Supply Chain Integration for Collaborative Innovation Projects: Unraveling the Role of Project Complexity and Project Management Methods

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Abstract

Supply chain integration (SCI) is crucial for the success of innovation projects led by focal firms in collaboration with customers and suppliers. However, prior research offers limited insights into how SCI configurations may vary according to project characteristics and project management (PM) methods. As alternatives to the traditional stage-gate PM approach have emerged, SCI has become increasingly complex. Drawing on project complexity theory, we seek to understand how different SCI configurations and PM methods intersect in fifteen cases of collaborative innovation projects across eleven multinational firms. Our findings reveal that projects with varying levels of supply, customization, and technological complexity require distinct arcs of integration, paired with appropriate PM methods. The implementation of these strategies hinges on the PM capabilities of the focal firm and its supply chain partners. This study contributes to the SCI literature by theorizing on how different sources of project complexity shape choices regarding PM methods and the arcs of integration that focal firms adopt.

Keywords or phrases: *Innovation; Supply chain integration; Project Management; Project Complexity Theory*

1. Introduction

Focal firms initiate and manage innovation projects within their supply chains to develop new or enhanced products, services, technologies, and processes (Artto et al., 2008). Such projects not only create novel products contributing to firm revenue streams but also significantly influence operational efficiencies and improve customer relationships, thus strengthening competitive advantage and profitability (Prajogo, 2016; Patrucco et al., 2022a).

While innovation projects may be managed internally, drawing exclusively on the firm's resources, many contemporary initiatives increasingly involve collaboration with supply chain counterparts (Sabri et al., 2018). These collaborative innovation projects, defined by Barbic et al. (2021, p. 175) as "*temporary entities comprising a set of purposively planned and managed knowledge flows between organizational representatives to solve a particular innovation problem,*" are central mechanisms through which focal firms and their suppliers and customers co-develop and implement innovative solutions (Bogers et al., 2019; Selviaridis & Spring, 2024). Successful examples of collaborative innovations include P&G and Angelini's development of technology for recycling absorbent hygiene products[1], Qatargas, Maersk and Shell to create liquified natural gas for marine fueling[2]; and Nike and Far Eastern New Century Corporation to develop a water-free dying process technology[3].

Given the increasing need for specialized capabilities, customized solutions, and rapid digital transformation, collaborative innovation within supply chains has assumed even greater strategic importance (Selviaridis & Spring, 2022). The successful execution of such innovation projects significantly depends on the focal firm's ability to integrate key suppliers and customers *at the project level*. Effective collaboration at this level requires deliberate and

[1] https://www.spglobal.com/marketintelligence/en/news-insights/trending/CsK_OvmTxoHisSEWFDumjQ2
[2] https://www.reuters.com/article/shipping-lng-idUKL8N1611S1/
[3] https://sustainablebrands.com/read/supply-chain/nike-inc-unveils-colordry-technology-and-facility-that-eliminate-water-chemicals-in-dyeing

strategic supply chain integration (SCI) i.e., a synchronized collaboration mechanism where focal firms actively engage suppliers and customers in real-time towards achieving common project goals[4] (Fabbe-Costes & Jahre, 2007; Chen et al., 2009a; 2009b; Molinaro et al., 2022). Strategic project management (PM) practices are also essential for effectively coordinating these complex inter-organizational collaborations, highlighting the strategic role of PM in contemporary supply chain management (SCM) (Gaudenzi & Christopher, 2016; Patrucco et al., 2022a; 2024).

Existing research has extensively explored the integration of suppliers and customers in collaborative innovation projects (e.g., Lau, 2011; Patrucco et al., 2022a; 2024). However, we still know little about how specific project characteristics determine SCI configurations, particularly in terms of selecting appropriate supply chain partners, deciding the timing of their involvement, and defining their roles. This knowledge gap is significant because the inherently complex and dynamic nature of innovation projects calls for differentiated integration strategies contingent on varying project characteristics (Geraldi et al., 2011). Additionally, effective collaborative innovation requires that focal firms clearly understand their supply chain partners' capabilities before engagement (Zacharia et al., 2009).

Traditionally, research on PM within SCM has focused predominantly on conventional, linear stage-gate project management (SGPM) models (Petersen et al., 2005; Cui & Wu, 2016). However, the rise of more adaptive PM methods such as agile project management (APM) and hybrid project management (HPM) has introduced considerable complexity into the coordination dynamics of SCI (Cooper, 2016; Cooper & Sommer, 2016; Conforto et al., 2016). Despite the growing adoption of APM and HPM, very limited knowledge exists about how

[4]Based on this definition (in line with Chen et al., 2009a; 2009b), in this paper, supply chain integration, as a form of collaboration, does not include asynchronous collaborations, which are forms of collaboration where participants work independently or at different times without requiring immediate real-time interaction. Such asynchronous collaboration typically involves exchanging information, sharing documents or files, and providing feedback without the need for synchronous communication.

these methods affect SCI configurations within collaborative innovation contexts (Jajja et al., 2017). There is thus a clear opportunity—and indeed necessity—to bridge the theoretical and empirical understanding between SCM and PM disciplines. PM scholars have particularly emphasized the importance of developing diverse SCI approaches that align with the specific complexity levels inherent in projects characterized by high customization or technological uncertainty (Sommer et al., 2015; Conforto et al., 2014; 2016).

