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# Developing a Competitive Advantage Acquisition Model for By-Products of the Sugar Industry

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## ABSTRACT

The present study aimed to develop a model of the factors influencing the achievement of competitive advantage for by-products of the sugar industry. The research was conducted using both qualitative and quantitative approaches. In the qualitative phase, a combined content analysis method (inductive–deductive) was employed, while the quantitative phase utilized a causal-correlational design. The statistical population in the qualitative phase consisted of 20 participants, including senior managers and industry researchers, who were selected through purposive non-probability sampling. In the quantitative phase, 151 experts participated through a complete census approach. The findings of the qualitative phase indicated that competitive intelligence, organizational resources, entrepreneurship, governance, and networking play significant roles in achieving competitive advantage for sugar industry by-products. Subsequently, the causal relationships among these factors were analyzed using Interpretive Structural Modeling (ISM). The results revealed that governance serves as the primary driving factor and exerts influence on both networking and entrepreneurship. Networking and entrepreneurship mutually influence one another, and both affect organizational resources. Organizational resources, in turn, act as a driver of competitive intelligence and competitive advantage. These relationships were further examined through Structural Equation Modeling (SEM). The results demonstrated that governance directly and strongly supports networking and entrepreneurship. However, the relationships between networking and entrepreneurship, as well as between networking and organizational resources, were not confirmed. Organizational entrepreneurship was found to have a direct and positive effect on organizational resources. Competitive intelligence was directly and positively influenced by organizational resources. Ultimately, organizational resources were shown to exert a strong and direct positive effect on enhancing competitive advantage. The measurement model was validated through the assessment of convergent validity (AVE), discriminant validity, and reliability indicators, including factor loadings, Cronbach's alpha, and composite reliability. Furthermore, the adequacy of the structural model was confirmed using the coefficients of determination ($R^2$), predictive relevance ($Q^2$), and goodness-of-fit (GOF) indices. The findings indicate that the role of government in the development of by-products is highly significant and serves as the primary driving force. In addition, within organizations, competitive advantage depends on marketing strategies and competitive dynamics. Organizational resources can support market development by providing high-quality products at lower production costs.

**Keywords:** By-products, Competitive Advantage Acquisition, Competitive Intelligence, Networking, Entrepreneurship, Governance, Sugar Industry.


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## Introduction

The sugar industry occupies a strategic position in agro-industrial development because it simultaneously contributes to food supply, rural employment, industrial processing, and the generation of large volumes of residual biomass and processing by-products. In conventional production systems, sugarcane and sugar beet processing generate by-products such as bagasse, molasses, filter cake, beet pulp, vinasse, and other organic residues that are often treated as low-value waste streams, although they possess considerable potential for conversion into value-added products, renewable energy, bio-based materials, animal feed, biochemical inputs, and environmentally sustainable industrial outputs. Recent studies on the valorization of sugar industry by-products emphasize that these materials can support biorefinery development, circular economy models, waste-to-value strategies, and industrial symbiosis across agricultural, energy, construction, packaging, food, and biotechnology sectors (1-5). From this perspective, the competitive position of sugar factories is no longer determined only by sugar output, production volume, or conventional cost efficiency, but also by their capacity to transform by-products into economically viable and marketable products. Studies on sugar beet and sugarcane by-product processing show that residues can be used for the extraction of functional compounds, fermentation-based products, bioenergy, value-added chemicals, and new industrial inputs, thereby creating new revenue streams and reducing environmental burdens (6-9). Therefore, by-product development has become a strategic issue in sugar industry management because it connects sustainability, innovation, industrial competitiveness, and market diversification.

Competitive advantage in agro-industrial sectors is increasingly dependent on the ability of firms to integrate internal capabilities with external market opportunities. Traditional approaches to competitiveness focused primarily on price, scale, and production efficiency; however, contemporary management literature highlights the importance of knowledge-based capabilities, innovation, dynamic capabilities, marketing intelligence, organizational culture, strategic configuration, and digital transformation in sustaining competitive superiority (10-13). In emerging and resource-dependent markets, competitive advantage is also shaped by business analytics, market intelligence, entrepreneurial orientation, network capability, and the ability to respond to unstable institutional and technological environments (14-16). This issue is especially important for sugar industry by-products because these products usually require new market identification, consumer acceptance, product standardization, green branding, pricing strategies, and technological upgrading. Evidence from studies on food-related and agricultural products shows that product quality, marketing strategy, product innovation, and market orientation can strengthen competitiveness when firms actively align production capabilities with customer needs and market expectations (17-19). Thus, gaining competitive advantage in by-product markets requires more than technical conversion of waste; it requires an integrated managerial model that explains how governance, organizational resources, entrepreneurship, networking, and competitive intelligence interact to create market value.

Competitive intelligence is one of the core mechanisms through which firms identify environmental opportunities, monitor competitors, understand customer preferences, assess market trends, and formulate effective strategies. Competitive intelligence enables firms to move beyond reactive decision-making and adopt proactive market positioning based on systematic information collection, analysis, and strategic interpretation. In industries characterized by technological change and market uncertainty, competitive intelligence supports pricing decisions, product differentiation, market segmentation, export planning, and sustainable competitive performance (20-22). In the context of sugar industry by-products, competitive intelligence is essential because producers must evaluate

competing materials, substitute products, green consumer preferences, international market opportunities, and the technological strategies of leading countries. Market intelligence has also been linked with product innovation, pricing capability, international performance, and the creation of sustainable competitive advantage in small and medium-sized enterprises and start-ups (15, 16). Therefore, competitive intelligence can be viewed as a strategic bridge between organizational capabilities and market outcomes, allowing by-product producers to convert internal resources into competitive market positions.

