

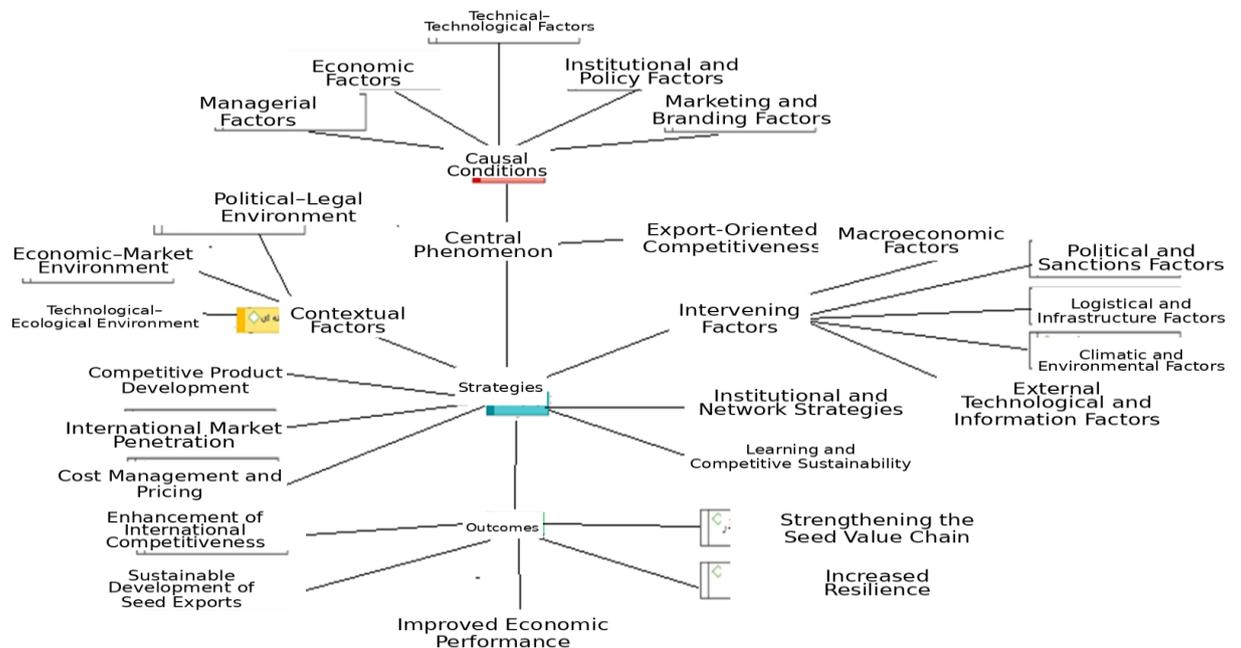


Figure 1. Export-Oriented Competitiveness Model of Iranian Hybrid Maize Seed in International Markets Developed Using ATLAS.ti Software

In the present study, Kendall's correlation test was used to confirm and validate the developed model. For this purpose, experts and specialists selected through purposive sampling in the qualitative phase participated in the consensus evaluation process. After identifying the sample members, a questionnaire was designed based on interview analyses and the proposed model and distributed among the experts. Following collection of questionnaires and analysis of expert opinions, the results of the first round, along with the mean responses and each member's previous evaluations, were redistributed to all panel experts in the second round. The same procedure was repeated in the third round considering the results obtained in the second round. This three-stage approach enabled gradual consensus formation. To determine the level of agreement among respondents, Kendall's coefficient of concordance (Kendall's W) was employed. This coefficient indicates the extent to which experts who ranked several categories according to importance made judgments based on similar criteria and indicators. The value of this coefficient ranges between 0 and 1, where $W = 1$ indicates complete agreement among experts and $W = 0$ indicates complete disagreement. In research methodology literature, a W value between 0.70 and 1.00 is considered indicative of a high and acceptable level of agreement for model validation, as shown in the following table.

