International Journal of Innovation Studies 9 (2025) 312–325

Contents lists available at ScienceDirect

International Journal of Innovation Studies

journal homepage: www.keaipublishing.com/en/journals/international-journal-of-innovation-studies

Identifying unobserved heterogeneity in agribusiness firms' innovation dynamic capabilities

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ARTICLE INFO

Keywords:
Innovation dynamic capabilities
Market orientation
Marketing capabilities
Relational capabilities
FIMIX-PLS
Agribusiness

ABSTRACT

Innovation dynamic capabilities (IDCs) are crucial for firms in competitive markets, yet their heterogeneous development and utilization remain underexplored. This study uses finite mixture partial least squares (FIMIX-PLS) to uncover unobserved heterogeneity in IDC configurations and their impact on market orientation (MO) in the Spanish agri-food sector. Three firm segments were identified, with IDCs positively influencing marketing capabilities and MO across all segments. However, relational capabilities significantly impacted MO only in segments K2 and K3. These findings challenge one-size-fits-all innovation strategies, urging managers to tailor approaches based on segment-specific resource configurations. This study advances IDC research and highlights the strategic importance of segment-focused innovation.

1. Introduction

Innovation dynamic capabilities (IDCs) have emerged as essential factors influencing a firm's ability to sustain competitive advantage and achieve long-term success in an increasingly dynamic and competitive business environment (Abell et al., 2008; Felin et al., 2012; Jantunen et al., 2012; Schoemaker et al., 2018; Ferreira et al., 2020). IDCs constitute a distinct and strategically significant subset within the broader framework of dynamic capabilities (DCs). While DCs are generally conceptualized as higher-order competences that enable firms to adapt, integrate, and reconfigure internal and external resources in response to environmental changes (Teece et al., 1997; Eisenhardt and Martin, 2000; Teece, 2007; Hodgkinson and Healey, 2011; Teece and Leih, 2016), IDCs specifically refer to the organizational capacity to generate, absorb, and apply knowledge for the continuous development of innovations (Nisula and Kianto, 2013). This distinction is important: whereas general DCs encompass a wide range of adaptive and transformative processes, IDCs are explicitly oriented toward innovation as a deliberate and sustained outcome. IDCs emphasize the knowledge mechanisms and resource configurations that underpin a firm's ability to innovate proactively rather than merely respond to change (Felin et al., 2012; Jantunen et al., 2012). Despite their relevance, the innovation-specific dimension of dynamic capabilities remains underexplored in the literature (Cordeiro et al., 2023), particularly in terms of how firms leverage these capabilities to disrupt markets and maintain competitive advantage through innovation-driven strategies (Ferreira et al., 2020; Schoemaker et al., 2018). Clarifying the conceptual boundaries between DCs and IDCs thus contributes to a more nuanced understanding of capability development and its

Peer review under the responsibility of China Science Publishing & Media Ltd.
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https://doi.org/10.1016/j.ijis.2025.07.007

Available online 30 July 2025

implications for strategic innovation management (de Aro and Perez, 2021).

However, despite the growing recognition of the importance of IDCs, there remains a significant lack of understanding of the underlying heterogeneity in how firms develop and utilize these capabilities. Traditional research methods for studying IDCs frequently assume that all firms are alike (Teece et al., 1997; O'Connor et al., 2008; Breznik and Hisrich, 2014; Cherubini et al., 2017; Schoemaker et al., 2018; Kurtmollaiev, 2020). This overlooks the reality that firms can significantly differ in their innovation strategies and capacity to accumulate and utilize IDCs. This lack of granularity restricts our understanding of the elements that contribute to innovation success in various types of firms.

The context-dependent nature of IDCs leads to unique configurations of human-based resources within each firm (Cordeiro et al., 2023). Existing literature suggests that IDCs can vary across firms due to differences in resource bases, competencies, and adaptations to changing environments (Jantunen et al., 2012; Strønen et al., 2017). Traditional methods often fail to capture unobserved heterogeneity—hidden factors that impact a firm's innovation performance but are not directly measurable. These unseen elements could encompass unique resources and capabilities specific to each firm, which are not typically captured by conventional IDC measures.

The finite mixture partial least squares (FIMIX-PLS) approach addresses these issues by enabling the detection and examination of this unobserved heterogeneity in innovation performance. FIMIX-PLS is a statistical method that merges the benefits of finite mixture modeling and partial least squares structural equation modeling. This combination allows for the simultaneous identification of distinct firm segments and estimation of relationships between hidden variables within each segment. No prior research has explicitly examined the role of unobserved heterogeneity in firm-level innovation dynamic capabilities. This study aims to contribute to this under-explored area by investigating the segments within firms concerning innovation using the FIMIX-PLS approach and evaluating the unseen heterogeneity across these segments.

The study explores these concerns within the context of the Spanish agri-food sector, thereby enriching the existing literature by shedding light on the identification of unobserved heterogeneity in the innovation dynamic capabilities of agribusiness firms. Addressing this research gap makes a significant contribution to the literature. First, it expands our understanding of the influence of firms' capabilities on market orientation and their impact on innovative orientation. Second, the analysis helps identify distinct segments within the agri-food industry, thereby facilitating the differentiation of firms based on their ability to generate innovations.

2. Theoretical background and conceptual model

IDCs refer to an organization's ability to effectively integrate, develop, and reconfigure its internal resources to adapt to environmental changes and continuously create innovations (Nisula and Kianto, 2013). Breznik and Hisrich (2014) emphasize that these capabilities include integrating and reconfiguring competencies to address rapidly changing environments, which are essential for fostering innovation. This continuous adaptation and innovation are crucial for maintaining a competitive advantage (Smith et al., 2017; Pedron et al., 2018; Wang et al., 2020). Innovativeness enhances firms' dynamic competitive advantage by improving their ability to adapt and drive continuous technological changes (Yuan et al., 2016; Ledesma-Chaves and Arenas-Gaitán, 2023; Daronco et al., 2023).

Heterogeneity in IDC configurations is not merely an empirical observation but is deeply rooted in the theoretical foundations of business strategy. From the perspective of the resource-based view (RBV), firms are considered unique collections of resources and capabilities that are inherently heterogeneous, difficult to imitate, and imperfectly substitutable (Barney, 1991). This diversity in underlying resources and in the organizational processes for integrating and reconfiguring them directly translates into distinct IDC configurations among firms.