Organizational resources constitute another fundamental pillar of competitive advantage. Resource-based and capability-based perspectives argue that firms achieve superior performance when they possess valuable, rare, difficult-to-imitate, and well-organized resources and capabilities. In current management research, such resources include technological systems, skilled human capital, green competencies, innovation routines, management information systems, knowledge-sharing practices, quality management systems, digital infrastructure, and dynamic capabilities (23-25). For sugar industry by-products, organizational resources are particularly important because by-product valorization requires technical expertise, research and development capacity, investment capability, production process improvement, quality control, supply management, and digital transformation. Studies on innovation and competitive advantage suggest that organizational culture, knowledge sharing, green dynamic capability, and innovation-oriented routines can improve the ability of firms to design new products and respond to market change (12, 13, 23). In addition, digital marketing and data-driven business capabilities provide firms with new ways to reach customers, communicate green value, and strengthen sustainable growth in competitive markets (26). Accordingly, organizational resources are not passive assets; rather, they are strategic enablers that allow firms to transform by-products into standardized, differentiated, and marketable outputs.

Entrepreneurship also plays a decisive role in transforming sugar industry by-products into competitive business opportunities. Entrepreneurial orientation, corporate entrepreneurship, proactiveness, innovativeness, opportunity recognition, and risk-taking have been widely discussed as drivers of firm performance and innovation, particularly in small and medium-sized enterprises (27, 28). In agro-industrial contexts, entrepreneurship is important because value creation often requires the discovery of new uses for existing resources, development of new supply chains, mobilization of local actors, and commercialization of products that were previously considered waste. Agri-business entrepreneurship and innovation can improve farmer income, strengthen value chains, and create new market structures when supported by appropriate policies and networks (29). The role of entrepreneurship in sugar industry by-products is therefore not limited to launching new ventures; it includes creating innovative business models, identifying market gaps, designing new conversion processes, forming partnerships, and introducing products such as bagasse-based panels, bioenergy products, pectin, tissue, animal feed, and biochemical derivatives. Entrepreneurial learning is also shaped by social networks, education, and interaction with other actors, which means that entrepreneurship in this field should be understood as both an individual and ecosystem-level phenomenon (25). Hence, the entrepreneurial dimension of by-product development requires integration with governance, networking, and organizational resource mobilization.

Networking is another critical factor in developing competitive advantage for by-products, particularly because by-product valorization usually depends on inter-organizational relationships rather than isolated firm-level actions. Networking capability enables firms to access information, technology, suppliers, customers, innovation partners, research centers, and institutional support. Systematic reviews of networking capability show that networks contribute to resource acquisition, learning, innovation, market access, and inter-firm collaboration (30). Empirical

studies in manufacturing and small firms similarly indicate that network capability and relational capability can improve performance through product innovation and knowledge exchange (31-33). In the sugar industry, networking is especially important because by-product production requires continuous access to raw materials from parent sugar factories, coordination with technology providers, links with customers and distributors, cooperation with research and development centers, and sometimes the formation of industrial clusters. Networks may also facilitate internationalization, as the pace of innovation can influence the speed at which small and medium-sized enterprises expand into foreign markets (34). However, networking does not automatically create competitive advantage unless it is aligned with organizational capability, entrepreneurial alertness, and strategic objectives (33). Therefore, it is necessary to examine how networking operates within a broader causal structure involving governance, entrepreneurship, organizational resources, competitive intelligence, and competitive advantage.

Governance and government support are particularly important in industries where value creation depends on regulation, infrastructure, investment incentives, environmental standards, and policy coordination. In emerging economies and agro-industrial sectors, government policies can shape market entry, technology diffusion, green innovation, export opportunities, financial support, and sustainable competitive position. Studies show that government support can strengthen the relationship between networking structures and sustainable competitive performance among small and medium-sized enterprises (35). Government support has also been identified as an important factor in sustainable competitive position and firm performance (36). In relation to green innovation, government policies and external governance environments can influence how enterprises adopt sustainable technologies and diffuse innovation among peer firms (37, 38). For sugar industry by-products, governance may include supportive regulations for industrial waste recycling, tax exemptions, investment incentives, export facilitation, intellectual property protection, technical infrastructure, renewable energy support, and policies that encourage industrial clusters and circular production systems. Because by-product production often involves environmental management and waste reduction, governance can also reduce uncertainty, increase investor confidence, and create institutional legitimacy for new green products. Therefore, governance may function as a foundational driver that enables entrepreneurship, networking, organizational resource development, and ultimately competitive advantage.

Despite the growing literature on competitive advantage, innovation, networking, entrepreneurship, and circular economy practices, there remains a need for an integrated model explaining how these factors interact specifically in the context of sugar industry by-products. Prior studies have separately examined competitive strategies in sugar industries, competitive advantage in agricultural sectors, business analytics in emerging markets, product quality and marketing strategy, and by-product valorization (3, 14, 17, 39, 40). However, fewer studies have simultaneously investigated how governance, networking, entrepreneurship, organizational resources, and competitive intelligence jointly contribute to the acquisition of competitive advantage in by-product markets. This gap is important because the successful commercialization of sugar industry by-products depends on a chain of interrelated managerial and institutional factors rather than a single technical or marketing factor. Methodologically, examining such a model requires both qualitative identification of relevant indicators and quantitative testing of causal relationships. In this regard, mixed-method approaches, Interpretive Structural Modeling, and Partial Least Squares Structural Equation Modeling are appropriate for developing and validating complex management models with multiple constructs and causal pathways; PLS-SEM is particularly useful when the research aims to predict endogenous constructs and evaluate measurement and structural models through reliability, validity, path coefficients, $R^2$, $Q^2$, and model fit

criteria (41). Therefore, the present study responds to both theoretical and practical gaps by developing and testing a comprehensive model of factors affecting the acquisition of competitive advantage for sugar industry by-products.

