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Article

A Framework for the Innovation Management Capacity: Empirical Evidence from the Porto Digital Cluster in Brazil

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Abstract: This study develops and validates an innovation management framework based on the integration of dynamic capabilities and multidimensional innovation process factors. A mixed-methods approach was employed, combining a quantitative survey of 267 respondents from the Porto Digital ecosystem with qualitative interviews conducted in 10 companies. Confirmatory factor analysis (CFA) was used to validate the proposed measurement model, confirming the reliability and validity of the identified constructs. The qualitative findings reinforced the contextual relevance of the framework and provided insights into managerial perceptions of innovation capabilities. The validated framework consolidates ten organizational factors into four hierarchical layers, offering a structured approach to assessing and strengthening innovation management capacity. This study contributes to the literature by proposing an empirically validated model that addresses gaps related to dynamic capabilities and integrated innovation processes. Practical implications are also discussed, providing managers with a diagnostic tool to support strategic innovation initiatives.

Keywords: innovation management; innovation capacity; confirmatory factor analysis; organization factors



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1. Introduction

Innovation has become a critical determinant of organizational competitiveness and sustainable business performance. Companies operating in technology-intensive environments must develop systematic capacities to manage the innovation process strategically, integrating internal resources and external networks (Crossan & Apaydin, 2010; Yang et al., 2023). However, effectively managing innovation demands more than isolated competencies; it requires a dynamic and multidimensional approach that acknowledges the complexities involved in generating innovation outcomes (Ellström et al., 2021; Matarazzo et al., 2021).

A multidimensional understanding extends beyond traditional process views, encompassing complexities associated with inputs, intermediaries, and outputs, particularly when measuring innovation performance in service and manufacturing sectors (Taques et al., 2020). Adopting multidimensional indicators enables a broader and more accurate representation of innovation phenomena, mitigating biases inherent to simplistic frameworks.

Organizations that fail to integrate strategic, technological, and environmental dimensions risk facing fragmented innovation efforts, resource misalignments, inefficiencies,

and, ultimately, diminished competitive positioning (Yang et al., 2023). Understanding how these dimensions interact collectively is, therefore, critical to enhancing innovation processes and sustaining long-term competitiveness.

Building on this perspective, this study aims to validate a comprehensive theoretical construct for innovation management capabilities. The proposed framework addresses critical gaps identified in prior models (Adams et al., 2006; Crossan & Apaydin, 2010), which predominantly treated innovation as a static, internally oriented phenomenon. In contrast, the framework developed here explicitly integrates dynamic capabilities, recognizing their role in enabling organizations to continuously sense opportunities, reconfigure resources, and adapt strategically to dynamic competitive landscapes.

The significance of this research lies in both its theoretical and practical contributions. Practically, technology-based firms and innovation ecosystems can benefit from a structured, empirically validated approach to assessing and enhancing their innovation management capabilities. Policymakers and managers within innovation clusters may also leverage insights from this framework to foster strategic resource allocation, knowledge sharing, and external collaboration. Theoretically, the study advances scholarly understanding by offering a dynamic capabilities-based perspective tailored to contemporary digital environments, bridging critical gaps in the innovation management literature.

Therefore, this article provides empirical validation of an integrated innovation management framework, emphasizing the strategic orchestration of dynamic capabilities and multidimensional innovation indicators to support sustained competitive advantage amid evolving market conditions.

To address these challenges, this study adopts a mixed-methods research design that integrates quantitative and qualitative approaches to assessing organizational capacity for innovation management. The quantitative phase involved the development and application of a structured survey instrument, validated through confirmatory factor analysis (CFA), which was administered to 267 professionals from 39 firms operating in the Porto Digital innovation ecosystem in Recife, Brazil. The qualitative phase complemented the analysis through semi-structured interviews with managers from ten selected companies, providing contextual insights into organizational routines and innovation practices. This combined strategy ensured both the empirical robustness of the proposed framework and a deeper understanding of how innovation capabilities are manifested in practice.

The remainder of this article is organized as follows: Section 2 reviews the conceptual background of the innovation process and dynamic capabilities. Section 3 synthesizes key innovation factors identified in the literature. Section 4 describes the research methodology. Section 5 presents and discusses the findings from the quantitative and qualitative analyses. Finally, Section 6 summarizes the key conclusions and validates the proposed theoretical framework.

2. Conceptual Background

This section presents innovation as a structured process and introduces the dynamic capabilities framework as a suitable theoretical lens for explaining the set of behaviors, routines, and organizational processes that enable the establishment, maintenance, and development of skills for managing innovation. This discussion lays the groundwork for the framework proposed in Section 5.

2.1. Innovation Process

The literature on innovation management depicts innovation efforts as a systematic process, often represented by a funnel model: broad at the input stage and narrowing toward the output stage (Crossan & Apaydin, 2010; Dewangan & Godse, 2014). This

representation highlights two key aspects: the sequential nature of innovation activities and the progressive filtering of ideas based on technical, financial, and market viability (Tidd, 2019).

Viewing innovation as a process implies the existence of structured sequences that transform inputs into desired outputs, requiring continuous performance assessment and idea selection mechanisms to ensure market success. Importantly, there is no single, universally accepted model defining the stages of the innovation process, and variations exist regarding how different studies conceptualize and emphasize each stage (Dewan-gan & Godse, 2014). Table 1 presents a synthesis of commonly recognized stages across organizations.

Table 1. Innovation process stages.

Stage	Characteristics	Authors
Pursuit (Search)	This initial stage focuses on detecting signals of potential opportunities or threats, either from within the organization or from the external environment. These signals may indicate openings for novel innovations. During this phase, a wealth of ideas is generated, setting the groundwork for future exploration.	Camisón and Forés (2010)
Selection	This stage requires direct involvement from the organization's top management as it involves strategic decisions regarding which innovation ideas have the highest potential for commercial success. The selection process considers the organization's resources and objectives, ensuring alignment with its long-term vision.	Sicotte et al. (2014)
Development (Implementation)	In this phase, the selected idea is transformed into a concrete and financially sustainable innovation. This stage involves structured development processes where the conceptual idea takes shape, integrating technical feasibility, prototyping, and iterative improvements.	Adams et al. (2006)
Commercialization and diffusion	The final stage aims to expand the innovation's reach within the market. This includes building and reinforcing brand identity, executing market promotion strategies, and managing distribution channels. Simultaneously, the organization begins to reap the benefits of its innovation, both financially and in terms of market influence.	Ren et al. (2015)

Building on this structured view, the emergence of open innovation has further challenged the traditional closed-funnel model. Chesbrough (2003) introduced the concept of a more permeable funnel, often visually represented by dashed lines, where ideas, information, and knowledge flow continuously between the firm and external actors throughout multiple stages of the innovation process.

Within this framework, openness is not conceived as a strict “open vs. closed” dichotomy but rather as a continuum characterized by varying degrees of external collaboration (Huizingh, 2011). Firms are thus encouraged to strategically leverage relationships with suppliers, customers, universities, and other partners to enhance their innovation capacity (Charterina et al., 2017).

Moreover, this concept has evolved further in the digital era, where ecosystem-based innovation and digital platforms redefine how firms collaborate and create value, expanding the boundaries of organizational innovation management (Matarazzo et al., 2021).

2.2. Dynamic Capabilities

Successfully managing innovation, particularly in digitally dynamic environments, requires more than isolated organizational competencies; it demands the orchestration of dynamic capabilities that enable firms to sense opportunities and threats, seize opportunities through resource reallocation, and continuously reconfigure assets and processes in response to rapid external changes (Teece, 2007; Ellström et al., 2021). These capabilities are not static attributes but are patterns of collective learning, strategic decision-making, and systematic reconfiguration embedded in organizational routines.

The rise of digital transformation has further amplified the relevance of dynamic capabilities. As demonstrated by Yang et al. (2023), merely integrating digital technologies is insufficient; organizations must also develop complementary capabilities that foster strategic agility, organizational learning, and ecosystem collaboration. Dynamic capabilities thus act as critical enablers for firms to navigate complex, fast-changing environments, ensuring innovation resilience and adaptability.