Furthermore, the dynamic capabilities framework posits that how firms learn, adapt, and respond to changing environments varies significantly (Teece et al., 1997). While these capabilities share common elements, they are the result of path-dependent trajectories and idiosyncratic organizational learning processes. This implies that the routines and processes constituting a firm's IDCs are developed and refined over time, influenced by past experiences, strategic decisions, and the accumulation of firm-specific knowledge (Eisenhardt and Martin, 2000). Consequently, even firms within the same industry can exhibit divergent IDC patterns due to differences in their history, knowledge base, and ability to perceive and exploit new innovation opportunities, thereby generating sustainable competitive advantage from unique IDC configurations.

Market orientation involves an organization's strategic orientation to understand and satisfy market needs. Slater and Narver (1995) view it as a cultural aspect where creating value for customers is central. Companies with a strong market orientation focus on understanding customers, competitors, and the environment to adapt their products and strategies. Varadarajan (2020) suggests that market orientation complements strategy and is vital for strategic direction. The debate on innovation revolves around whether market orientation fosters business innovation or focuses on incremental changes based on customer preferences (Prifti and Alimehmeti, 2017).

Organizations with strong innovation capabilities are also likely to have a robust market orientation. Such firms can quickly adapt to market changes and customer demands, leading to successful innovations. Market orientation is seen as a precursor to developing new ideas that positively influence innovation (Hurley and Hult, 1998; Taghvaee and Talebi, 2023). Corchuelo et al. (2025) highlight that a market-oriented approach stimulates both exploratory and exploitative innovation, particularly in agri-food companies, by prioritizing customer needs and promoting interdepartmental collaboration.

In the agribusiness sector, innovation dynamic capabilities are fundamental due to evolving consumer preferences, technological advancements, and regulatory changes. Companies that adapt quickly to these changes and generate new ideas are more likely to succeed. Market orientation helps understand and meet market needs, identify trends, and adapt products accordingly. There is a positive relationship between innovation dynamic capabilities and market orientation, as seen in firms that develop products aligned

with market expectations and respond to changing conditions (Schiavon et al., 2022). Leo et al. (2022) and Thindisa and Urban (2023) support the significance of these capabilities in the agricultural sector, where market-oriented firms are more likely to adopt new and improved products and services. Doucouré and Diagne (2023) demonstrate that in the Senegalese agro-industrial sector, competitive advantage is influenced by market orientation only when linked with innovation capacity. Based on these considerations, the following hypothesis is proposed.

H1. Innovation dynamic capabilities are positively related to market orientation.

Firms' marketing capabilities encompass the skills, resources, and processes used to execute effective marketing activities, focusing on generating and communicating superior customer value efficiently (Ledesma-Chaves and Arenas-Gaitán, 2023). These capabilities are critical for firm performance and maintaining a competitive advantage. The hypothesis that IDCs are positively related to firms' marketing capabilities suggests that firms strong in dynamic innovation also excel in marketing strategies. Innovation as a dynamic capability indicates the presence of skills and tools that provide a competitive edge (Vladova, 2018). Such firms can develop distinctive products and services, which can be effectively marketed, aiding in the successful commercialization of innovations (Breznik and Hisrich, 2014). Several studies highlight the positive relationship between IDCs and marketing capabilities. Wang et al. (2020) showed how Chinese firms use innovative marketing strategies driven by dynamic capabilities for survival. Teguh et al. (2021) analyzed how marketing and innovation capabilities contribute to competitive advantage from a dynamic capabilities perspective. Ledesma-Chaves and Arenas-Gaitán (2023) emphasized marketing's importance in international business management as a dynamic capability, crucial for company performance during economic crises.

In the agri-food industry, innovation dynamics and marketing capabilities are interlinked to enhance competitiveness. Companies must adapt to changing consumer preferences, with dynamic innovation enabling the development of new processes, technologies, and products. Marketing capabilities facilitate the market introduction of these innovations, which are essential for effective product positioning and differentiation (Yao et al., 2016). Singh et al. (2021) emphasized the positive influence of green dynamic capabilities on green innovation, aligning with the concept that dynamic innovation capabilities positively impact marketing capabilities in agribusiness. He et al. (2021) reported a significant positive correlation between a marketing department's innovation-related capabilities and its impact on corporate innovation, highlighting the importance of marketing in driving innovation. Based on these considerations, the following hypothesis is proposed:

H2. Innovation dynamic capabilities are positively related to firms' marketing capabilities.

Relational capabilities are increasingly recognized as a foundational element of dynamic capabilities, particularly in their role of enabling firms to sense and respond to market changes. From a relational-based view, relational capabilities facilitate the development of trust-based networks, inter-organizational learning, and information exchange, which are essential for understanding customer needs and anticipating market trends (Dyer and Singh, 1998; Pigola and Rezende da Costa, 2024). These capabilities enhance a firm's ability to gather and interpret market intelligence through close stakeholder interactions, thereby reinforcing market orientation as a strategic posture. Moreover, relational capabilities support the alignment of internal processes with external expectations, fostering responsiveness and customer-centric innovation (Smirnova et al., 2011). Although the empirical results show variation in the strength of this relationship across segments, the theoretical logic suggests that relational capabilities should universally contribute to market orientation by embedding firms in knowledge-rich networks that inform strategic decision-making.

The relationship between relational capabilities and market orientation is key to understanding how companies manage their market relationships and adapt strategies. Relational capabilities involve a company's ability to establish and maintain effective relationships with stakeholders such as customers, employees, suppliers, and partners (Smirnova et al., 2011), fostering trust and collaboration (Dyer and Singh, 1998; Sivadas and Dwyer, 2000; Jacob, 2006; Dyer et al., 2018). Market orientation focuses on understanding and meeting market needs (Slater and Narver, 1995). Companies with strong relational capabilities can gather valuable information from their relationships, including customer feedback, supplier insights, and market trends, which influence decision-making.

Strong relationships with suppliers and partners enhance strategic collaboration in product or service development, facilitate effective communication, and enable agile responses to market opportunities or challenges. These relationships underpin deeper market understanding and adaptability. Shafei and Zhodi (2014) found a positive correlation between market orientation and relational capabilities in Iranian industrial companies, highlighting their importance for competitive advantage and success.