Table 10. Results of Consensus Index Across Three Rounds of Kendall's Correlation Test

Dimensions	Components	Kendall Coefficient Round 1	Round 2	Round 3
Causal Categories	Technical–Technological Factors	0.542	0.642	0.874
	Economic Factors	0.485	0.623	0.825
	Managerial Factors	0.571	0.665	0.895
	Institutional and Policy Factors	0.489	0.645	0.820
	Marketing and Branding Factors	0.576	0.620	0.810
Contextual Factors	Political–Legal Environment	0.480	0.670	0.823
	Economic–Market Environment	0.552	0.618	0.870
	Technological–Ecological Environment	0.599	0.621	0.850
Intervening Factors	Macroeconomic Factors	0.523	0.631	0.821
	Political and Sanctions Factors	0.511	0.698	0.851
	Logistical and Infrastructure Factors	0.478	0.522	0.743
	Climatic and Environmental Factors	0.523	0.621	0.885
	External Technological and Information Factors	0.542	0.645	0.826
Outcomes	Enhancement of International Competitiveness of Iranian Seed	0.562	0.541	0.896
	Sustainable Development of Seed Exports	0.576	0.715	0.893
	Improvement of Economic Performance of Seed Companies	0.523	0.728	0.854
	Strengthening the National Seed Value Chain	0.478	0.705	0.885
	Increased Resilience Against Environmental Shocks	0.564	0.711	0.821
Strategies	Competitive Product Development Strategies	0.486	0.589	0.772
	Marketing and International Market Penetration Strategies	0.512	0.621	0.802
	Cost Management and Pricing Strategies	0.573	0.705	0.821
	Institutional and Network Strategies	0.523	0.728	0.772
	Learning and Competitive Sustainability Strategies	0.599	0.631	0.826
Total		0.563	0.644	0.815

Based on the above table and the acceptable level of consensus achieved among specialists regarding the components and the developed model, it can be concluded that the proposed model possesses adequate validity.

Discussion and Conclusion

The findings of the present study provide an integrated explanation of export-oriented competitiveness of Iranian hybrid maize seed in international markets by revealing a systemic interaction among causal factors, contextual conditions, intervening forces, strategic responses, and performance outcomes. The qualitative and quantitative results jointly demonstrate that competitiveness in the seed export sector is not determined by a single variable such as price advantage or technological superiority, but rather emerges from the alignment of technological capability, managerial competence, institutional support, market responsiveness, and environmental adaptability. This systemic interpretation confirms contemporary competitiveness theory, which argues that export success results from a configuration of capabilities embedded within broader value chain and institutional environments rather than isolated firm-level strengths (5, 9).

One of the most significant findings concerns the dominant role of technical–technological factors as causal drivers of competitiveness. Participants emphasized genetic purity, yield stability, innovation in plant breeding, and adaptation to diverse climatic conditions as core determinants of export success. This result aligns with studies demonstrating that hybrid maize competitiveness in global markets depends primarily on technological performance and agronomic reliability rather than solely commercial positioning (7). Agricultural input competitiveness research similarly indicates that product quality, innovation capability, and compliance with international standards constitute decisive export advantages in emerging economies (8). The prominence of technological factors also reflects the transformation toward knowledge-based agricultural industries, where scientific capability and innovation capacity serve as the main sources of sustainable advantage (20). Hence, the findings confirm that export-oriented competitiveness in hybrid seed markets is fundamentally technology-driven.

Economic factors formed the second major causal dimension identified in the model. Competitive pricing, economies of scale, access to financial resources, and long-term profitability were found to influence export competitiveness significantly. These findings are consistent with classical and modern competitiveness frameworks, which emphasize efficiency and cost advantage as essential components of revealed comparative advantage in international trade (3). At the same time, the results extend this perspective by demonstrating that economic competitiveness in seed exports is inseparable from technological and managerial capabilities. Similar conclusions have been reported in agricultural export studies showing that production efficiency and investment capacity interact with institutional and market conditions to shape export performance (18). Therefore, the study confirms that cost competitiveness remains necessary but insufficient without accompanying innovation and strategic management.