Strategically, dynamic capabilities are essential not only for capturing new opportunities but also for safeguarding intangible assets such as organizational knowledge, routines, and brand reputation. By continuously adapting internal structures, reinforcing learning mechanisms, and strengthening absorptive capacities, firms can protect these critical resources from obsolescence and imitation (Cheng & Chen, 2013; Gao & Zhu, 2015).

In ecosystem-driven economies, organizations that excel in developing dynamic capabilities are better positioned to co-create value with external partners, manage interorganizational networks effectively, and sustain superior innovation outcomes (Matarazzo et al., 2021). These capabilities thus represent a core source of long-term competitive advantage.

While prior innovation management models (e.g., Adams et al., 2006; Crossan & Apaydin, 2010) provided valuable insights, many treated innovation as a static, internally driven process and did not sufficiently incorporate the role of dynamic capabilities in enabling continuous adaptation and external collaboration. This gap in the literature justifies the development of updated frameworks that integrate dynamic capabilities as central elements of innovation management, particularly in digitally intensive environments.

The literature review not only provided a conceptual foundation but also revealed specific gaps that informed the design of the proposed framework. In particular, the need for greater operationalization of innovation constructs, the integration of dynamic capabilities and knowledge management practices, and the adaptation to digitally driven ecosystems were recurring themes. These insights directly guided the selection and definition of the research variables presented in the following sections, ensuring that the framework addresses both theoretical advances and practical demands in contemporary innovation management.

3. Innovation Factors

This section synthesizes findings from the literature review to detail the organizational factors that support the development of the proposed innovation management framework. Ten key factors were identified, integrating perspectives from various innovation management models to create a holistic, multidimensional approach. These factors serve as the conceptual foundation for the formulation of measurable research variables, supporting both theoretical advancement and practical application in technology-based firms.

3.1. Innovation Strategy

The influence of strategic decision-making on organizational innovation capacity is well documented, highlighting the need for continuous and systematic implementation (Adams et al., 2006). The alignment between innovation and business strategies, supported

by top management, is emphasized as crucial (Bedford, 2015). A thorough SWOT analysis is recommended to ensure alignment with the organization's innovation capabilities (Bowonder et al., 2010).

3.2. Human Resources Management

The strategic management of human resources is a cornerstone in fostering knowledge management and innovation capabilities. The knowledge, technological skills, and experience of individuals are fundamental for creating new products and services (Bornay-Barrachina et al., 2012; Loufrani-Fedida & Aldebert, 2020). Practices such as recruitment, training, and performance-based compensation play a critical role in enhancing knowledge management capabilities (Aryanto et al., 2015). Additionally, environmental uncertainties and market turbulence influence an organization's learning capacity and innovative potential (Bornay-Barrachina et al., 2012).

3.3. Organizational Culture

Several studies have explored the relationship between Organizational Culture and Innovation Performance (Prajogo & McDermott, 2011). Innovation efforts occur in highly uncertain environments, driven by rapid and unpredictable shifts in both the market and technology landscape (Asmawi & Mohan, 2011). Consequently, senior management must mitigate risks and ensure that innovation efforts yield meaningful results (Naranjo-Valencia et al., 2011).

Certain organizational behaviors contribute to risk mitigation and enhanced innovation performance. For instance, autonomy fosters creativity, a crucial factor in developing impactful innovations (Naranjo-Valencia et al., 2011). Likewise, collaboration enables firms to identify and respond to market opportunities and threats while promoting creativity across the organization (Asmawi & Mohan, 2011). Additionally, challenging work environments serve as a catalyst for innovation.

Building upon the organizational foundation, the next stage in the innovation process emphasizes opportunity identification and idea generation.

3.4. Idea Generation

The early stages of the innovation process involve opportunity identification, idea generation and selection, and concept development. Adams et al. (2006) emphasize that, while these activities are relatively inexpensive, they have a substantial impact on later innovation stages and outcomes.

Two primary factors contribute to superior idea generation and management: (a) collaborative networks: engaging consumers, suppliers, and partners in collaborative networks is crucial for managing the flow of ideas, information, and knowledge entering and exiting the organization (Zeng et al., 2010); (b) formal idea management systems: establishing structured policies, goals, and metrics for idea evaluation, along with reward systems (e.g., salary raises and promotions), is essential. Additionally, tracking the cycle time from idea generation to product launch ensures a structured and efficient innovation process.

3.5. Portfolio Management

Strategic portfolio management is a critical phase in the selection stage of the innovation process. It is a dynamic and continuous decision-making process that reviews and updates the portfolio of ongoing projects, ensuring resource allocation aligns with organizational and innovation strategies.

Effective portfolio management requires capabilities that facilitate learning from past project experiences (Sicotte et al., 2014). This accumulated knowledge helps organizations

balance value maximization and strategic alignment (Artto et al., 2011). Lerch and Spieth (2013) advocate for a hybrid approach that integrates expert decision-making with scoring models, combining qualitative (expert discussions) and quantitative (objective evaluation criteria) elements.

3.6. Project Management

The innovation process is inherently complex, involving multiple activities and significant changes (Hanisch & Wald, 2011). Therefore, organizations need a structured process to manage uncertainty and foster innovation capacity (Adams et al., 2006; Artto et al., 2011).

The skills of project leaders in handling uncertainty and risk are crucial as they facilitate communication, cooperation, and team integration (Hunter & Cushenbery, 2011). Additionally, cross-functional teams enhance decision-making by incorporating diverse professional perspectives, leading to higher-quality outcomes (Gutiérrez-Broncano et al., 2025).

3.7. Marketing Capabilities

Marketing capabilities refer to the skills and routines that enhance the marketing process. This includes using tangible and intangible assets to understand market demands (Frösén et al., 2013) and achieve product differentiation (Hunt & Madhavaram, 2020).

A consumer-centric approach focuses on creating, sharing, and utilizing consumer knowledge, ensuring superior consumer value (Alpkan et al., 2012). Moreover, a strong marketing capability contributes to long-term innovation, leading to higher product quality, increased market share, and improved financial performance (Paladino, 2007).

3.8. Organizational Learning

Organizational learning is essential for sustained competitive advantage as it enables organizations to capture, process, and generate knowledge (Franco & Haase, 2009). This process supports market orientation (Paladino, 2007) and involves interactions with partners, consumers, suppliers, and research institutes, fostering continuous improvement and innovation (Büschgens et al., 2013).

3.9. Absorptive Capacity

Absorptive capacity is the ability to recognize, assimilate, and apply external knowledge for commercial purposes (Y.-S. Chen et al., 2009; Escribano et al., 2009). It consists of two components: potential absorptive capacity, the ability to identify and assimilate new knowledge, and realized absorptive capacity, the ability to adapt and apply acquired knowledge (Ritala & Hurmelinna-Laukkanen, 2013; Spithoven et al., 2010).

Without effective integration of these capabilities, innovation may not occur (Camisón & Forés, 2010).

3.10. Knowledge Management

Knowledge management involves the systematic capture, preservation, sharing, and utilization of both tacit and explicit knowledge within an organization (Purwanto et al., 2021). It ensures that knowledge assets align with market demands, reinforcing innovation capabilities. The three primary domains of knowledge management are: idea generation, managing information flows (including external knowledge acquisition and communication channels), and knowledge repositories (Adams et al., 2006). The information and communication technology (ICT) revolution has significantly improved knowledge management, enhancing innovation capabilities (García-Álvarez, 2015).

While the frameworks developed by Adams et al. (2006) and Crossan and Apaydin (2010) significantly advanced the understanding of innovation management processes, important gaps remain. Unlike prior models that predominantly conceptualized innovation

capabilities at an abstract or procedural level, the present study offers a more operationalized and integrated framework specifically tailored to technology-based firms. The proposed model articulates ten organizational dimensions into measurable constructs, explicitly embedding dynamic capabilities, absorptive capacity, and knowledge management mechanisms as foundational elements. This integration enhances the model's empirical applicability and provides managers with a practical tool to diagnose and strengthen innovation management practices in rapidly evolving ecosystems.