However, the relationship between relational capabilities and market orientation may not be universally consistent across all organizational contexts. Contingency factors such as firm size, competitive intensity, and market dynamism can moderate this relationship. For instance, smaller firms may lack the structural and informational resources to fully leverage relational networks for market sensing, thereby weakening the influence of relational capabilities on market orientation. Similarly, in highly competitive or volatile environments, firms may prioritize short-term operational efficiency over long-term relational investments, limiting the strategic value of relational capabilities. These contextual variations suggest that the effectiveness of relational capabilities in fostering market orientation is contingent upon the firm's external environment and internal resource configuration, warranting further empirical investigation (Teece, 2007; Wang and Ahmed, 2007).

In the agri-food industry, relational capabilities are crucial for understanding customer preferences, market trends, and demand changes, which are vital for market orientation and adapting to market shifts (Oteh et al., 2023). The relationship between relational capabilities and market orientation is bidirectional and synergistic: strong relational capital enhances market orientation, and a strong market orientation reinforces relational capital. Both are essential for long-term success in a competitive and dynamic environment. Based on these considerations, the following hypothesis is proposed.

H3. Relational capabilities are positively related to market orientation.

Relational capabilities are crucial for enhancing firms' marketing capabilities and overall performance (Salisu and Bakar, 2019). They build trust between companies and stakeholders, which is essential for consumer engagement. Effective two-way communication through strong relationships provides constant feedback, helping companies understand customer needs and improve marketing strategies. Timely market information through these relationships enables firms to adapt their marketing strategies to market changes, enhancing their operational efficiency and overall success. Pham et al. (2017) reported that relational capability strengthens marketing efficiency and predicts export performance.

The relationship between relational capabilities and marketing capabilities may also be contingent upon contextual factors such as firm size, competitive intensity, and resource availability. In smaller firms, limited managerial capacity and informal structures may constrain the ability to translate relational insights into structured marketing strategies. Conversely, larger firms may possess the formalized systems and cross-functional integration needed to capitalize on relational knowledge for marketing innovation. Moreover, in highly competitive environments, firms may prioritize rapid market responses over long-term relationship building, weakening the link between relational and marketing capabilities. These contingencies suggest that the strength of the H4 relationship may vary depending on organizational and environmental conditions, aligning with the dynamic capabilities perspective that emphasizes the path-dependent and context-specific nature of capability deployment (Teece, 2007; Helfat et al., 2007).

In the agribusiness sector, relational capabilities enhance marketing by providing insights into customer preferences and behaviors, while effective marketing strengthens customer relationships by delivering value. Agribusinesses rely on complex supply chains with multiple stakeholders. Relational capabilities are vital for managing these relationships and fostering collaboration. Marketing capabilities facilitate communication and coordination among supply chain partners. Studies support this relationship: Ngugi et al. (2010) highlighted the role of relational capabilities in product development and delivery, while Sachitra and Chong (2018) confirmed the importance of marketing capability in enhancing the competitive advantage of minor export crop farms. Rungsithong et al. (2017) found that relational capabilities influence marketing capabilities and contribute to agribusiness performance. Based on these considerations, the following hypothesis is proposed:

H4. Relational capabilities are positively related to firms' marketing capabilities.

Firms' marketing capabilities are essential for implementing a market orientation strategy, translating market understanding into actions that satisfy customer needs and maintain competitiveness. These capabilities include market research, customer segmentation, product development, promotion, and customer relationship management. The literature widely recognizes the relationship between marketing capabilities and market orientation. Ali et al. (2021) highlighted marketing capabilities as a behavioral representation of market orientation, enhancing performance outcomes like product innovation. Ngo and O'Cass (2013) reported a significant relationship between a firm's marketing capability, market orientation, and innovation. Oteh et al. (2023) emphasized the importance of marketing capabilities in achieving market orientation and improving food security performance.

In agribusiness, marketing capabilities help translate a customer-centric approach into actionable strategies, such as product development, branding, pricing, and distribution tailored to agricultural markets. Kamarulzaman et al. (2023) reported that these capabilities significantly affect agri-food industry performance. Raj et al. (2020) emphasized how market orientation influences marketing capabilities in agribusiness firms. Leo et al. (2022) found that development capability positively impacts agribusiness firms, aligning with the idea that marketing capabilities are positively related to market orientation in this sector. The following hypothesis is proposed:

H5. Firms' marketing capabilities are positively related to market orientation.

Fig. 1 shows the conceptual model and hypotheses.

3. Materials and methods

3.1. Research context

The agri-food sector is undergoing significant changes, requiring innovation and product adaptation to align with evolving consumer preferences and market demands for enhanced competitiveness. Companies must adjust their structures and marketing

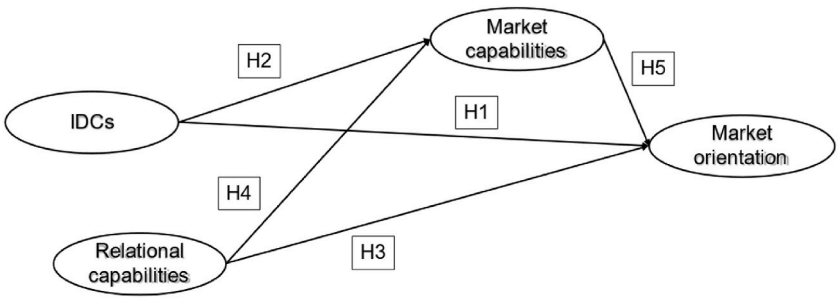

Fig. 1. The conceptual model.

strategies to stay competitive internationally, moving beyond just technological innovation. Innovation in the agri-food sector boosts revenue, enhances productivity, and strengthens competitiveness, which are crucial for economic growth (Trott and Simms, 2017; Corchuelo and Sama-Berrocal, 2022). Innovation is now viewed as a systemic process involving product/service, market, knowledge, and society, emphasizing the interconnectedness of various agents and the influence of social, cultural, and legal factors (Swafield et al., 2019).