Managerial factors emerged as another crucial component influencing export-oriented competitiveness. Strategic planning, supply chain coordination, and long-term decision-making were repeatedly identified as mechanisms enabling firms to translate technical capability into export performance. These findings support strategic management theory suggesting that competitive advantage arises from coherent strategy implementation rather than resource possession alone (4). The importance of export planning and competitor monitoring also aligns with research indicating that export customer responsiveness and proactive market orientation significantly enhance export market advantage (11, 12). In the Iranian context, previous studies have shown that organizational ambidexterity and absorptive capacity strengthen export competitiveness by enabling firms to exploit existing competencies while exploring new international opportunities (19). Accordingly, the present findings reinforce the

argument that managerial capability acts as the conversion mechanism transforming technological potential into international competitiveness.

Institutional and policy factors were identified as critical enabling conditions. Government incentives, stable regulations, trade diplomacy, and export support structures significantly affected competitiveness outcomes. This observation confirms policy-oriented analyses emphasizing that agricultural export performance depends heavily on institutional frameworks governing quality certification, financing, and market access (2). The results also resonate with global development research highlighting technology policy and institutional innovation as key pathways for escaping commodity dependence and achieving sustainable export growth (1). For Iranian hybrid maize seed, institutional coordination appears particularly important because seed exports involve regulatory approval, phytosanitary compliance, and cross-border collaboration. Thus, competitiveness emerges not only from firm actions but from the effectiveness of national governance systems supporting export activities.

Marketing and branding factors constituted another important causal category revealed in the analysis. Findings indicate that brand recognition, understanding target markets, and development of distribution networks strongly influence export penetration. This supports empirical evidence that marketing capabilities and communication strategies significantly affect export performance through competitive positioning mechanisms (14). Market responsiveness studies further demonstrate that understanding customer preferences and adapting offerings accordingly enhance sustainable export competitiveness (13). The findings also correspond with international research on export diversification and national branding, which shows that brand development can reshape countries' export trajectories and strengthen long-term market presence (22). Consequently, Iranian hybrid maize seed competitiveness requires not only agronomic excellence but also strategic brand-building capable of generating trust among foreign farmers and distributors.

The analysis of contextual conditions revealed that political–legal, economic–market, and technological–ecological environments significantly shape competitiveness outcomes despite remaining largely outside organizational control. These findings align with globalization competitiveness indicators emphasizing that external macro conditions—including trade regulations, technological diffusion, and market structure—strongly influence firm performance in international trade (6). The importance of international regulatory environments is also consistent with research demonstrating how external policy frameworks and regulatory regimes reshape export opportunities and constraints across industries (16). Therefore, successful export-oriented competitiveness strategies require adaptive capabilities enabling firms to respond effectively to contextual uncertainty.

Intervening factors such as sanctions, macroeconomic volatility, logistical constraints, and climate risks were identified as moderating forces affecting the effectiveness of competitiveness strategies. These findings highlight the relevance of organizational resilience in export performance. Studies show that exporter survival and growth depend on resilience capabilities that allow firms to maintain operations under environmental turbulence and institutional uncertainty (17). Similarly, analyses of export potential emphasize that firms must continuously manage risk, uncertainty, and changing market conditions to sustain competitiveness (23). The present results extend these insights by demonstrating that resilience is not merely a reaction to shocks but an embedded dimension of export-oriented competitiveness in the seed sector.