The aim of this study is to develop and validate a model of the factors influencing the acquisition of competitive advantage for by-products of the sugar industry, with emphasis on the roles of governance, networking, entrepreneurship, organizational resources, and competitive intelligence.

## Methods and Materials

The present study was conducted in two qualitative and quantitative phases. The nature of the research in the qualitative phase was based on combined content analysis, including deductive and inductive approaches, and the data coding technique; in the quantitative phase, it was causal-correlational.

The participants in the qualitative phase included senior managers of the sugar cultivation industry, managers involved in national sugar industry planning and programming, managers of start-ups active in research and development and by-product production, entrepreneurs producing by-products from sugar industry waste, and university professors and industry researchers. A total of 20 participants were selected through purposive non-probability sampling until theoretical saturation was reached. The experts had strong professional backgrounds, including full familiarity with the research topic, extensive managerial experience, relevant academic qualifications, and research experience in the production and sale of by-products from sugar industry waste. In the quantitative phase, data were required from experts regarding the current status of the model indicators. Therefore, experts from marketing, research and development, procurement, production and planning, human resources, and environmental units of 14 production units active in bagasse-based MDF production, tissue production from bagasse, pectin production, and sugar recovery from molasses at small and medium scales were selected through a complete census, totaling 151 participants. These individuals were capable of answering the specialized questions of the present study due to their familiarity with the subject.

In the qualitative phase, open codes were identified through a combination of semi-structured interviews with the research participants and a systematic review of the theoretical literature based on the PRISMA protocol. They were then categorized through two stages of axial and selective coding, and the model variables and indicators were formed. Subsequently, the content validity ratio (CVR) was assessed by 20 experts to identify nonessential indicators. The threshold value proposed for evaluating CVR with 20 experts was 0.42.

In the quantitative phase, Interpretive Structural Modeling (ISM) was used to construct the model and determine causal relationships. In this process, 20 experts evaluated the influence of each model variable on the others through pairwise comparisons using the scale of no influence (0), low influence (1), moderate influence (2), high influence (3), and very high influence (4). The stages of Interpretive Structural Modeling were then implemented, and the model was developed. In the next phase, the relationships within the model were tested using Structural Equation Modeling (SEM) and SmartPLS software. In this phase, 151 experts evaluated the current status of each question extracted from the qualitative phase based on a five-point Likert scale, and the data were analyzed.

The validity of the qualitative phase was examined using credibility, dependability, confirmability, transferability, and authenticity to ensure the relevance, meaning, and recurrence of the data and codes. The validity of the quantitative phase was assessed using convergent validity through the average variance extracted (AVE ≥ 0.50) and discriminant validity through the Fornell and Larcker (1981) criterion. The reliability of the quantitative phase was evaluated using Cronbach's alpha (≥ 0.70), composite reliability (≥ 0.70), and factor loading coefficients (≥

0.50). To confirm the relationships among the model variables, the standardized coefficients of the relevant paths were assessed at t ≥ 1.96 with an error level of 0.05. Finally, the adequacy of the model was examined using $R^2$, $Q^2$, and GOF criteria.

## Findings and Results

In the qualitative data analysis phase, a review of the theoretical literature based on the PRISMA protocol was first conducted to identify the indicators. For this purpose, keywords including “by-products of sugar production industries,” “competitive advantage,” “value creation of by-products,” “key factors of competitive advantage,” and “challenges of by-product production” were searched in reputable databases such as ISI Web of Science and Scopus between 2000 and 2025, and 70 articles were identified. After removing duplicates and screening irrelevant articles, 21 relevant articles with desirable findings were finally selected, and the indicators were extracted. Then, the semi-structured interview protocol with experts was developed, and open codes were identified. In the next step, the indicators were categorized through selective coding, and the research variables were formed. Subsequently, CVR was used to screen the indicators. Finally, out of 96 identified indicators, 9 indicators were removed, and 87 indicators were confirmed for designing the final model. Table 1 shows the research variables along with the indicators extracted in the qualitative phase.

**Table 1. Variables and indicators influencing the achievement of competitive advantage for by-products in the sugar industry**

| Factors | Indicators | Source |
|---|---|---|
| Competitive intelligence | Studying market demand for by-products; market development and green branding of by-products; foreign marketing of by-products; customer orientation of by-products; competitive pricing strategy for by-products; digital marketing of by-products; targeting the by-product market | Hakim et al. (2023); Sitisom et al. (2022) |
| Competitive intelligence | Identification, analysis, and evaluation of by-product competitors; benchmarking against existing competitors, particularly China; analysis of competitive strategies of by-product producers; foresight and business development of by-products | Ramadanloo and Benar (2022); Filippini et al. (2020) |
| Organizational resources | Managerial foresight and identification of market-entry opportunities for by-product production; managerial support and commitment; financing, investment, and cost management for by-product production; risk management and assessment in the by-product industry; investment in human resources and employees’ green competencies; management of knowledge acquisition and utilization and innovative learning in by-product production | Yuan and Kou (2022) |
| Organizational resources | Smart recycling programs for the reuse of by-products; green research and development for producing by-products from sugar industry waste; renewable energies for by-product production; programs and systems for reducing waste and production costs of by-products | Frida and Setiawan (2022) |
| Organizational resources | Advanced and updated production systems for by-product production; upgrading by-product production processes; smart packaging of by-products; quality management system and continuous improvement for by-product production; demand and supply management system for by-product production | Experts |
| Organizational resources | Quality of in-house research and development for new by-product production methods; emerging technologies, including artificial intelligence, cloud computing, the Internet of Things, and related technologies; advanced information systems for managing by-product production; digital transformation management for by-product production; innovative business model for by-product production | Experts |
| Entrepreneurship | Identification of opportunities for creating new products and new methods of by-product production; innovative value creation for by-products; efficient initiative for exploiting by-product production opportunities; benchmarking against successful entrepreneurs in by-product production; entrepreneurial leadership; generation of new and practical ideas for by-product production | Experts |