Spain's leading industrial sector, encompassing food, beverages, and tobacco, significantly contributes to economic growth. This sector accounts for 24.2 % of manufacturing turnover, employs 22.6 % of the labor force, and contributes 20.4 % to added value (INE, 2023). The food and beverage sector includes 30,159 companies, with 96.3 % having fewer than 50 employees. It employs 551,500 people, representing 22.2 % of the manufacturing industry (Ministerio de AgriculturaPesca y Alimentación, 2023). The agri-food sector also addresses growing food demand, promotes consumer health, counters rural depopulation, and supports environmental sustainability by managing natural resources and addressing climate change (Corchuelo et al., 2020).

3.2. Data collection

Data for the research was gathered from an independent database of 9125 companies in the agri-food sector in Spain (excluding Ceuta and Melilla), based on 2009 CNAE codes: 10-Food Industry, 11-Beverages, and 12-Tobacco. An *ad hoc* questionnaire survey was used (Corchuelo and Mesías, 2017; Corchuelo and Sama-Berrocal, 2022). Data collection occurred from June to July 2022 via random interviews, yielding a sample of 751 companies. The sample, with a 95.5 % confidence interval and a sampling error of ±3.60 %, is representative of the study variables such as primary activity, geographical location, and company size. The final sample of 751 companies represents a response rate of approximately 8.2 % from the initial population of 9125 firms. Although the sample is statistically representative, with a response rate of approximately 8.2 %, we acknowledge the potential for non-response bias. We mitigated this risk through random sampling, proportional stratification by region and firm size, and rigorous supervision during data collection.

To minimize potential common method bias, several procedural remedies were implemented during data collection. The questionnaire was pilot tested and refined to improve clarity and reduce ambiguity. The pilot test was conducted with a small group of agri-food firms to evaluate the clarity, relevance, and structure of the questionnaire. Feedback from this phase led to minor adjustments in wording and item sequencing to enhance respondent understanding and ensure the reliability of the instrument. The pilot test also helped confirm the appropriateness of the survey format and administration method. The interviews were conducted via telephone in a structured format, and quality control procedures such as logical consistency checks and dual supervision were applied.

To assess the potential influence of common method bias, Harman's single-factor test was performed on all the study variables. The results indicated that the single factor extracted accounted for 32.5 % of the total variance. As this value is below the commonly recommended threshold of 50 %, common method bias is not considered a significant threat to the validity of the findings in this study (Podsakoff et al., 2003).

Although all the data were collected from a single respondent per firm, the random sampling strategy, proportional stratification, and rigorous supervision help mitigate the risk of common method bias. While this rate is consistent with similar large-scale surveys in the agri-food sector, the potential for non-response bias cannot be entirely ruled out. Although the sample was stratified by activity, region, and size to ensure representativeness, future studies could benefit from a formal non-response analysis (e.g., comparing early and late respondents or benchmarking against known population parameters) to further validate the robustness of the findings.

Table 1
Respondents' characteristics.

	Respondents	% of total
Gender		
Female	335	44.6
Male	416	55.4
Position		
Manager/General Manager/Owner	315	41.9
Director/Department Head	342	45.5
Technicians/Middle Management	75	10
Other	19	2.5
Age		
Under 30 years old	80	10.6
Between 31 and 45 years old	266	35.4
Between 46 and 55 years old	238	31.7
More than 55 years old	167	22.3
Educational level		
Basic education	70	9.5
Intermediate studies	172	23.2
Higher education	498	67.3

3.3. Sample

Managers from various levels of agri-food companies responded to the questionnaire, providing consent by participating. The respondents were predominantly men (55.4 %), aged 31–55 years (67.1 %), and held university degrees (67.3 %). Information on the characteristics of the respondents is shown in Table 1.

Companies were evenly distributed geographically in the individual regions of Spain. Table 2 displays the allocation of companies across Spanish Autonomous Communities.

The sample included 597 firms in the food industry (79.6 %), 152 in beverage manufacturing (20.3 %), and two in the tobacco industry. Table 3 details the distribution by size and legal structure: 66.4 % were micro-firms with fewer than 10 employees, and 89.2 % had fewer than 50 employees. Limited liability companies made up 66.9 % of the sample, and agri-food cooperatives 13.8 %. Additionally, 47.3 % of the companies engaged in export activities.

3.4. Data analysis

Partial least squares structural equation modeling (PLS-SEM) was conducted using SmartPLS software (v4.0.9.6) (Ringle et al., 2022) to estimate the measurement model and structural paths. PLS-SEM combines principal component analysis (PCA) and regression to explain construct variance, making it suitable for prediction and exploratory research without requiring a normal data distribution. The sample size of 751 exceeded the minimum requirement.

The measurement model was evaluated using Cronbach's alpha (CA) and composite reliability (CR), ensuring convergent validity, with average variance extracted (AVE) values above 0.5 and CR values above 0.7. Discriminant validity was confirmed by ensuring that the AVEs were greater than the correlation coefficients between the constructs. The structural model assessment included bootstrapping resampling.

Unobserved heterogeneity was examined via FIMIX-PLS, identifying segment numbers based on likelihood-based criteria such as Akaike information criterion 3 (AIC3), consistent Akaike information criterion (CAIC), and Bayesian information criterion (BIC). Segment separation was assessed using entropy statistic norm (EN), ensuring that segment sizes exceeded 10 %. FIMIX-PLS provided group membership probabilities and specific model estimates, enabling segment labeling.

4. Results and discussion

The PLS model evaluation involved three stages: (1) assessing the measurement model for reliability and validity (Table 4), (2) evaluating the structural model for predictive power (Table 5), and (3) determining the optimal number of segments and assessing the model within each segment (Table 6). The measurement model met the criteria for reliability (CA and CR values), convergent validity (AVE >0.5, CR > 0.7), and discriminant validity (diagonal > off-diagonal values).

The structural model assessment included path coefficients (β value, t-statistic, significance), the coefficient of determination (R^2), predictive relevance (Q^2), and goodness-of-fit (GOF) index, all of which indicate a good fit. The optimal number of segments was determined via FIMIX-PLS, with segment-specific models estimated for each segment (Table 7), allowing a granular understanding of the data relationships.

The model's predictive power was assessed via the coefficient of determination (R^2), which measures the overall effect size and variance explained by the endogenous constructs. The R^2 values for the two endogenous constructs, marketing orientation (MO) and marketing capabilities (MKcap), were 0.458 and 0.317, respectively. These values fall between the moderate and substantial ranges,

Table 2
Distribution of companies by Spanish Autonomous Communities.