The literature review presented in this section, together with the associated discussion, guided the formulation of the research variables used to assess the intangible aspects of an innovation management system.

4. Methodology

This study employed a mixed-methods approach, aiming to generate new insights into the organizational capacity for innovation management, with a focus on technology-based firms (TBFs) operating in the IT sector.

A mixed-methods approach was chosen because it enables the integration of quantitative validation techniques, such as confirmatory factor analysis (CFA), with qualitative insights that enrich the contextual understanding of innovation management capabilities. This strategy addresses the research gap identified in the literature, which calls for a more operationalized and context-sensitive assessment of organizational innovation capacities.

The research methodology followed a structured sequence organized into five phases (A–E), as illustrated in Figure 1. These stages include the theoretical foundation, identification and synthesis of organizational factors, pre-test and refinement of the measurement instrument, data collection, and finally, model validation and interpretation.

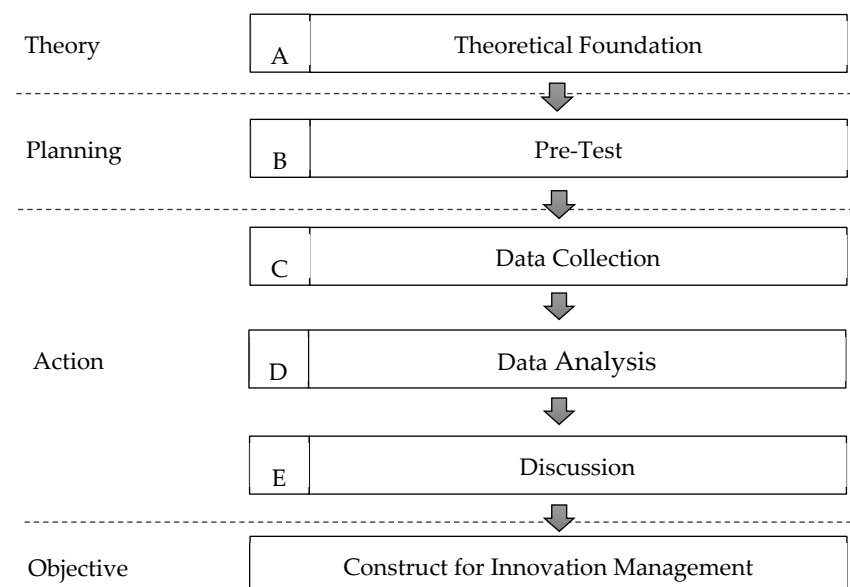


Figure 1. Research stages.

All participants in this study were fully informed about the confidentiality of their responses. Before completing the questionnaire, they explicitly agreed to participate by signing an online informed consent form. The online data collection process was designed to prevent the collection of any personally identifiable information.

The following subsections provide a detailed description of each research phase.

4.1. Theoretical Foundation (Stage A)

Searches were conducted across four focus areas, each using specific keyword combinations to refine the selection process and ensure a comprehensive theoretical foundation for the development of the innovation management model:

1. Innovation management, to identify the organizational capacities involved in innovation (latent variables). The search was conducted using the keyword combination: “Innovation Management” AND “Management of Innovation”;
2. Organizational capacities related to the innovation process, to define investigative questions (manifest variables). The search was conducted using the keyword combination: “Innovation” AND “Innovation Process”;
3. Specific maturity models for managing innovation, to understand existing frameworks that assess innovation capabilities. The search was conducted using the keyword combination: “Innovation Maturity Model” AND “Maturity Model for Innovation”;
4. Maturity models in other contexts, to identify those that address organizational factors contributing to innovation. The search was conducted using the keyword combination: “Maturity Model” AND “Organizational Maturity”.

Articles were sourced from the Web of Science, Scopus, and ScienceDirect databases (2004–2024), and selection was based on language (English), title relevance, and abstract clarity. Studies that focused solely on regional or national innovation systems, specific implementations, periodic evaluations, and legal or patent-related issues were excluded. Conversely, articles addressing barriers to organizational innovation, drivers across industries, and sector-wide trends were included.

After applying the inclusion and exclusion criteria, 129 articles were selected for in-depth review, providing a comprehensive and multidimensional foundation for identifying relevant constructs to be included in the model.

The constructs included in the instrument were derived from this systematic review, with a focus on innovation management models and organizational capabilities. Influential frameworks, such as those proposed by [Adams et al. \(2006\)](#), [Crossan and Apaydin \(2010\)](#), and [Boly et al. \(2014\)](#), served as theoretical anchors for identifying ten organizational factors to be operationalized. These references guided the conceptual mapping of innovation-related dimensions, which were subsequently translated into measurable variables during the design of the survey instrument. The operationalization process ensured theoretical alignment and empirical applicability, forming the foundation for the instrument tested in the pre-test phase.

4.2. Pre-Test of the Data Collection Instrument (Stage B)

The pre-test of the research instrument was conducted using an initial questionnaire comprising 72 questions, organized into 12 categories: innovation strategy, organizational culture, knowledge management, potential absorptive capacity, realized absorptive capacity, idea generation, project management, marketing capability, human resources management, portfolio management, innovation performance, and organizational learning. The objective was to assess the consistency of the questionnaire and identify potential improvements.

The questionnaire items were not directly adapted from existing instruments but rather constructed based on the conceptual definitions of each organizational factor identified in the systematic review presented in Section 4.1. Each item was developed to reflect the operational meaning of its corresponding construct as discussed in prior models (e.g., [Adams et al., 2006](#); [Crossan & Apaydin, 2010](#); [Boly et al., 2014](#)). This process ensured that the content of the items was aligned with the theoretical framework proposed in this study.

To ensure clarity and validity, the items underwent expert review by academics and professionals with experience in innovation management and organizational studies. Their

feedback guided the refinement of item wording and structure to eliminate ambiguity and improve the precision of language. The final version of the questionnaire consisted of 49 items, distributed across 10 organizational factors that were validated in the empirical phase of the study.

4.2.1. Characterization of the Test Sample

The research instrument was tested through a trial data collection at the Atlântico Institute, a Research and Development Institute in Information Technology located in Fortaleza, Brazil. This institute was selected due to its expertise in innovation and its Capability Maturity Model Integration (CMMI) Level 4 certification, which ensures a mature organizational process structure.

A total of 55 professionals were invited to participate, with 42 (76%) responding to the pre-test. The participants represented various competencies within the innovation process, ensuring alignment with the profile of companies participating in the quantitative study.

The respondents had an average tenure at the company of 3.5 years ($SD = 2.5$) and an average tenure in their current role of 5.6 years ($SD = 2.9$). The sample included experienced professionals capable of providing reliable insights into organizational practices.

After characterizing the sample profile, the internal consistency of the questionnaire items was evaluated to validate the reliability of the instrument.

4.2.2. Test of the Data Collection Instrument

The internal consistency of the questionnaire was evaluated using Cronbach's alpha, a widely applied metric for assessing the reliability of research instruments (Bedford, 2015; L. Chen & Fong, 2015; Frösén et al., 2013; Paladino, 2007).

The Cronbach's alpha values for all categories exceeded 0.7, ensuring an acceptable level of internal consistency (Gliem & Gliem, 2003). Table 2 presents the detailed results, compared against the classification scales of Landis and Koch (1977) and George and Mallery (2003).

Table 2. Test collection results compared to reference scales.