| | | |
|---|---|---|
| Entrepreneurship | Government support for new ideas in producing by-products from sugar industry waste; participation of entrepreneurs in different sectors for by-product production; visualization of the future green economy resulting from value creation from sugar industry waste; cooperation and coordination between research and development units and entrepreneurs and provision of new solutions for by-product production; introducing the potentials for entering by-product production from sugar industry waste; establishment of entrepreneurial consulting centers for producing by-products from sugar industry waste; support for collective entrepreneurship in producing by-products from sugar industry waste | Gemina et al. (2026); Sharma and Bhat (2025) |
| Governance | Regulations related to supporting industrial waste companies; removal of barriers and redundant regulations for producing by-products from sugar industry waste; facilitation of export trade regulations for producing green-cycle by-products; appropriate policies for creating trade cooperation with friendly countries; investment regulations for producing by-products from sugar industry waste; intellectual property regulations for producing by-products from sugar industry waste | Experts |
| Governance | Development of technical infrastructure and facilities for producing by-products from sugar industry waste; facilitation of advanced technology absorption for producing by-products from sugar industry waste; authorization to exploit the potential geographical capacities of the region, such as agricultural lands and access routes; support for inexpensive and sufficient primary suppliers for producing by-products from sugar industry waste | Experts |
| Governance | Tax exemptions for producing by-products from sugar industry waste; financial, banking, and investment support for recycling and waste management; support for production cost-reduction programs, such as the deployment of renewable energy; technical and investment consulting for producing by-products from sugar industry waste | Choi et al. (2015); Songlin et al. (2018); Wu et al. (2024) |
| Networking | Integration and coordination between the parent company and by-product production within the industrial cluster supply chain; access to target markets for by-products produced from sugar industry waste; creation of an industrial cluster for exchanging technologies related to by-product production from sugar industry waste; downsizing by-product production industries based on sugar industry waste; access to inexpensive raw materials produced by the parent sugar company; continuous and high-quality supply of waste from the parent sugar company | Experts |
| Networking | Cooperation and value-chain creation through relationships with suppliers and providers; interaction and communication with government institutions for by-product production; connection with innovative, knowledge-based, and research and development centers for quality production and innovation in by-products; communication with stakeholders and other businesses involved in by-product production; management of communication and information flows among by-product stakeholders | Riccardi et al. (2024); Arasti et al. (2022) |
| Networking | Creation of a public culture supporting green products derived from sugar industry waste; formation of NGOs and advertising campaigns supporting green by-products; network settings and configuration for interactions with by-product production partners; export networking for by-products produced from sugar industry waste | Fan et al. (2022) |
| Competitive advantage | Reduction of production costs for sugar by-products; appropriate and competitive pricing for producing by-products from sugar industry waste; appropriate profit margin for producing by-products from sugar industry waste | Osorio et al. (2019) |
| Competitive advantage | Increase in the quality production of by-products from sugar industry waste; reduction in the return rate of by-products from sugar industry waste; new and practical by-products derived from sugar industry waste; quality of internal processes for producing sugar industry by-products | Osorio et al. (2019) |
| Competitive advantage | Timely delivery of sugar industry by-products; speed of introducing new products derived from sugar industry waste; speed of customer support services for by-products; speed of producing by-products from sugar industry waste | Osorio et al. (2019) |
| Competitive advantage | Available market volume for sugar industry by-products; rate of customers for by-products derived from sugar industry waste; available market rate for selling by-products derived from sugar industry waste | Osorio et al. (2019) |

After identifying the model variables and indicators in the qualitative phase, it was necessary to determine the causal relationships for model formation. For this purpose, Interpretive Structural Modeling was used. The first step

in this method was to develop the Structural Self-Interaction Matrix, in which experts' opinions regarding the influence of variables on one another were specified as no influence (0), low influence (1), moderate influence (2), high influence (3), and very high influence (4). The responses of 20 experts were collected, and the matrix was formed, as shown in Table 2.

**Table 2. Structural Self-Interaction Matrix**

| Factors | Competitive intelligence | Organizational resources | Entrepreneurship | Governance | Networking | Competitive advantage |
|---|---|---|---|---|---|---|
| Competitive intelligence | 0 | 53 | 48 | 38 | 44 | 68 |
| Organizational resources | 66 | 0 | 52 | 49 | 43 | 75 |
| Entrepreneurship | 62 | 76 | 0 | 35 | 73 | 63 |
| Governance | 74 | 72 | 68 | 0 | 71 | 72 |
| Networking | 70 | 77 | 62 | 42 | 0 | 68 |
| Competitive advantage | 37 | 44 | 52 | 39 | 40 | 0 |

Then, the reachability matrix and the final reachability matrix after consistency were obtained. In the final step, in order to level the model variables based on the study by Karimi Shirazi et al. (2017), the reachability and antecedent sets were obtained and then arranged in descending order. This information is presented in Table 3, and based on it, the Interpretive Structural Model was formed, as shown in Figure 1.