Autonomous community	No. companies	% of total
Andalusia	141	18.8
Aragon	25	3.3
Asturias	17	2.3
Balearic Islands	14	1.9
Canary Islands	27	3.6
Cantabria	10	1.3
Castilla-León	74	9.9
Castilla-La Mancha	58	7.7
Catalonia	96	12.8
Valencian Community	63	8.4
Extremadura	35	4.7
Galicia	61	8.1
La Rioja	42	5.6
Community of Madrid	26	3.5
Region of Murcia	15	2
Navarra	32	4.3
Basque Country	15	2
Total	751	100

Table 3
Sample distribution according to size and legal form.

	No. companies	% of total
Number of employees		
Less than 10 employees	499	66.4
10-49 employees	171	22.8
50-199 employees	60	8
More than 200 employees	21	2.8
Legal form		
Cooperative	104	13.8
Limited Company	503	66.9
Public Limited Company	137	18.2
Other	8	1.1

Table 4
Model quality assessment.

Variable	Range of factor loadings	IDC	MO	MKCap	Rcap
IDC	0.885–0.920**	**0.902**			
MO	0.780–0.883**	0.610	**0.828**		
MKCap	0.786–0.853**	0.559	0.574	**0.895**	
Rcap	0.736–0.866**	0.563	0.431	0.369	**0.818**
Cronbach's alpha (CA > 0.7)		0.886	0.770	0.864	0.754
Composite reliability (CR > 0.7)		0.887	0.782	0.867	0.778
Average variance extracted (AVE >0.5)		0.814	0.685	0.648	0.669

Note: Bolded indicators in the diagonal are the square root of AVE. Below the diagonal are the correlation coefficients; IDC: Innovation dynamic capabilities; MO: Market orientation; MKcap: Marketing capabilities; Rcap: Relational capabilities. ** significant $p < 0.01$.

Table 5
Results of hypothesis testing.

	Path	β values (t-values) and significance	Result
H1	IDC - > MO	0.368(7.082)***	Supported
H2	IDC - > MKCap	0.515(12.757)***	Supported
H3	Rcap - > MO	0.102(2.484)**	Supported
H4	Rcap - > MKCap	0.079(1.982)*	Supported
H5	MKcap - > MO	0.331(8.046)***	Supported

Note: IDC: Innovation dynamic capabilities; MO: Market orientation; MKcap: Marketing capabilities; Rcap: Relational capabilities. * significant $p < 0.05$; ** significant $p < 0.01$; *** significant $p < 0.001$.

Table 6
FIMIX-PLS results.

	$K = 2$	$K = 3$	$K = 4$
AIC	6967.245	6881.964	6820.106
AIC3	6996.245	6925.964	6879.106
AIC4	7025.245	6969.964	6938.106
BIC	7101.265	7085.305	7092.769
CAIC	7130.265	7129.305	7151.769
HQ	7018.883	6960.311	6925.162
MDL5	7869.348	8250.673	8655.421
EN	0.433	0.479	0.522
Segment relative size			
S1	54.2 %	42.8 %	37.4 %
S2	45.8 %	35.8 %	31.0 %
S3		21.4 %	25.8 %
S4			5.90 %

suggesting that the model has moderate predictive power.

To further assess the model's predictive relevance, the cross-validated redundancy index (Q^2) was calculated using the blindfolding technique. Q^2 values greater than zero indicate that the model has predictive relevance. The Q^2 values for MO and MKcap were 0.38

Table 7
FIMIX-PLS results for the total sample, segments, and multi-group analysis (MGA).

			FIMIX Segmentation			MGA		
		Total sample	$K = 1$	$K = 2$	$K = 3$	$K = 1/K = 2$	$K = 1/K = 3$	$K = 2/K = 3$
Segment size		751(100 %)	377(50.2 %)	231(30.8 %)	143(19.0 %)			
Hypothesis	Path	Path coefficients and significance						
H1	IDC - > MO	0.368***	0.546***	0.260**	0.567***	0.286***	0.320 **	−0.306*
H2	IDC - > MKCap	0.515***	0.668***	0.307***	0.742***	0.361***	0.374 **	−0.435***
H3	Rcap - > MO	0.102**	0.080**	0.185**	−0.002 *n.s.*	−0.105 *n.s.*	0.082 *n.s.*	0.186 *n.s.*
H4	Rcap - > MKCap	0.079*	−0.125 *n.s.*	0.209*	0.339***	−0.333***	−0.463***	−0.130 *n.s.*
H5	MKcap - > MO	0.331***	0.201*	0.275***	0.334*	0.474 ***	0.333 **	0.359**
R^2								
MO		0.458	0.535	0.332	0.775			
MKcap		0.317	0.365	0.211	0.911			
Model quality criteria								
Convergent validity (AVE)		✓	✓	✓	✓			
Reliability (CR and CA)		✓	✓	✓	✓			
Discriminant validity		✓	✓	✓	✓			

Note: * significant $p < 0.05$; ** significant $p < 0.01$; *** significant $p < 0.001$; n.s. – not significant; $\surd$ indicates that the criterion is fulfilled.

and 0.31, respectively, confirming that the model has satisfactory predictive relevance. Finally, to ensure that the model adequately explains the data, three model fit indices were computed: normed fit index (NFI) and standardized root mean square residual (SRMR). The values of 0.832 and 0.071, respectively, were found to be below the recommended thresholds, indicating that the underlying model has a good fit.