ITEM	Questionnaire Factors	Cronbach's Alpha	Landis and Koch Classification	George and Mallery Classification
1	Innovation Strategy	0.7974	Substantial	Acceptable
2	Organizational Culture	0.7668	Substantial	Acceptable
3	Knowledge Management	0.8160	Almost Perfect	Good
4	Potential Absorptive Capacity	0.7930	Substantial	Acceptable
5	Realized Absorptive Capacity	0.7723	Almost Perfect	Acceptable
6	Idea Generation	0.7613	Substantial	Acceptable
7	Project Management	0.7580	Substantial	Acceptable
8	Marketing Capability	0.8529	Almost Perfect	Good
9	Human Resource Management	0.8123	Almost Perfect	Good
10	Portfolio Management Capability	0.8508	Almost Perfect	Good
11	Innovation Performance	0.8609	Almost Perfect	Good
12	Organizational Learning	0.8396	Almost Perfect	Good

The results confirm that all factors exceeded the commonly accepted minimum threshold of 0.7 (Hair et al., 2018), ensuring the instrument's reliability. Six factors scored above 0.8, indicating higher internal consistency. The questionnaire as a whole achieved an average Cronbach's alpha of 0.8068, reinforcing its adequacy for research purposes.

However, based on feedback from respondents and a theoretical review, the questionnaire was revised. The final version was reduced to 49 questions and 11 factors, excluding

“Innovation Performance” as it was determined that this variable could be assessed indirectly through other dimensions of the model. Furthermore, a conceptual mapping of the research variables and their interrelationships was developed, allowing for greater precision in question formulation and factor measurement.

4.3. Data Collection (Phase C)

Following the pre-test and refinement of the measurement instrument, Phase C marked the beginning of the main data collection stage. This phase was conducted at Porto Digital, a leading innovation ecosystem located in Recife, Brazil, where the final version of the survey, implemented in SurveyMonkey (Momentive Inc., San Mateo, CA, USA), was applied to a broader sample. The cluster hosts more than 300 firms, including startups, SMEs, and large corporations operating across various segments of the information and communication technology (ICT) sector, such as software development, digital media, IT consulting, and creative industries. Porto Digital also brings together key stakeholders from academia, government, and private accelerators, fostering a dynamic environment conducive to open innovation and collaborative development. This strategic context provided a fertile ground for evaluating organizational capabilities related to innovation management.

The survey instrument was constructed based on the organizational factors and constructs detailed in Sections 2 and 3. A five-point Likert scale was employed, enabling respondents to indicate their level of agreement with each statement. This scale format is widely adopted in organizational studies due to its intuitive structure and compatibility with confirmatory factor analysis (CFA), which, in this study, was performed using Mplus, version 7.31 (Muthén and Muthén (2017), Los Angeles, CA, USA).

The quantitative survey was distributed online to professionals working in 39 companies within the cluster. Participation was voluntary, and all respondents were informed of the confidentiality and academic purpose of the study. Before completing the questionnaire, participants explicitly agreed to participate by signing an online informed consent form. The online data collection process was designed to prevent the collection of any personally identifiable information.

A total of 302 individuals responded to the questionnaire, with 267 fully completing it, resulting in an 88.4% valid response rate. To ensure the robustness of the sample size, we followed Hair et al. (2018), which recommends a minimum ratio of five respondents per observable variable. As the instrument contained 49 observed variables (see Appendix A, Table A1), the required minimum sample was 245 respondents, which was exceeded.

The sample composition included 21 small companies (up to 49 employees), 13 medium-sized companies (50–249 employees), and 5 large companies (250 or more employees), based on company-reported size. The companies were selected from the official registry of Porto Digital and represent a mix of firms actively engaged in innovation-related projects. Each company nominated participants with direct experience in innovation processes, spanning multiple departments such as R&D, project management, marketing, and operations. This ensured a diverse and functionally representative sample, allowing for a comprehensive perspective on organizational innovation capabilities. Although the sampling strategy was non-probabilistic, it was designed to maximize relevance and practical insight. Future research could explore stratified or probabilistic sampling strategies to increase generalizability across different innovation ecosystems and firm sizes.

To complement the survey findings and enrich the contextual interpretation, semi-structured interviews were also conducted with key innovation professionals. These interviews were carried out in 10 selected companies within Porto Digital and included innovation directors, project managers, engineers, software developers, designers, and marketing professionals. The qualitative interviews aimed to capture perceptions of innovation-

related routines, knowledge flow, and organizational practices, providing deeper insights into the organizational innovation environment.

4.4. Data Analysis (Phase D)

The data analysis phase combined two complementary approaches: (1) statistical processing of the quantitative data collected via questionnaires and (2) content analysis of the qualitative data gathered through interviews with managers.

For the quantitative analysis, descriptive statistics of relative and absolute frequencies were used to examine the distribution of item responses. To identify multivariate outliers, Mahalanobis squared distance (D^2) was computed for each case, considering all questionnaire items simultaneously. A conservative significance threshold of $p < 0.001$ was applied based on the chi-square distribution, with degrees of freedom equal to the number of observed variables. This approach ensured the detection of respondents whose response patterns significantly deviated from the multivariate centroid. In addition, normality was assessed using univariate and multivariate skewness and kurtosis coefficients.

Subsequently, confirmatory factor analysis (CFA) was conducted to validate the factorial structure of the innovation capacity assessment Instrument, which comprises eleven latent variables. CFA was performed using a polychoric correlation matrix due to the polytomous nature of the items, with estimation based on the weighted least squares mean and variance adjusted method (WLSMV) (Byrne, 1998). The model's fit was evaluated using several indices: Standardized Factor Loadings, Comparative Fit Index (CFI), Tucker-Lewis Index (TLI), and Root-Mean-Square Error of Approximation (RMSEA). CFI and TLI values above 0.90 were considered acceptable (Hu & Bentler, 1999), while RMSEA values below 0.08 indicated satisfactory fit (Browne & Cudeck, 1992). A significance level of $p < 0.05$ was adopted for all statistical tests. Analyses were conducted using Mplus version 7.31 (Muthén & Muthén, 2017).

In addition to the quantitative analysis, qualitative data from the interviews were examined through content analysis following Bardin's methodology (Bardin, 2011). The process included three main phases: Pre-analysis, Material Exploration, and Treatment of Results and Interpretation. These phases encompassed five procedural steps: preparation of collected data, coding of meaning units, categorization into conceptual themes, description of findings, and inference. This structured approach ensured methodological rigor and contributed to a comprehensive understanding of the organizational practices related to innovation management.

5. Discussion

This section presents and discusses the findings from the quantitative and qualitative analyses conducted in the study. The results provide insights into the validation of the proposed innovation management capability framework and the contextual factors influencing its application in organizations.

5.1. Quantitative Results

The CFA performed on data from 267 complete questionnaires indicated that the data aligned well with the theoretical model. The fit indices of the hypothetical model for the sample were considered satisfactory. Table 3 presents the three key fit indices: CFI and TLI, which exceed 0.90, and RMSEA, which resulted in 0.000. The RMSEA value suggests an excellent fit, indicating no need for model reformulations (Browne & Cudeck, 1992).

Table 3. General fit indices of the model.

Index	Value
CFI (Comparative Fit Index)	0.917
TLI (Tucker Lewis Index)	0.909
RMSEA (Root-Mean-Square Error of Approximation)	0.000

For estimating the model's factorial parameters, the weighted least squares mean and variance (WLSMV) method was applied using Mplus software. The factor loadings, ranging from 0.44 to 0.94, were all statistically significant, confirming that the latent variables adequately explain the variance of the observed variables (Table 4). The estimated regression coefficients demonstrated high values and strong statistical significance, further supporting the robustness of the model.

Table 4. Standardized factor loadings of the 49 items (observable variables) of the instrument.