**Table 3. Classification of variables related to achieving competitive advantage for by-products of sugar production industries**

| Variables | D (Driving power) | R (Dependence) | D–R | Level |
|---|---|---|---|---|
| Competitive advantage | 1 | 6 | -5 | 1 |
| Competitive intelligence | 2 | 5 | -3 | 2 |
| Organizational resources | 3 | 4 | -1 | 3 |
| Entrepreneurship | 5 | 3 | 2 | 4 |
| Networking | 5 | 3 | 2 | 4 |
| Governance | 6 | 1 | 5 | 5 |

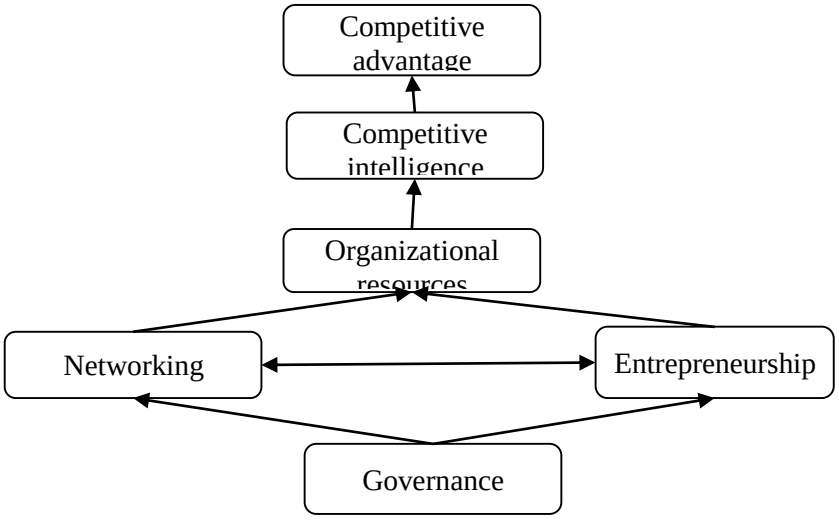


**Figure 1. Interpretive Structural Model of the factors influencing the achievement of competitive advantage for by-products of sugar production industries**

Based on Figure 1, “governance” is the most influential variable, affecting the two variables of entrepreneurship and networking. These two variables also affect organizational resources. Organizational resources, in turn, drive competitive intelligence, and ultimately competitive advantage depends on the other factors. Structural Equation Modeling was used to test these relationships. Table 4 presents the demographic information in the descriptive statistics section.

**Table 4. Demographic information**

| Variable | Category | Frequency percentage |
|---|---|---|
| Gender | Female | 23.18% |
| Gender | Male | 76.82% |
| Education | Bachelor’s degree | 17.88% |
| Education | Master’s degree | 45.03% |
| Education | Doctoral degree | 37.09% |
| Work experience | Less than 5 years | 3.31% |
| Work experience | 6 to 10 years | 11.26% |
| Work experience | 11 to 15 years | 25.83% |
| Work experience | 16 to 20 years | 14.57% |
| Work experience | More than 21 years | 45.03% |
| Job position | Senior managers | 5.30% |
| Job position | Deputies | 5.96% |
| Job position | Middle managers | 34.44% |
| Job position | Experts | 54.30% |

The statistical data were also analyzed. The observed skewness and kurtosis values for the variables were within the range of -1 to +1, indicating a normal distribution of the data. The data were then analyzed using SmartPLS software. In the first step, the criteria for confirming the measurement model were examined. The factor loadings of all indicators were greater than 0.50, indicating a strong correlation between the indicators and the constructs. Cronbach’s alpha and composite reliability values for the constructs were also greater than 0.70, indicating that the constructs were reliable. In addition, the average variance extracted in the validity section was greater than 0.50 for all constructs, indicating strong correlations among the items. This information is presented in Table 5. Based on the study by Hair et al. (2019), the measurement model was satisfactory.

**Table 5. Criteria for confirming the measurement model**

| Construct | Cronbach’s alpha | Composite reliability | Average variance extracted |
|---|---|---|---|
| Governance | 0.951 | 0.957 | 0.614 |
| Networking | 0.962 | 0.966 | 0.674 |
| Competitive advantage | 0.959 | 0.965 | 0.681 |
| Organizational resources | 0.960 | 0.964 | 0.642 |
| Competitive intelligence | 0.943 | 0.944 | 0.604 |
| Entrepreneurship | 0.949 | 0.957 | 0.692 |

Discriminant validity was also evaluated based on the Fornell and Larcker (1981) criterion. The findings of this section are presented in Table 6. These findings indicate that discriminant validity was confirmed at the 95% confidence level because the square root of the average variance extracted on the main diagonal was greater than the correlation coefficients of the other variables.

**Table 6. Correlation coefficients and discriminant validity among the model variables**

| | Governance | Networking | Competitive advantage | Organizational resources | Competitive intelligence | Entrepreneurship |
|---|---|---|---|---|---|---|
| Governance | 0.783 | | | | | |
| Networking | 0.734 | 0.821 | | | | |
| Competitive advantage | 0.732 | 0.809 | 0.825 | | | |
| Organizational resources | 0.757 | 0.770 | 0.815 | 0.801 | | |
| Competitive intelligence | 0.711 | 0.654 | 0.796 | 0.784 | 0.777 | |
| Entrepreneurship | 0.725 | 0.820 | 0.766 | 0.834 | 0.714 | 0.832 |

In the second part of Structural Equation Modeling, path evaluation was examined. Figure 2 and Table 7 present the standardized coefficients and significance values (T) for the relationships between the independent and dependent variables. In this path analysis, coefficients greater than 1.96 indicate confirmation of the relationship between variables.