The strategic responses extracted from the grounded theory analysis—competitive product development, market penetration strategies, cost management, institutional networking, and learning-oriented sustainability—provide empirical confirmation of contemporary strategic management models. Internalization theory suggests that firms

enhance competitiveness by organizing cross-border activities in ways that reduce uncertainty and protect strategic assets (10). The identified strategies similarly emphasize coordination across the seed value chain, technological upgrading, and relationship-building with foreign markets. Moreover, the emphasis on organizational learning and continuous innovation aligns with findings showing that competitive intelligence enables firms to adapt and pivot effectively in dynamic markets (15). These results indicate that competitiveness in hybrid seed exports requires ongoing learning processes rather than static competitive advantages.

The outcome analysis demonstrates that successful implementation of these strategies leads to measurable benefits, including improved international competitiveness, sustainable export growth, enhanced economic performance, strengthened value chain integration, and increased resilience against environmental shocks. These outcomes reflect broader development perspectives asserting that upgrading agricultural input industries can stimulate innovation-led growth and long-term economic transformation (24). Additionally, the linkage between export competitiveness and organizational performance supports empirical evidence that strategic alignment between capabilities and market conditions improves export profitability and market sustainability (21). Thus, the findings confirm that export-oriented competitiveness functions simultaneously as a firm-level performance mechanism and a national development pathway.

The quantitative validation using Kendall's coefficient further strengthens the credibility of the proposed model. The increasing agreement levels across Delphi rounds indicate convergence among experts regarding the relevance and interdependence of identified dimensions. This gradual consensus formation reflects the complexity of competitiveness phenomena, which require iterative evaluation and expert judgment. The validated model therefore integrates theoretical insights from trade theory, strategic management, value chain analysis, and export marketing into a coherent framework applicable to technology-based agricultural exports.

Overall, the discussion suggests that export-oriented competitiveness of Iranian hybrid maize seed should be understood as a dynamic ecosystem composed of technological innovation, strategic management, institutional support, market intelligence, and resilience capabilities. The study advances existing literature by providing a context-specific yet theoretically grounded model linking causal drivers to strategic actions and measurable outcomes. By integrating classical comparative advantage theory with contemporary capability-based and innovation-driven perspectives, the findings contribute to a more holistic understanding of competitiveness in agricultural input exports.

This study is subject to several limitations. First, the qualitative phase relied on expert perceptions, which, although valuable for theory development, may introduce subjective bias. Second, the sample size of experts, while appropriate for grounded theory and Delphi validation, limits generalizability to all seed firms or agricultural export sectors. Third, environmental conditions such as sanctions and macroeconomic instability may change over time, potentially affecting the stability of identified relationships. Finally, the model was validated primarily through expert consensus rather than longitudinal performance data, which restricts causal inference regarding long-term export outcomes.

Future studies could test the proposed model quantitatively using large-scale datasets across multiple seed companies or agricultural input industries. Comparative cross-country research may reveal how institutional environments influence export-oriented competitiveness differently. Longitudinal studies examining how competitiveness evolves over time under changing technological and political conditions would also enhance theoretical robustness. Additionally, integrating digital transformation variables, sustainability metrics, and climate

adaptation indicators may provide deeper insights into emerging competitiveness drivers within global agricultural markets.

Managers of seed companies should prioritize technological innovation, market intelligence systems, and coordinated value chain management to strengthen export competitiveness. Policymakers are encouraged to design stable regulatory frameworks, export incentives, and international cooperation mechanisms that facilitate market access for domestic seed firms. Investment in branding, international certification, and digital traceability systems can enhance trust among foreign buyers and distributors. Furthermore, strengthening collaboration among universities, research institutes, private firms, and export institutions can accelerate knowledge transfer and support sustainable expansion of hybrid maize seed exports in international markets.

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Authors' Contributions

All authors equally contributed to this study.

Declaration of Interest

The authors of this article declared no conflict of interest.

Ethical Considerations

All ethical principles were adhered in conducting and writing this article.

Transparency of Data

In accordance with the principles of transparency and open research, we declare that all data and materials used in this study are available upon request.

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