Subfactors (Manifest Variables)	Factors (Latent Variables)										
	1	2	3	4	5	6	7	8	9	10	11
Communication of Strategy	0.76 **										
Innovation Routine	0.77 **										
Strategic Alignment	0.79 **										
Strengths and Weaknesses Analysis	0.76 **										
Involvement of Senior Management	0.84 **										
Recognition		0.80 **									
Autonomy		0.74 **									
Collaborative Behavior		0.45 **									
Motivating Work		0.59 **									
Risk		0.71 **									
Knowledge Base			0.71 **								
Corporate Education			0.79 **								
Technological Infrastructure			0.66 **								
Interaction Practices			0.65 **								
Knowledge Sharing			0.75 **								
Critical Thinking				0.50 **							
Continuous Improvement				0.51 **							
Learning-Promoting Management				0.94 **							
Learning Focus				0.85 **							
Knowledge of Competition					0.79 **						
Opportunity Identification					0.88 **						
External R&D Cooperation					0.64 **						
Internal R&D Cooperation					0.52 **						
Encouragement for Postgraduate Studies					0.46 **						
Information Technology						0.60 **					
R&D Management						0.67 **					
Response to Changes						0.74 **					
Patents						0.44 **					
Portfolio Renewal						0.64 **					
Idea Management Metrics							0.75 **				
Effectiveness of Idea Generation							0.84 **				
Time for Idea Generation							0.72 **				
Manager Involvement								0.65 **			
Multidisciplinary Teams								0.60 **			
Project Leader Skills								0.69 **			
Constraint Management								0.69 **			
Lessons Learned								0.62 **			
Consumer Focus									0.76 **		
Consumer Satisfaction									0.60 **		
Response to Threats									0.74 **		
Communicating Marketing Actions									0.67 **		
Organizational Integration									0.80 **		
Recruitment for Innovation										0.77 **	
Reward										0.78 **	
Talent Acquisition Programs										0.82 **	
Portfolio Alignment											0.78 **
Portfolio Development											0.80 **
Project Selection											0.75 **
Portfolio Evaluation											0.74 **

Caption: 1—Innovation Strategy; 2—Organizational Culture; 3—Knowledge Management; 4—Organizational Learning; 5—Potential Absorptive Capacity; 6—Realized Absorptive Capacity; 7—Idea Generation; 8—Project Management; 9—Marketing Capability; 10—Human Resource Management; 11—Portfolio Management.

** $p < 0.001$.

Prior to conducting the confirmatory factor analysis (CFA), the dataset was assessed for outliers and normality. Outliers were identified using the Mahalanobis distance (D^2) method, based on a conservative significance threshold of $p < 0.001$, as recommended for small-to-medium sample sizes (Kline, 2023). Three multivariate outliers were excluded from the sample to ensure the robustness of the subsequent analysis. Normality assumptions were evaluated through skewness and kurtosis coefficients for each item, and all values fell within the acceptable range of ± 2.0 , supporting the adequacy of the data for maximum likelihood estimation.

The model demonstrated good global fit, with acceptable values for χ^2/df , CFI, TLI, and RMSEA. Based on the modification indices (MI) provided by the estimation software, minor adjustments were applied to improve the model fit. These modifications involved covariance between error terms of items within the same construct and were implemented only when theoretically justifiable (Byrne, 2016).

Although the confirmatory factor analysis (CFA) results demonstrated a satisfactory overall fit, certain constructs, such as realized absorptive capacity and resource mobilization, exhibited average variance extracted (AVE) values slightly below the recommended 0.50 threshold. This slight deviation does not compromise the quality of the theoretical construct, particularly given the complexity and multidimensionality of innovation management capabilities in dynamic environments. The observed lower AVE values may reflect the inherent difficulty in capturing the full scope of organizational absorptive behaviors and resource mobilization practices through standardized survey instruments.

In addition to Cronbach's alpha, which was used to evaluate the internal consistency of the constructs, composite reliability (CR) was calculated to provide a more robust assessment. CR is particularly appropriate for confirmatory factor analysis (CFA) as it accounts for the actual factor loadings and associated measurement errors, offering a more accurate reliability estimate when compared to traditional metrics.

The results are presented in Table 5. All constructs achieved CR values above the recommended threshold of 0.70, indicating satisfactory levels of internal consistency. The lowest CR observed was for the "Realized Absorptive Capacity" construct ($\text{CR} = 0.7585$), which aligns with its lower factor loadings and reinforces the need for further refinement of this dimension. These findings, when considered alongside the model fit indices and factor loadings presented earlier, reinforce both the internal reliability and factorial validity of the measurement model.

Table 5. Composite reliability (CR) of construct measures.

	Construct	Composite Reliability (CR)
1	Innovation Strategy	0.8888
2	Organizational Culture	0.797
3	Knowledge Management	0.8379
4	Potential Absorptive Capacity	0.8063
5	Realized Absorptive Capacity	0.7998
6	Idea Generation	0.7585
7	Project Management	0.8147
8	Marketing Capability	0.7857
9	Human Resource Management	0.8401
10	Portfolio Management Capability	0.833
11	Organizational Learning	0.8517

To complement the presentation of the quantitative findings, Figure 2 illustrates the composite reliability (CR) values for each of the validated innovation management capability constructs. All dimensions achieved CR values above the recommended threshold of 0.70, indicating strong internal consistency (Hair et al., 2018). This graphical representation facilitates a clearer comparison of the reliability across the different organizational factors assessed.

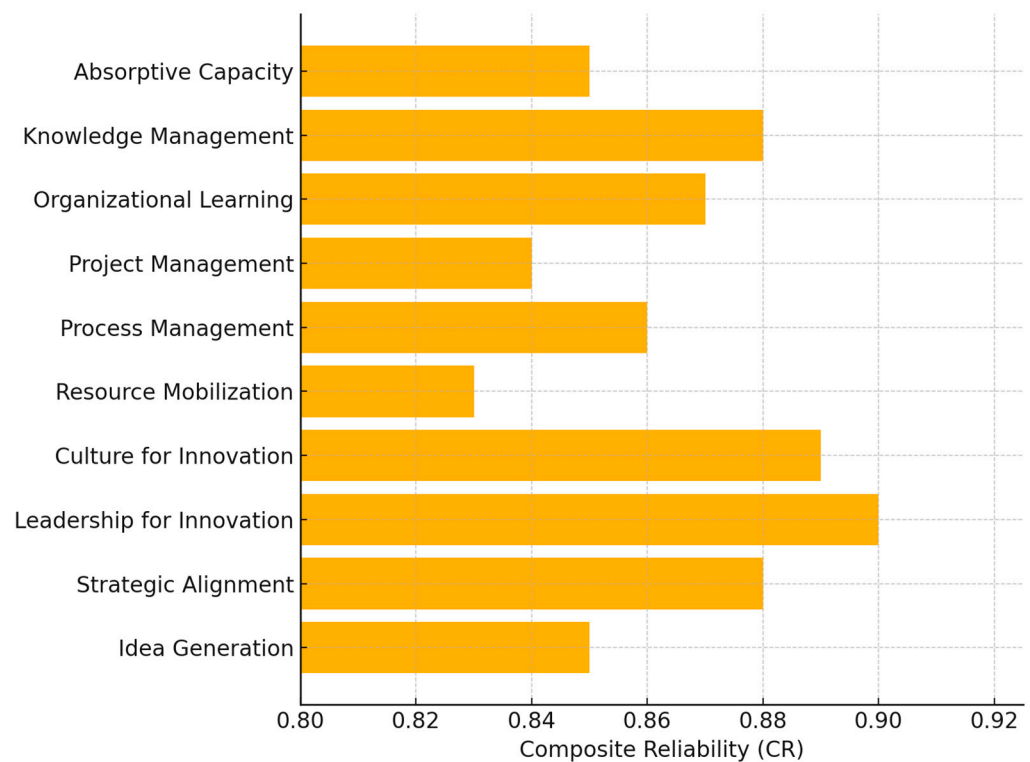


Figure 2. Composite reliability values for the validated innovation management capabilities.

As shown in Tables 3 and 4, the objective of the CFA was successfully achieved. The analysis, applied to a sample exceeding five times the number of evaluated items (49 manifest variables), validated the theoretical structure of the proposed model. These results enhance the understanding of organizational capacity to continuously foster innovation. Furthermore, they reinforce the theoretical reflection on the organizational factors that support the innovation process, providing both researchers and managers with insights into how these elements influence the continuous generation of innovation.

The extracted variance (EV) for each construct was calculated using Equation (1):

$$EV_j = \frac{\sum_{i=1}^n \lambda_i^2}{n} \quad (1)$$

where λ_i represents the standardized factor loading of the i -th item in the j -th construct, and n is the number of items within the construct.