All hypotheses of the structural model are supported. Table 5 shows that IDC positively influences market orientation ($\beta = 0.368$, $p < 0.001$), supporting H1. This confirms previous studies in the agri-food sector (Leo et al., 2022; Thindisa and Urban, 2023; Doucouré and Diagne, 2023). IDC also significantly and positively influences firms' marketing capabilities ($\beta = 0.515$, $p < 0.001$), supporting H2. Similar findings are noted in studies by Wang et al. (2020) and Teguh et al. (2021). He et al. (2021) also found a significant positive correlation between marketing innovation capabilities and corporate innovation in agribusiness. H3 is supported, indicating that relational capabilities positively influence market orientation ($\beta = 0.102$, $p < 0.01$). This aligns with the findings of Shafei and Zhodi (2014) and Oteh et al. (2023). Insights from relational capabilities, such as customer preferences and market trends, are vital for market orientation. Relational capabilities also positively influence marketing capabilities, supporting H4 ($\beta = 0.079$, $p < 0.05$), as confirmed by Ngugi et al. (2010), Pham et al. (2017), Rungsithong et al. (2017), and Sachitra and Chong (2018). Firms' marketing capabilities mediate the relationship between innovation dynamics, relational capabilities, and market orientation, directly influencing market orientation and supporting H5 ($\beta = 0.331$, $p < 0.001$). This aligns with studies by Ngo and O'Cass (2013), Ali et al. (2021), and Oteh et al. (2023), as well as Raj et al. (2020), Leo et al. (2022), and Kamarulzaman et al. (2023) in agribusiness.

After validating the measurement and structural model, FIMIX-PLS was applied to estimate the number of segments. FIMIX-PLS revealed unobserved heterogeneity, assigning each observation to the segment with the greatest probability. The process started with a two-segment model, increasing to four segments. It was decided not to test for more segments because the solution with four segments resulted in one segment with less than 10 %. Table 6 shows the results of five information criteria (AIC, AIC3, AIC4, BIC, and CAIC) and two classification criteria (MDL5 and EN) after running PLS with different numbers of K partitions.

AIC indicates a four-segment solution, but this option was excluded as mentioned previously. Minimum-distance least squares 5 (MDL5) indicates a two-segment solution. The results suggest that either a two- or three-segment solution is suitable for segmenting firms through market orientation. Following Hair et al. (2016), the optimal number of segments minimizes AIC3 (modified AIC with Factor 3) and CAIC (consistent AIC) values, supporting a three-segment solution (Table 6).

Each segment's inner structural relationships were subsequently analyzed to uncover differences in how innovation dynamic capabilities and related constructs interact across groups. Table 7 presents the measurement model and structural model estimates for the total sample and for each of the three identified segments. The measurement model demonstrates strong reliability and validity across all segments, ensuring that comparisons among them are meaningful and robust.

Regarding the structural model, 13 out of the 15 hypothesized relationships were found to be significant at the aggregate level, confirming the overall soundness of the theoretical framework when applied to the full sample. However, a more detailed examination using multi-group analysis (MGA) reveals that 11 out of 15 path relationships significantly differ across segments. This finding highlights substantial heterogeneity in the way firms configure and deploy innovation dynamic capabilities, marketing capabilities, and relational capabilities.

Such differences confirm that the three segments are not only statistically distinct but also strategically and behaviorally differentiated in their approaches to innovation and market engagement. These results reinforce the importance of adopting segment-specific strategies and provide deeper insight into the unique resource configurations and dynamic capabilities characterizing each group of agri-food firms.

Table 7 shows that the hypotheses for the total sample are supported (first column). Among the five hypotheses, H1 (IDC -> MO), H2 (IDC -> MKCap), and H5 (MKCap -> MO) have the highest significance, while H4 (Rcap -> MKCap) is less significant.

The study's objectives were met by analyzing segments of Spanish agri-food firms ($K = 1$, $K = 2$, $K = 3$), revealing differences among them. In segment $K = 1$, H4 is non-significant, indicating that strong relational capacities do not lead to increased marketing strategy development, contradicting previous studies by Ngugi et al. (2010) and Sachitra and Chong (2018). The other hypotheses are supported in this segment.

In segment $K = 2$, all hypotheses are supported, though H4 has the lowest significance. This segment includes firms where innovation dynamic capabilities, marketing activities, and market orientation are interrelated, supporting findings by Breznik and Hisrich (2014).

In segment $K = 3$, H1, H2, and H4 are highly significant. Companies in this segment show a strong relationship between innovation dynamic capabilities and market orientation (H1), aligning with research indicating that companies adapt internal resources for continuous innovation and market adaptation. Firms with a strong market orientation effectively identify trends and formulate competitive strategies, which is consistent with Leo et al. (2022). Innovation dynamic capabilities also correlate with significant marketing activities, supported by Singh et al. (2021), enhancing company competitiveness and market presence. Agri-food firms in this segment exhibit strong relational and marketing capabilities, highlighting the importance of trust-building as a key marketing strategy, as noted by Sachitra and Chong (2018). However, H3 remains unexplained in this segment.

Differences between segments were analyzed based on descriptive variables such as size, legal form, industry type, exporting, and innovation status. Additional variables, evaluated on a Likert scale (0-10), further distinguish these firms. Table 8 summarizes the main characteristics of the companies in the three segments.

Based on the characteristics of agri-food companies in different segments (Table 8), $K = 2$ has a higher percentage of micro-firms, while $K = 1$ consists mainly of larger firms. Cooperatives are highly represented in $K = 3$. $K = 1$ companies are primarily in the beverage industry, $K = 2$ in the food industry. $K = 2$ firms have a lower external projection, whereas $K = 3$ firms are more innovative. These segments are categorized accordingly.

4.1. $K = 1$ (Large-sized, moderately internationalized, competitive, and innovative firms - LMICIF)

This segment consists of 377 firms characterized by their relatively large size and moderate levels of internationalization and innovation activities. In addition to these descriptive traits, these firms can be interpreted as *adaptive consolidators* within the agri-food sector. Drawing on the RBV, these firms leverage substantial tangible and intangible resources, providing them with the operational stability needed to navigate moderately dynamic environments without pursuing aggressive innovation leadership (Barney, 1991). Their size offers economies of scale, stronger supply chain control, and the ability to absorb market shocks, aligning with the notion that large resource endowments enable strategic flexibility (Teece et al., 1997).

From a dynamic capabilities perspective, these firms exemplify an intermediate path-dependent trajectory in capability development. Their IDCs are developed to maintain competitiveness rather than disrupt markets radically, reflecting a deliberate and incremental innovation approach rather than exploratory radical innovations (Jantunen et al., 2012; Breznik and Hisrich, 2014). Their moderate internationalization level suggests that they balance global market opportunities with strong domestic market positions, reflecting a cautious expansion strategy.