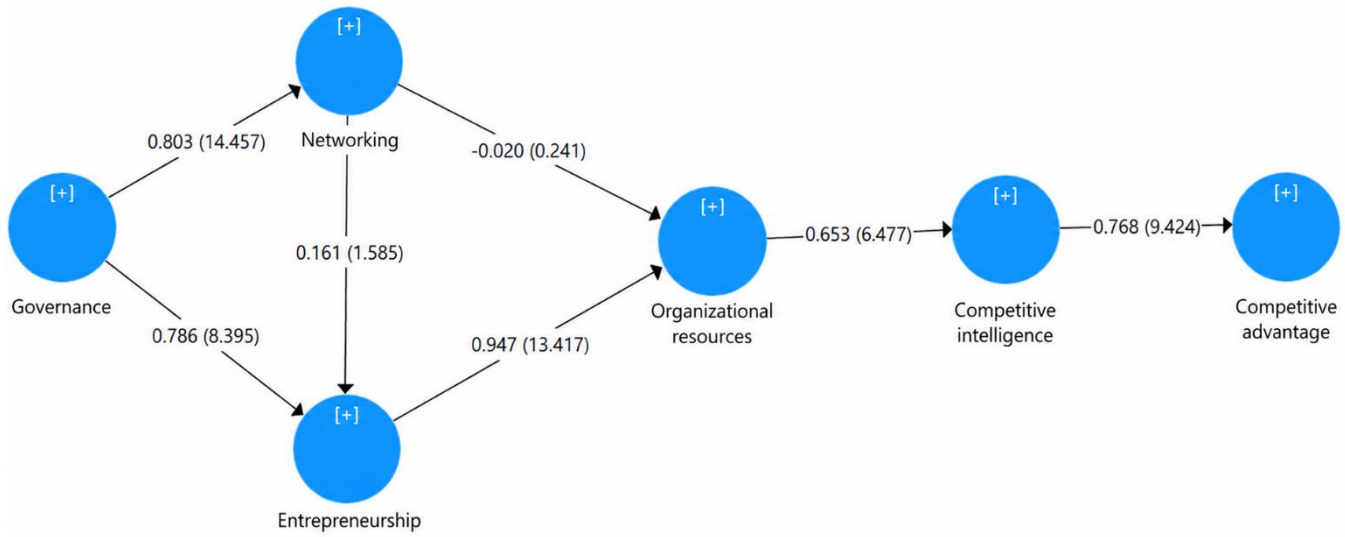


**Figure 2. Structural model of confirmatory factor analysis and significance coefficients (T) of the model**

**Table 7. Results of Structural Equation Modeling and testing of the direct relationships in the model**

| Relationships | Beta | t-statistic | P values | Result | Direction of relationship |
|---|---|---|---|---|---|
| Governance → Networking | 0.803 | 17.457 | 0.000 | Confirmed | + |
| Governance → Entrepreneurship | 0.786 | 8.395 | 0.000 | Confirmed | + |
| Networking → Entrepreneurship | 0.161 | 1.585 | 0.114 | Not confirmed | |
| Networking → Organizational resources | -0.020 | 0.241 | 0.810 | Not confirmed | |
| Entrepreneurship → Organizational resources | 0.945 | 13.417 | 0.000 | Confirmed | + |
| Organizational resources → Competitive intelligence | 0.653 | 6.477 | 0.000 | Confirmed | + |
| Competitive intelligence → Competitive advantage | 0.768 | 9.424 | 0.000 | Confirmed | + |

Based on the findings in Table 7, the effect between “governance” and “networking” was positive and significant (β = 0.803, t = 17.457). This finding shows that regulations, infrastructure, and financial and legal incentives were able to support clustering, communication, and networks for creating a continuous production cycle of by-products in the sugar industry. The second relationship showed that the effect between “governance” and “entrepreneurship” was positive and significant (β = 0.786, t = 8.395). Therefore, government regulations, infrastructure, and financial

and legal incentives supported creativity, innovation, and the expansion of entrepreneurship in sugar industry by-products. The third relationship, namely the effect of “networking” on “entrepreneurship” (β = 0.161, t = 1.585), was not confirmed because the t-statistic was not significant and was lower than 1.96. This finding shows that networking was not a driver of entrepreneurship. In addition, the effect of “networking” on “organizational resources” (β = -0.020, t = 0.810) was not confirmed because the t-statistic was not significant and was lower than 1.96. This finding indicates that networking was unable to influence the organizational resources of producers of sugar industry by-products, which may be due to the weakness of networking in coordinating the foundations of by-product production. The fifth relationship, namely the effect between “entrepreneurship” and “organizational resources” (β = 0.945, t = 13.417), was confirmed as positive and significant. In the sixth relationship, the effect of “organizational resources” on “competitive intelligence” (β = 0.653, t = 6.477) was confirmed as positive and significant. By using organizational resources and producing high-quality products at appropriate prices, producers of by-products were able to increase competitiveness. Finally, the relationship between “competitive intelligence” and “competitive advantage” (β = 0.768, t = 9.424) was confirmed as positive because the t-statistic was significant and greater than 1.96. This finding shows that marketing strategy programs and competitor analysis were able to create competitive advantage for producers of sugar industry by-products.

The quality of the structural model was evaluated using two criteria, $R^2$ and $Q^2$. The findings for these two criteria are presented in Table 8. The results show that “organizational resources” had the highest coefficient of determination, with 87% of changes in this variable explained by the independent variables of “networking” and “entrepreneurship.” In addition, the $R^2$ value for “competitive advantage” was equal to 80%, which explains and accounts for a moderate-to-strong level of changes in the dependent variables.