The extracted variance (EV) of each construct is presented in Table 6.

Table 6. Extracted variance of each construct.

Factor/Construct	Extracted Variance
1	0.61556
2	0.44846
3	0.50976
4	0.52905
5	0.45802
6	0.39194
7	0.5955
8	0.42382
9	0.51482
10	0.624567
11	0.589625

Hair et al. (2018) recommend that extracted variance (EV) values should exceed 0.50 for a construct to be considered well-defined. In this study, most factors met or exceeded this threshold, confirming a strong explanatory capacity of the latent variables.

However, factors 2, 5, 6, and 8 presented EV values slightly below 0.50. Despite this, the small discrepancy does not compromise the theoretical validity of the model as the factor loadings were significant, and the global fit indices confirmed model adequacy.

As shown in Table 6, several constructs achieved extracted variance (EV) values above the recommended threshold of 0.50 (Hair et al., 2018), confirming their explanatory power. However, factors such as realized absorptive capacity and marketing capability fell slightly below the ideal level. This suggests that while the latent structure is statistically valid, some dimensions may require refinement or further empirical testing to improve item alignment. These observations reinforce the need for managerial focus on practices that translate knowledge into innovation outcomes.

The confirmatory factor analysis confirmed the internal consistency of most constructs; however, the construct “Realized Absorptive Capacity” displayed comparatively lower factor loadings and a marginal composite reliability value ($CR = 0.7585$). This outcome is consistent with earlier research by Zahra and George (2002) and Todorova and Durisin (2007), who identified the transformation and application of external knowledge as critical yet underdeveloped aspects of organizational innovation processes.

This limitation, observed statistically, finds clear resonance in the qualitative accounts provided by innovation managers during the interviews. Several respondents noted that, although their companies actively acquire knowledge through client feedback, market observation, or collaboration with universities, the integration of that knowledge into internal routines and innovation projects remains ad hoc or informal. For instance, one project manager stated:

“We often learn from projects and from what we observe in the market, but we don’t have a structured way to share this internally or apply it to future projects.”

This finding exemplifies a point of convergence between the quantitative and qualitative strands of the study. While potential absorptive capacity (e.g., knowledge acquisition and assimilation) appears to be reasonably structured in the studied firms, the realized dimension (i.e., transformation and exploitation) is hindered by the lack of formalized mechanisms for knowledge dissemination and reuse.

This triangulation strengthens the validity of the findings and reveals a systemic bottleneck in the innovation capacity of several firms. It also highlights a relevant opportunity for managerial intervention aimed at improving the consistency and impact of knowledge exploitation practices within innovation strategies.

5.2. Synthesis of Qualitative Assessment

The qualitative interviews provided complementary insights that enriched the understanding of the quantitative findings. The analysis, conducted using Bardin’s content analysis methodology, revealed that managerial perceptions consistently emphasized the importance of fostering an innovation-supportive culture, strategic leadership, and knowledge management systems, dimensions that corresponded to the constructs with higher reliability scores in the CFA. Additionally, challenges reported by managers in systematically absorbing external knowledge and mobilizing innovation resources helped contextualize the lower AVE values observed for realized absorptive capacity and resource mobilization, reinforcing the need for continuous development of these capabilities.

The qualitative analysis followed Bardin’s content analysis methodology (Bardin, 2011) through five steps: (1) preparation—organizing collected data; (2) coding—identifying key themes in the responses; (3) categorization—classifying findings into conceptual categories; (4) description—structuring the findings; and (5) interpretation—drawing conclusions based on inferences from the data.

Through transcript analysis and multiple readings, four factors emerged as highly relevant to managers: innovation strategy (IS) and organizational culture (OC) are highly relevant for almost all the investigated companies, followed by marketing Capability (MC) and knowledge management (KM).

The innovation strategy findings highlight a strong market orientation, shaping innovation-related decisions with consistency. Additionally, the organizational culture is marked by employee empowerment, experimentation, and shared decision-making, involving all hierarchical levels.

Despite these strengths, managers acknowledged weaknesses in some areas. innovation strategy elements often remain implicit, requiring greater formalization for effective dissemination across the organization. Similarly, while knowledge management is recognized as crucial for innovation, many companies fail to systematically map and retain critical knowledge, creating gaps in long-term knowledge sustainability.

Moreover, an interest in strengthening the marketing capability was noted. However, factors such as realized absorptive capacity (RAC), idea generation (IG), and portfolio generation (PG) were perceived as less critical to organizational innovation. Respondents acknowledged the need for improvements in these areas but did not view them as immediate priorities.

While all innovation-promoting factors are acknowledged by managers, certain aspects receive insufficient attention or are mismanaged, ultimately affecting the long-term sustainability of these companies. This suggests that different maturity levels exist in organizational capacity to sustain continuous innovation, reinforcing the need for more structured innovation strategies and knowledge management practices.

5.3. The Research Framework

Figure 3 presents the validated innovation management framework, developed through a structured process of theoretical derivation and empirical confirmation via confirmatory factor analysis. The model consolidates ten organizational factors into four hierarchical layers, offering both academic and managerial value. The framework emphasizes the dynamic capacities associated with the stages of the innovation process and structures the elements necessary for innovation management into four distinct but interrelated levels. These layers function as a hierarchical system where each preceding layer supports the subsequent one.

The ten organizational factors consolidated into the framework are: innovation strategy, knowledge management, leadership for innovation, organizational culture, resource mobilization, idea generation, portfolio management, realized absorptive capacity, project management, and learning mechanisms.

Strategic planning capabilities provide the foundation for innovation-related decision-making; enabling behaviors shape the cultural and human resource dimensions; process management capabilities operationalize innovation efforts; and learning capabilities ensure continuous adaptation and renewal. This structured approach enables an integrated and dynamic understanding of innovation management. The four layers will be presented and discussed from the bottom up in the following subsections.

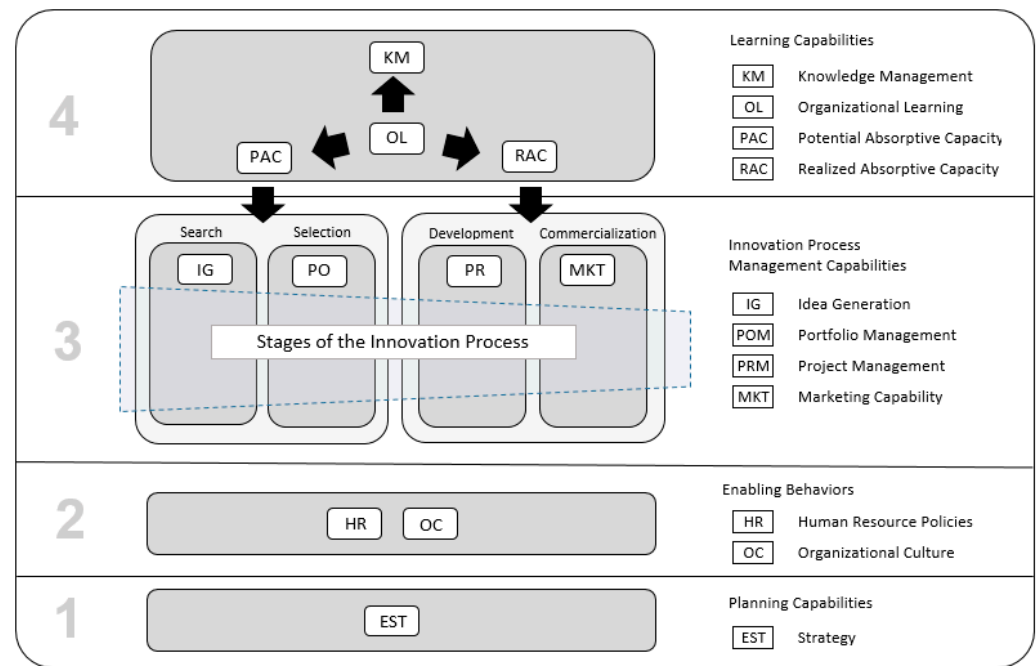


Figure 3. Conceptual framework for the management of innovation and the development of a firm's innovative capacity.