Moreover, these firms exhibit a balanced but not leading-edge technological orientation, prioritizing operational efficiency and continuous improvement over frontier-pushing innovation. This strategic posture resonates with Cordeiro et al.'s (2023) idea of firms configuring capabilities in a typological map according to strategic fit rather than maximal dynamism. While they engage in innovation to sustain their market position and respond to evolving consumer needs (Schiavon et al., 2022), they do not aggressively invest in risky, transformative R&D initiatives.

Table 8
Segments by company characteristics.

	$K = 1$ ($n = 377$)		$K = 2$ ($n = 231$)		$K = 3$ ($n = 143$)	
	N	%	*N*	%	*N*	%
Size						
<10 employees	239	63.4	168	72.7	92	64.3
10-49 employees	90	23.9	48	20.8	34	23.8
50-199 employees	34	9.1	12	5.2	14	9.8
>200 employees	14	3.8	3	1.3	3	2.1
Legal form						
Cooperative	47	12.5	31	13.4	27	18.9
Limited Company	245	65.0	159	68.8	99	69.2
Public Company	80	21.2	41	17.7	15	10.5
Others	5	1.3	0	0	2	1.4
Industry						
Food	289	76.7	193	83.5	114	79.7
Beverage	88	23.3	37	16	28	19.6
Tobacco	0	0	1	0.4	1	0.7
Exporting firms	188	49.8	97	42	71	49.7
Innovative firms	175	46.5	94	40.5	72	50.3

Their competitive approach emphasizes consolidating market share through adaptive strategies and incremental product or process improvements. Instead of being first movers, they are often *fast followers* or pragmatic innovators, rapidly integrating proven market trends and technological advancements once risks are better understood. This positions them as dependable actors in the agri-food value chain, capable of maintaining stable growth and contributing to sectoral resilience (Ferreira et al., 2020).

4.2. $K = 2$ (Small-sized, domestically focused firms in less competitive environments - SDFLCE)

This segment comprises 231 firms characterized by their small size, limited export activity, and lower levels of innovation. These firms can be interpreted as *local stabilizers* within the agri-food ecosystem, prioritizing operational continuity and local market responsiveness over aggressive growth or technological advancement.

Drawing on the RBV, these firms operate with constrained tangible and intangible resources, often lacking the scale advantages and absorptive capacities of larger firms (Barney, 1991). Their focus on domestic markets suggests a strategic reliance on close customer relationships, local distribution networks, and established reputational capital rather than expanding into more volatile international arenas (Dyer and Singh, 1998).

From a dynamic capabilities perspective, these firms exemplify a path of *limited capability deployment*, where IDCs are underdeveloped or only modestly mobilized. They tend to adopt incremental improvements and react to market changes in a cautious and reactive manner rather than proactively pursuing new opportunities (Breznik and Hisrich, 2014; Jantunen et al., 2012). This strategic posture aligns with the idea that dynamic capabilities are context-dependent and contingent on resource endowments and environmental dynamism (Teece, 2007).

Moreover, their limited technological orientation indicates a focus on incremental product refinement or process optimization aimed at local market needs rather than radical innovation. These firms often lack specialized R&D resources and depend on existing knowledge bases and operational know-how (Cordeiro et al., 2023). While this may reduce competitiveness in fast-moving global contexts, it enables them to maintain steady relationships with local stakeholders and minimize operational risk.

Their strong reliance on relational capabilities suggests that trust-based relationships with suppliers, customers, and local communities are critical for their market survival and incremental performance improvements (Ngugi et al., 2010; Dyer and Singh, 1998). However, their overall lower market dynamism means that these relational networks serve primarily as a stability mechanism rather than as a platform for innovation-driven growth.

4.3. $K = 3$ (Medium-sized, highly internationalized, competitive, and innovative firms - LHIHCF)

This segment includes 143 firms distinguished by their medium size, high levels of internationalization, and pronounced commitment to innovation. These firms can be interpreted as *dynamic pioneers* in the agri-food sector, actively leveraging innovation dynamic capabilities IDCs to maintain competitiveness in highly dynamic and uncertain environments.

From the RBV, these firms exhibit a strong bundle of unique, difficult-to-imitate resources, including advanced technological know-how, market intelligence, and strong brand equity, which collectively provide a foundation for sustained competitive advantage (Barney, 1991). Their high internationalization level reflects their proactive strategic orientation, which is aimed at capturing new market opportunities and diversifying revenue streams beyond domestic constraints (Teece et al., 1997).

The dynamic capabilities framework suggests that these firms excel in sensing, seizing, and transforming opportunities, embodying the micro-foundations necessary for rapid adaptation and innovation (Teece, 2007; Felin et al., 2012). Their strong technological orientation and intensive investment in product and process innovations allow them to pursue both exploratory and exploitative innovation strategies, supporting continuous renewal and market differentiation (Jantunen et al., 2012; Schoemaker et al., 2018).

Furthermore, these firms actively engage in global value chains, integrating external knowledge and co-creating value with partners, customers, and suppliers. This relational embeddedness aligns with the relational view, emphasizing that inter-organizational relationships and networks are crucial sources of competitive advantage (Dyer and Singh, 1998; Ngugi et al., 2010). The significant role of relational capabilities in this segment indicates that these firms not only gather market intelligence through partnerships but also utilize these insights to rapidly innovate and reposition in dynamic markets.

Their strategic emphasis on agility and proactive market engagement resonates with the notion of "innovation ambidexterity", the ability to balance incremental improvements with radical innovations to adapt and shape markets simultaneously (Cordeiro et al., 2023). By combining robust innovation systems with strong market orientation and marketing capabilities, these firms can achieve faster product development cycles and better alignment with evolving global consumer preferences (Leo et al., 2022; Doucouré and Diagne, 2023).

5. Conclusions

5.1. Theoretical contributions

The empirical findings of this study reinforce and extend the dynamic capabilities framework by demonstrating how IDCs operate differently across firm segments. The identification of segment-specific relationships between IDCs, marketing capabilities, and market orientation illustrates that dynamic capabilities are not uniformly deployed or effective across firms. This finding supports the theoretical view that dynamic capabilities are path-dependent and context-specific (Teece et al., 1997; Eisenhardt and Martin, 2000). Moreover, the varying influence of relational capabilities across segments highlights the importance of complementary assets and

organizational configurations in shaping the effectiveness of dynamic capabilities. These results underscore the need to move beyond generic models and adopt a more nuanced, contingent perspective on how dynamic capabilities contribute to competitive advantage.