Moreover, the $Q^2$ values for the endogenous variables of the model were calculated as positive and at desirable and acceptable levels, indicating the acceptable predictive power of the model for these variables. The variables of “entrepreneurship” and “organizational resources” had the highest $Q^2$ values and predictive power, indicating the high adequacy of the structural model.

**Table 8. Results related to $R^2$ and $Q^2$ of the model variables**

| Variable | R Square | $Q^2$ |
|---|---|---|
| Governance | - | - |
| Networking | 0.696 | 0.380 |
| Competitive advantage | 0.803 | 0.361 |
| Organizational resources | 0.873 | 0.494 |
| Competitive intelligence | 0.614 | 0.216 |
| Entrepreneurship | 0.864 | 0.536 |

Finally, the overall goodness-of-fit quality of the Structural Equation Model was assessed using the Goodness-of-Fit (GOF) index. The obtained value was GOF = $\sqrt{(0.651 \times 0.770)} = 0.708$. This value is greater than the threshold of 0.36 and indicates the high fit quality of the structural model. This finding shows that the tested model has 71% reliability and that the constructs and the relationships among them can be trusted. Therefore, this model can be considered by government officials, policymakers, decision-makers, entrepreneurs, and producers of by-products from sugar factory waste.

## Discussion and Conclusion

The present study aimed to develop and validate a model of the factors influencing the acquisition of competitive advantage for by-products in the sugar industry. The findings of the qualitative phase demonstrated that competitive intelligence, organizational resources, entrepreneurship, governance, and networking constitute the primary dimensions affecting competitive advantage. The Interpretive Structural Modeling results further revealed that governance serves as the most influential driving variable within the system, while competitive advantage represents the ultimate dependent outcome. The Structural Equation Modeling results largely supported the proposed model and showed that governance significantly influences networking and entrepreneurship, entrepreneurship positively affects organizational resources, organizational resources strengthen competitive intelligence, and competitive intelligence directly enhances competitive advantage. These findings collectively indicate that achieving competitive advantage in sugar industry by-products is not the result of a single organizational capability but rather emerges from a hierarchical system of institutional support, entrepreneurial initiatives, resource development, and market-oriented intelligence.

One of the most important findings of the study was the dominant role of governance as the primary driving force affecting both networking and entrepreneurship. This result suggests that the development of by-products derived from sugar industry waste is highly dependent on governmental regulations, infrastructure, incentives, and policy support. Unlike many traditional manufacturing industries where competitive advantage is largely generated internally, by-product industries often operate within environments that require regulatory approval, environmental compliance, investment incentives, technology transfer mechanisms, and market facilitation. Therefore, governance creates the institutional foundation upon which other organizational activities can emerge. This finding is consistent with studies emphasizing the role of government support in creating sustainable competitive positions and improving organizational performance (36). Similarly, research has demonstrated that governmental support strengthens the relationship between networking structures and sustainable competitive performance, particularly in small and medium-sized enterprises (35). The results also align with studies highlighting the influence of governance mechanisms and policy environments on green innovation and technology adoption (37, 38). Because by-product production frequently involves environmental sustainability initiatives and circular economy practices, supportive governance appears to be a prerequisite for encouraging investments, reducing uncertainty, and promoting innovation. Therefore, policymakers play a strategic role in transforming industrial waste streams into competitive economic opportunities.

Another important finding was the significant positive effect of governance on entrepreneurship. This result demonstrates that entrepreneurial activities in sugar industry by-product markets are stimulated by supportive legal, financial, and institutional environments. Entrepreneurship in this context requires access to capital, market opportunities, technological knowledge, and regulatory certainty. Government interventions such as tax incentives, financial assistance programs, export support, and innovation grants can reduce barriers to entry and encourage entrepreneurial initiatives. This finding supports previous studies suggesting that entrepreneurship and innovation flourish when supported by effective value-chain systems, institutional policies, and collaborative development programs (29). The result is also consistent with research indicating that entrepreneurial orientation, including innovativeness, proactiveness, and risk-taking, contributes significantly to organizational performance and competitive outcomes (27, 28). In emerging sectors such as sugar industry by-products, entrepreneurs often act as

pioneers who identify new applications for industrial waste and convert them into commercially viable products. Therefore, governance not only creates favorable conditions for entrepreneurship but also enables entrepreneurs to transform environmental challenges into profitable business opportunities.

The findings further showed that the relationship between networking and entrepreneurship was not statistically significant. This result contrasts with several studies suggesting that social and business networks facilitate entrepreneurial learning, opportunity recognition, and innovation development (25, 32). A possible explanation for this discrepancy is that networking structures in the sugar industry by-product sector may still be underdeveloped and fragmented. Although networks can theoretically support knowledge exchange and entrepreneurial activities, their effectiveness depends on the quality of interactions, trust, resource sharing, and strategic coordination among participants. If networks remain limited to transactional relationships rather than collaborative partnerships, their influence on entrepreneurship may be weak. Another explanation may be that governmental support and entrepreneurial capabilities play a stronger role than networking in this specific industry context. Consequently, networking alone may not be sufficient to stimulate entrepreneurship unless accompanied by institutional support and internal organizational capabilities. This interpretation is consistent with research emphasizing that network effectiveness depends on complementary organizational capabilities and strategic alignment (30, 33).