5.3.1. Strategic Planning Capabilities

The conceptualization of innovation capacity as a result of strategic decisions, which need to be continually and systematically implemented (Adams et al., 2006), significantly influences the development of the framework proposed in this paper. In Layer 1 of the framework, the innovation strategy is positioned as a central factor. This factor delineates the approach to innovation at the highest levels of corporate decision-making, thereby influencing whether the commitment to continuous innovation is embraced organization-wide. Consequently, the innovation strategy must be aligned with the company's overarching strategic goals, ensuring that innovation becomes a core business process rather than a sporadic effort (Teece, 2007). A well-established strategic positioning permeates the entire organization, setting the foundation for an effective and sustainable innovation process. Top management support is essential to ensure that strategic innovation planning provides the necessary conditions for execution and sustains other dynamic innovation capabilities (C. J. Chen & Huang, 2009; Jansen et al., 2006).

Given the continuous pursuit of innovation, company leaders must also navigate tensions between stability and experimentation. Organizations seeking distinct, profitable, and long-lasting market positions must balance two opposing forces in knowledge management: (1) exploitation—the refinement and efficient use of existing knowledge to meet consumer and market needs; (2) exploration—the acquisition and assimilation of new knowledge to respond to emerging trends and technological disruptions.

The successful integration of exploitation and exploration is referred to as organizational ambidexterity (March, 1991; O'Reilly & Tushman, 2013). While excessive focus on exploration may lead to inefficiencies and difficulty in capturing value from embedded knowledge, an overemphasis on exploitation increases the risk of obsolescence over time. For well-established companies, particularly medium and large enterprises, developing ambidextrous capabilities is crucial to maintaining competitive advantage in dynamic environments (Popadiuk, 2012). The ability to orchestrate both exploitation and exploration efforts simultaneously determines an organization's long-term innovation potential and resilience in the face of disruptive changes.

Thus, an effective innovation strategy must not only define strategic priorities and resource allocation but also establish mechanisms to balance the dual demands of exploration and exploitation. This balance ensures that innovation efforts are not just reactive but proactively embedded in the company's core strategic vision, allowing it to continuously evolve and adapt to new market conditions.

5.3.2. Enabling Behaviors

Layer 2 of the innovation management framework integrates human resources policies and organizational culture, which together establish the necessary contextual conditions for fostering behavioral patterns conducive to innovation. A well-structured management system ensures that employees can develop and sustain innovative work behaviors, contributing to both incremental and radical innovation efforts.

New knowledge generation benefits from the integration of diverse knowledge and perspectives (Nonaka & Takeuchi, 1995; Østergaard et al., 2011). Therefore, an organizational environment that fosters interaction among professionals with varied backgrounds, experiences, and mental models is more conducive to innovation. HR policies should be strategically aligned with innovation objectives, ensuring that recruitment, training, and performance evaluation criteria reinforce a culture of knowledge-sharing, creativity, and risk-taking (Aryanto et al., 2015).

The mental models and behaviors of employees are shaped by and, in turn, shape the prevailing organizational culture. However, for organizational culture to act as a driver of innovation performance, it must be intentionally cultivated and reinforced by leadership. Denison and Mishra (1995) emphasize that cultural traits such as adaptability, mission clarity, and employee involvement are positively correlated with innovation outcomes. In this regard, leadership alignment is critical; when top management inconsistently supports innovation initiatives, even organizations with a strong innovation-oriented culture may struggle to maintain long-term innovation capability (Jung et al., 2003).

The extent to which these cultural traits foster incremental or radical innovation depends on the organization's flexibility and market orientation (Asmawi & Mohan, 2011; Büschgens et al., 2013; Naranjo-Valencia et al., 2011; Prajogo & McDermott, 2011). Seiler et al. (2022) highlight how companies that integrate values-based innovation management (which promotes autonomy, trust, and shared vision) with evidence-based innovation management (which relies on structured knowledge-sharing mechanisms and decision-making frameworks) achieve greater innovation success, particularly in idea generation and implementation phases.

In summary, human resource policies and organizational culture contribute to innovation performance as they represent deliberate managerial efforts to establish an environment that nurtures creativity, experimentation, and knowledge exchange. By shaping employees' behaviors and attitudes, these factors enhance the organization's ability to develop and sustain the dynamic capabilities required for managing innovation processes and continuously renewing its knowledge base.

5.3.3. Innovation Process Management Capabilities

To a significant extent, the capability to drive innovation is centered around the innovation process, which governs the transformation of ideas into tangible products, services, and competitive advantages. This process plays a crucial role in enhancing economic performance and ensuring sustained organizational growth. Layer 3 of the proposed framework focuses on the factors that directly impact the effectiveness of the innovation process, namely: idea generation, portfolio management, project management, and marketing capability.

The first stage (Search) involves the organization's efforts to monitor internal and external environments to identify opportunities and threats related to innovation. At this stage, the ability to generate ideas and develop concepts is essential to the overall process outcome. Thus, the idea generation factor represents the implementation of structured idea management programs, which encourage and recognize individuals who contribute to the creation and enhancement of innovation projects.

The second stage (Selection) encompasses the portfolio management factor, which involves the strategic selection and prioritization of ideas for development and commercialization. Effective portfolio management ensures that resources are allocated to projects that align with strategic goals, while also maintaining a balanced risk profile (Cooper et al., 2001). Organizations must implement evaluation mechanisms that consider financial viability, technological feasibility, and market potential (McNally et al., 2013). A frequent challenge in this stage is that executives tend to engage primarily in later phases of innovation projects, often after significant financial commitment has already been made (Artto et al., 2011). However, it is important to recognize that choices made during idea generation and portfolio selection have a profound impact on the ultimate success or failure of innovation initiatives. Rhaïem and Halilem (2023) emphasize that organizations can improve innovation performance by systematically learning from both successful and failed innovation projects, incorporating insights at both individual and organizational levels.

The third stage (Development) revolves around project management, which ensures that innovation initiatives are executed effectively. Due to the discontinuous nature of innovation work, companies must balance time, cost, scope, and quality constraints while fostering cross-functional, as emphasized by Hanisch and Wald (2011). The absence of well-defined processes at this stage can lead to knowledge fragmentation, misaligned objectives, and inefficiencies. Consequently, organizations must establish innovation project management frameworks that facilitate knowledge creation, encourage problem-solving, and support structured decision-making throughout the development cycle (Artto et al., 2011).

The fourth stage (Commercialization) involves marketing capability, a key differentiator in the proposed model compared to other academic frameworks. Marketing capability encompasses the strategies and processes that drive market adoption of innovations, ensuring that innovative offerings effectively reach their intended audience. Unlike conventional innovation models that focus primarily on R&D and development phases, the proposed framework highlights the critical role of marketing in successfully positioning innovations in competitive markets.

5.3.4. Learning Capabilities

Layer 4 of the proposed framework brings together organizational learning, potential absorptive capacity, realized absorptive capacity, and knowledge management, all of which contribute to a firm's ability to acquire, process, and apply knowledge effectively in innovation processes. These elements ensure that organizations do not just generate new ideas but also develop mechanisms to retain, refine, and leverage knowledge for long-term competitive advantage.

Organizational learning is an ongoing process that extends beyond simple knowledge acquisition; it requires the structured integration and practical application of new insights within the company (Argote, 2012). Organizations that implement knowledge-sharing practices, such as communities of practice and dedicated knowledge repositories, are better positioned to embed learning across departments and foster a culture of continuous improvement (Wenger, 1999). Moreover, the interaction between organizational learning and absorptive capacity strengthens the firm's ability to convert external knowledge into practical innovation (Zahra & George, 2002).

Within this framework, absorptive capacity is a key enabler of organizational adaptability. It consists of two complementary dimensions: potential absorptive capacity, which reflects the ability to identify and understand external knowledge, and realized absorptive capacity, which determines how effectively a company integrates and applies that knowledge in its operations and strategic decision-making (Zahra & George, 2002). This distinction highlights the fact that acquiring knowledge alone does not drive innovation—what truly matters is how firms translate insights into action.