The findings of this study pave the way for a more comprehensive and nuanced understanding of how firms leverage IDCs to achieve sustainable competitive advantage in today's dynamic business environment. Overall, it advances the theoretical understanding of IDCs by (1) highlighting the importance of considering unobserved heterogeneity. By acknowledging and investigating unobserved heterogeneity across firms through the FIMIX-PLS approach, the study addresses a critical limitation in IDC research and reveals hidden factors within different firm segments. (2) Unveiling segment-specific relationships between IDCs and other innovative drivers. The study examines how relationships among market orientation, marketing capabilities, and relational capabilities differ across segments, offering a nuanced understanding of these interactions. For instance, the varying significance of relational capabilities (H4) across segments challenges the universality of previously established relationships. (3) Providing empirical evidence in the agri-food sector. This study presents empirical evidence specific to the agri-food sector, highlighting its unique context. (4) Emphasizing firm idiosyncrasy within the RBV. While the RBV emphasizes the role of resources in achieving competitive advantage, this study suggests that the specific configuration and interaction of these resources within a firm crucially determine its innovative performance.

5.2. Managerial implications

Our research on identifying unobserved heterogeneity in IDCs offers valuable insights for managers, particularly concerning firm idiosyncrasy and resource configuration. First, the identification of three distinct segments highlights the importance of tailoring innovation strategies to a firm's unique resource configuration. A one-size-fits-all approach may not be optimal. Managers should conduct self-assessments to identify their segment membership and leverage their strengths in IDC development.

Second, the concept of unobserved heterogeneity emphasizes the role of firm-specific factors beyond measured variables in influencing innovation performance. As such, managers should encourage knowledge sharing and cross-functional collaboration to uncover hidden strengths that can be leveraged for innovation. More specifically, the non-significant relationship between relational capabilities and market orientation (MO) in segment K1 suggests that simply building strong relationships may not be enough for all firms. Managers in K1 should focus on developing marketing capabilities to complement their relational capabilities and achieve market orientation. However, in segments K2 and K3, where the Rcap-MO link is significant, managers can leverage strong relational networks as a foundation for effective marketing strategies.

Third, it is also important to balance capabilities across segments. While the study confirms the positive effects of IDCs on MKCap and MO (H1, H2, H5) across most segments, the significance level may vary. Accordingly, managers should prioritize developing capabilities based on their segment's needs and resource allocation. For instance, firms in K2 might need to invest more in marketing capabilities to fully capitalize on their IDCs.

Finally, continuous monitoring and adaptation are strongly advised. The dynamic nature of the business environment necessitates ongoing monitoring of firm resources and capabilities. As such, managers should re-evaluate their segment membership periodically and adapt their strategies based on changes in unobserved heterogeneity or the broader market landscape.

5.3. Limitations and areas for future research

This study sheds light on unobserved heterogeneity in IDCs within the Spanish agri-food sector. However, there are limitations to consider and avenues for future research to explore. First, the specificity of the sample of Spanish agri-food firms should be taken into consideration. Applying FIMIX-PLS to firms in different sectors or geographical locations could reveal variations in segment structures and relationships between variables. Second, we adopted a cross-sectional design, which limits the ability to draw causal inferences and to fully capture the temporal processes inherent to dynamic capabilities. Because dynamic capabilities fundamentally involve change, learning, and adaptation over time, longitudinal studies would be especially valuable in tracing how firms develop, deploy, and reconfigure these capabilities and how these evolutions influence market orientation and performance. Future research could employ longitudinal designs to provide stronger evidence of causality and better illuminate the dynamic nature of these relationships. We also recognize that the stability of the identified segments over time was not assessed. Given the dynamic nature of firm capabilities and market contexts, future research should explore segment stability using longitudinal data or repeated cross-sectional studies to confirm the consistency of these configurations and support their practical application.

Third, qualitative exploration of the results and hypothesized relationships is strongly recommended to uncover the specific firm-level factors contributing to unobserved heterogeneity within each segment. Future research could incorporate qualitative methods, such as in-depth interviews or case studies, to capture richer insights into the managerial perceptions and strategic perspectives that shape the deployment of capabilities within each segment. Fourth, the results suggest that some moderating effects can be identified regarding the relationships between IDCs, capabilities, and MO. For instance, firm size, technological intensity, or competitive pressure could play a role. Furthermore, the findings challenge the universality of the relationship between Rcap and MO. Our results show that in segment K1, strong Rcap does not translate to stronger MO, suggesting that contextual factors might influence this connection. Finally, our focus on Spanish agri-food firms, while providing valuable industry-specific insights, may limit the generalizability of our findings to other sectors or countries. Future studies should replicate this segmentation approach in different cultural and industrial contexts to assess the external validity and broader applicability of the results.

Ethic statement

Not applicable because this work does not involve the use of animal or human subjects.

Data availability

Data will be made available on request.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgments

This work was supported by [Junta de Extremadura (Spain) and European Regional Development Fund] under Grant [IB18040]; and [Fundação para a Ciência e a Tecnologia] under Grant [UIDB/00315/2020].

Appendix. Questionnaire items and factor loadings

IDC	**Loadings**
IDC1: [The company always seeks to develop new improvements]	0.902
IDC2: [The company is open and receptive to new ideas]	0.920
IDC3: [The company is receptive to changes in work routines]	0.885
Relational Capital (Rcap)	**Loadings**
RCAP1: [The company trusts the companies it cooperates with]	0.866
RCAP2: [There is a strong relationship with employees within the company]	0.845
RCAP3: [Contracts with suppliers are based on long-lasting relationships]	0.736
Marketing capabilities (MKcap)	**Loadings**
MKT1: [Ability to develop new products and services]	0.841
MKT2: [Successfully launching new products and services]	0.853
MKT3: [Using pricing skills and systems to respond quickly to market changes]	0.768
MKT4: [Attracting and retaining the best distributors]	0.773
MKT5: [Creative and advertising management skills]	0.786
Market Orientation (MO)	**Loadings**
MO1: [The company is able to respond quickly to competitors' actions]	0.883
MO2: [The company's competitive activity is driven by the creation of customer satisfaction]	0.816
MO3: [Competitors' behaviour is frequently evaluated]	0.780

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