Similarly, the study found no significant relationship between networking and organizational resources. This finding suggests that networking activities within the sugar industry by-product sector have not yet translated into meaningful improvements in organizational capabilities, technological assets, financial resources, or managerial competencies. While previous studies have emphasized the importance of networking capability for resource acquisition, innovation, and organizational performance (30-32), the current results indicate that such benefits may not automatically occur in all contexts. One explanation is that many by-product producers remain relatively small and lack formal collaborative mechanisms capable of generating tangible resource exchanges. Another explanation may involve insufficient integration between industrial actors, research institutions, and supply-chain partners. Therefore, although networking is theoretically important, its practical contribution to organizational resources may depend on stronger institutional frameworks, more mature industrial clusters, and deeper collaborative relationships among stakeholders.

The strongest relationship observed in the model was the positive effect of entrepreneurship on organizational resources. This finding indicates that entrepreneurial activities contribute significantly to the development of organizational capabilities, technological assets, knowledge systems, and strategic resources. Entrepreneurial organizations are generally more proactive in identifying opportunities, investing in innovation, adopting new technologies, and improving operational processes. These characteristics enable firms to strengthen their internal resource base and enhance long-term competitiveness. This result aligns with studies demonstrating that entrepreneurial orientation positively influences both financial and non-financial performance through innovation and capability development (27, 28). It is also consistent with literature emphasizing the role of entrepreneurship in creating value through innovation, opportunity exploitation, and strategic renewal (29). In the context of sugar industry by-products, entrepreneurial behavior appears essential for converting waste materials into marketable products, developing new production technologies, and building sustainable competitive capabilities.

The findings also confirmed the significant positive influence of organizational resources on competitive intelligence. This result indicates that organizations possessing stronger technological capabilities, knowledge management systems, human capital, and innovation resources are better equipped to collect, analyze, and utilize

competitive information. Competitive intelligence requires sophisticated information systems, managerial expertise, analytical skills, and organizational learning processes. Therefore, organizations with superior resources can more effectively monitor competitors, identify market opportunities, and respond to environmental changes. This finding is consistent with studies showing that management information systems, technological intelligence, and organizational knowledge contribute directly to competitive intelligence and sustainable competitiveness (21, 22). The result is further supported by research emphasizing the importance of knowledge sharing, organizational culture, and innovation capabilities in generating strategic advantages (12, 24). Consequently, organizational resources function as the foundation upon which competitive intelligence capabilities are developed and maintained.

Another major finding was the strong positive effect of competitive intelligence on competitive advantage. This result confirms that firms capable of understanding market trends, monitoring competitors, analyzing customer needs, and identifying strategic opportunities are more likely to achieve superior competitive performance. Competitive intelligence enhances decision quality, reduces uncertainty, supports innovation, and improves market responsiveness. These capabilities are particularly important in emerging markets for sugar industry by-products, where customer awareness, market demand, and competitive structures continue to evolve. The finding aligns with studies indicating that competitive intelligence contributes significantly to sales performance, strategic effectiveness, and organizational competitiveness (20). Similarly, research has shown that market intelligence, pricing capability, and product innovation collectively enhance international performance and competitive advantage (15, 16). Other studies have highlighted the role of business analytics, digital marketing, and market-oriented strategies in creating sustainable competitive growth (14, 26). Therefore, competitive intelligence appears to be the immediate mechanism through which organizational resources are translated into market success and competitive advantage.

The broader implications of the study suggest that competitive advantage in sugar industry by-products should be understood as a multilevel phenomenon involving institutional, organizational, entrepreneurial, and market-oriented dimensions. At the institutional level, governance establishes the conditions necessary for innovation and investment. At the entrepreneurial level, opportunity recognition and innovative behavior stimulate resource development. At the organizational level, resources support the creation of competitive intelligence capabilities. Finally, at the market level, competitive intelligence facilitates the achievement of sustainable competitive advantage. This integrated perspective is consistent with contemporary theories of strategic management emphasizing the interaction between external environments and internal capabilities in generating superior performance (10, 11, 13). Moreover, the findings reinforce the importance of circular economy approaches and sustainable value creation through the utilization of industrial by-products (1-3). By demonstrating how governance, entrepreneurship, resources, and intelligence interact, the study provides a comprehensive explanation of the mechanisms through which sugar industry waste can be transformed into sources of competitive advantage.

One limitation of the present study is that the quantitative data were collected from a specific group of experts and managers operating within sugar industry by-product production units, which may limit the generalizability of the findings to other industrial sectors or geographical contexts. Another limitation relates to the cross-sectional nature of the quantitative phase, which restricts the ability to examine causal relationships over time. Additionally, although the mixed-method approach strengthened the comprehensiveness of the model, some potentially relevant

variables such as technological readiness, environmental uncertainty, organizational culture, and international market dynamics were not explicitly incorporated into the final model.

Future studies may examine the proposed model in different countries and industrial sectors to determine the stability of the identified relationships across contexts. Researchers may also incorporate additional variables such as digital transformation, green innovation capability, supply-chain resilience, organizational learning, and technological readiness to expand the explanatory power of the model. Longitudinal research designs could provide deeper insights into the dynamic evolution of competitive advantage in by-product industries, while comparative studies between successful and less successful organizations may reveal additional mechanisms affecting competitiveness.

Managers and policymakers should prioritize the development of supportive governance systems that facilitate investment, innovation, and market access for by-product producers. Organizations should strengthen entrepreneurial initiatives and allocate resources toward research and development, technology adoption, quality improvement, and market intelligence systems. Greater collaboration among producers, universities, research centers, and governmental agencies may also improve the effectiveness of innovation activities and accelerate the commercialization of value-added by-products. Furthermore, firms should invest in competitive intelligence capabilities and market-oriented strategies to better understand customer needs, identify emerging opportunities, and maintain sustainable competitive positions in increasingly dynamic 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 adheried 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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