The knowledge management factor reinforces this learning structure by ensuring that critical information is efficiently captured, shared, and applied across the organization. Instead of treating knowledge management as a standalone function, the proposed framework incorporates it into the firm's innovation strategy and absorptive processes, fostering a cohesive system of knowledge utilization. Companies that invest in robust knowledge-sharing networks and structured information flows tend to sustain continuous innovation cycles as they improve their ability to harness both internal expertise and external insights.

While this study focused on firms operating within the Porto Digital Technology Park, the findings offer potential insights applicable to other technology-based firms embedded in dynamic innovation ecosystems. The structural, strategic, and behavioral factors identified are not exclusive to Porto Digital but reflect broader patterns observed in firms operating under high innovation intensity and technological dynamism. Nevertheless, generalizations should be made cautiously. Regional, sectoral, and cultural differences may influence how firms develop and orchestrate their innovation capabilities. Future research is encouraged to replicate and extend the proposed innovation management model across diverse sectors and geographic locations, enabling a more robust validation of its constructs and relationships.

6. Conclusions

The results of both quantitative and qualitative analyses confirm the validity of the theoretical framework developed to assess organizational capacity for managing the innovation process. The confirmatory factor analysis supported the model's internal consistency and structural validity, while qualitative insights reinforced the relevance and applicability of the identified dimensions, fulfilling the research objectives.

Understanding innovation capacity as a dynamic capability emphasizes the need for organizations to develop: (a) behaviors and skills that foster adaptability and change, (b) routines and processes that detect opportunities and manage innovation risks, and (c) learning mechanisms that ensure long-term sustainability. These components are integrated into the validated framework, which offers a structured, yet flexible, basis for strengthening innovation capabilities across diverse organizational contexts.

From a practical standpoint, the proposed framework provides a diagnostic tool for assessing innovation management maturity. Managers can use the measurement scale to identify priority areas, such as idea generation, project management, or knowledge absorption, and design targeted interventions. The model also supports benchmarking efforts across time or peer organizations and can guide the development of innovation strategies aligned with firm-specific goals.

The framework addresses the need for organizational ambidexterity by balancing the exploitation of existing knowledge with exploration and experimentation. This is particularly critical for firms in rapidly evolving markets, where over-reliance on past routines may hinder adaptability, while excessive experimentation can dilute strategic focus.

Despite these contributions, some limitations must be acknowledged. First, the data collection relied on self-reported questionnaires, which are subject to social desirability bias

and may not fully capture latent organizational capabilities. Second, the study used a non-probabilistic sampling strategy and focused on a single innovation cluster in Brazil, which may limit the external validity and generalizability of the findings. Finally, although the sample was diverse in terms of company size and functional roles, longitudinal data would be necessary to capture the temporal dynamics of innovation capability development.

Given these limitations, future research should apply the framework across different industries and geographic contexts to test its broader applicability. Additionally, incorporating longitudinal approaches or alternative analytical methods (e.g., Item Response Theory) could refine the evaluation of maturity levels. A promising direction would be the development of a dedicated maturity model derived from this framework, enabling organizations to map their innovation trajectories and guide continuous improvement.

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Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The original contributions presented in this study are included in the article. Further inquiries can be directed to the corresponding authors.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Table A1. Questionnaire applied in the quantitative study.

Unobservable Variables (Latent)	Observable Variables (Manifest)
Innovation Strategy	1—The innovation strategy is communicated to all organizational levels.
	2—The work of my colleagues is aligned with the concept of innovation stated in the mission, vision, or values of the company.
	3—The innovation strategy is aligned with the organization’s strategy.
	4—The organization discusses its strengths and weaknesses to improve the innovation process.
	5—I observe managers improving the company’s innovation process.
Organizational Culture	6—The company has good practice in recognizing employees’ innovation initiatives.
	7—Employee autonomy is encouraged in the company’s innovation process.
	8—I know that others will help me if I ask for it.
	9—I perceive employees are motivated to work with innovation.
	10—The company handles risks well.

Table A1. Cont.

Unobservable Variables (Latent)	Observable Variables (Manifest)
Knowledge Management	11—The organization's knowledge base is managed.
	12—The company's training programs are focused on future challenges of the innovation process.
	13—There is adequate investment in technological infrastructure for knowledge sharing.
	14—There are formal practices in the organization that promote the sharing of good practices from different areas.
	15—People who share their knowledge are recognized.
Organizational Learning	16—We question the current ways of thinking and acting within the organization.
	17—We challenge beliefs about how things should be done.
	18—Managers act as learning agents for the organization.
	19—Our shared vision provides a focus for learning.
Potential Absorptive Capacity	20—The company captures relevant knowledge from its competitors.
	21—The company identifies market trends to seize opportunities.
	22—The company cooperates with universities, schools, and institutes to innovate.
	23—The company brings in external personnel for research development.
Realized Absorptive Capacity	24—The company encourages its employees to participate in postgraduate programs.
	25—Employees use Information Technology for knowledge sharing.
	26—The company properly manages project, production, and marketing tasks.
	27—The organization has the capacity to adapt to external changes.
Idea Generation	28—The organization frequently registers patents.
	29—The organization continuously renews its product/service portfolio.
	30—Our idea management indicators contribute to the improvement of the innovation process.
	31—The Idea Generation Program works.
Project Management	32—The company encourages its employees to use part of their time for personal projects.
	33—Senior management is involved in all stages of projects.
	34—The projects involve multiple areas in their development.
	35—Project leaders have the appropriate skills for project management.
Marketing Capability	36—Projects are completed within the planned time, cost, and scope.
	37—The Lessons Learned system from previous projects is used for new projects.
	38—Our market strategies focus on creating value for consumers.
	39—We adequately assess consumer satisfaction.
Human Resource Management	40—The company reacts to competitors' threats.
	41—Information about marketing actions is communicated to everyone.
	42—All our organizational functions are integrated to respond to market and consumer needs.
Portfolio Management Capability	43—Employee recruitment values profiles necessary for the innovation process.
	44—The company rewards people who are strongly involved in innovation projects.
	45—The development of innovation competencies is part of the objectives of our professional training programs.
	46—The selection of ideas for new products/services is aligned with the company's long-term strategic needs.
	47—The development of portfolios is guided by techniques for measuring benefits, economic models, or portfolio models.
	48—Projects are selected based on well-defined criteria.
	49—Information on expenses and resource usage of executed projects is compared to evaluate portfolio returns.

QUESTIONS APPLIED IN THE INTERVIEW WITH MANAGERS (QUALITATIVE STUDY)**INNOVATION STRATEGY**

1. Is there an explicit strategy related to innovation?
2. What internal barriers hinder innovation?
3. What external barriers hinder innovation?
4. Does the organization measure performance in innovation?

PROJECT MANAGEMENT

5. What are the main reasons for failure in your innovation projects?
6. What are the main reasons for success in your innovation projects?

PORTFOLIO MANAGEMENT

7. How is the selection of innovation projects carried out?

ORGANIZATIONAL CULTURE

8. Which aspects of your company's organizational culture contribute to innovation?
9. Which aspects of your company's organizational culture hinder innovation?

KNOWLEDGE MANAGEMENT

10. What measures are taken to prevent the loss of critical knowledge?

ABSORPTIVE CAPACITY (POTENTIAL)

11. How does your company seek and assimilate external knowledge critical to its operations?

ABSORPTIVE CAPACITY (REALIZED)

12. What routines in the organization allow for the transformation and application of knowledge acquired from an external source?

IDEA GENERATION

13. What mechanisms promote encouragement for new ideas to be presented?

MARKETING CAPABILITY

14. How are consumer needs identified and met?

HUMAN RESOURCE MANAGEMENT

15. How do the company's HR policies favor its capacity to generate innovation?

ORGANIZATIONAL LEARNING

16. What are the main challenges in employee training for innovation?

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