In response to these knowledge gaps, we introduce the concept of "innovation PM strategy," defined here as the integrated set of strategic decisions regarding PM methods and SCI configurations that focal firms adopt, contingent upon distinct project complexities. Informed by project complexity theory (Maylor & Turner, 2017), we propose that effective integration of suppliers and customers at the project level necessitates strategic adaptation to specific complexity dimensions—namely, supply complexity, customization complexity, technological complexity, and organizational complexity. Although prior research indicates that SCI should align with firms' operational environments (Lee, 2002; Flynn et al., 2010; Wagner et al., 2012; Sabet et al., 2017; Selviaridis & Spring, 2018; Zimmermann et al., 2020), the temporary, exploratory, and innovation-focused nature of collaborative projects demands a renewed examination of integration configurations (Williams, 1999; 2005). We therefore pose the following research question: *How and why do focal firms differentiate their innovation PM strategies, specifically by combining SCI configurations with different PM methods, based on the level of project complexity?*

We address this question through an in-depth analysis of fifteen collaborative innovation projects from eleven multinational firms actively engaging their supply chain partners. Specifically, we explore how varying project complexity characteristics shape focal firms' innovation PM strategies in terms of SCI configurations and PM method choices.

This paper makes three key contributions. First, it extends recent SCI literature (Molinaro et al., 2022; Wiedmar et al., 2024; Jiang et al., 2024) by offering theoretical and empirical insights into how focal firms strategically align PM methods with SCI configurations at the project level. Second, it contributes to prior SCI research through detailed investigation of how specific project complexity dimensions influence the strategic choice of PM methods and arcs of integration (Frohlich & Westbrook, 2001; Schoenherr & Swink, 2012). Third, we advance existing understanding of collaborative innovation projects by elucidating how the PM capabilities of supply chain partners influence SCI implementation at the project level (Zacharia et al., 2009; Selviaridis and Spring, 2025).

2. Theoretical background

2.1 Collaborative innovation and the role of supply chain integration

SCI is widely recognized as a crucial determinant of successful innovation projects within interorganizational contexts (Wong et al., 2013; Yan et al., 2017; Selviaridis & Spring, 2022). Effective integration of suppliers and customers significantly contributes to the development of innovative products, processes, and services by leveraging the collective expertise, resources, and capabilities present across supply networks (Van Echtelt et al., 2008; Lau, 2011; Mackelprang et al., 2014; Tsinopoulos & Mena, 2015; Suurmond et al., 2020). While prior research has examined SCI configurations and their role in enhancing focal firm innovation performance (Wong et al., 2013; Sabri et al., 2018; Turner et al., 2018; Ramos et al., 2021), the broader implications of these integration activities across the entire supply network often remain underexplored (Carnovale & Yeniyurt, 2015).

Successful SCI necessitates coordinated actions, continuous information exchange, and joint decision-making between focal firms and their supply chain counterparts (Flynn et al., 2010). Such integration frameworks frequently employ collaborative technologies and tools that facilitate seamless, real-time interactions and knowledge flows, ensuring effective contributions from all participating supply chain partners (Narasimhan & Kim, 2001).

Customer integration, in particular, encourages customers' active involvement in the innovation process (Cui & Wu, 2016), allowing focal firms to access critical customer feedback, insights, and expertise that directly inform product and service development. Such customer involvement ensures alignment with market demands and reduces market-related uncertainties (La Rocca et al., 2016). The depth and nature of customer involvement may vary, ranging from transactional exchanges of basic feedback to integrative engagements, including co-design or joint development activities, strategically timed throughout different project phases to maximize effectiveness (Lagrosen, 2005; Moon et al., 2018).

Supplier integration is crucial for accessing specialized technological knowledge and capabilities that suppliers possess (Van Echtelt et al., 2008; Suurmond et al., 2020; Patrucco et al., 2024). Prior literature distinguishes varying levels of supplier integration, typically categorized into "white box," "grey box," or "black box" models, reflecting suppliers' distinct roles, responsibilities, and degrees of transparency during the innovation process (Le Dain & Merminod, 2014). Beyond the extent of supplier integration, appropriate timing of supplier involvement—whether introduced early or later in the innovation process— also shapes the scope and effectiveness of supplier contributions to innovation projects (Parker et al., 2008).

2.2 Supply chain integration at the innovation project level

While SCI positively influences innovation performance of focal firms, it also introduces managerial and operational challenges within supply chain contexts (Selviaridis, 2016; Sabet et al., 2017; Turkulainen et al., 2017; Brewer et al., 2019). Previous SCM research, predominantly anchored in contingency theory, has extensively explored how strategic alignment between SCI configurations and environmental conditions impacts firm performance

(Lee, 2002; Flynn et al., 2010; Zimmerman et al., 2020). This literature argues that the extent and form of supplier and customer integration should reflect the business environment in which firms operate (Qi et al., 2011; Wagner et al., 2012). For instance, empirical evidence suggests that turbulent or highly uncertain business environments typically demand increased integration with external partners to mitigate uncertainty and respond dynamically to emergent conditions (Tsinopoulos & Mena, 2015; Sabri et al., 2018; Zimmerman et al., 2020).

The PM literature extends this understanding, emphasizing that projects—particularly those focusing on innovation—present unique complexities that require distinctive managerial competencies, flexible coordination practices, and adaptive collaboration mechanisms involving supply chain partners (Lu & Yan, 2007; Eriksson, 2015). Although SCM scholarship has begun to address project-level decisions, particularly regarding collaborative relationships with suppliers and customers (Melander & Lakemond, 2015; Melander & Pazirandeh, 2019; Patrucco et al., 2022a; 2024), we still have a limited understanding of how innovation project characteristics and complexities influence specific SCI configurations (Maylor & Turner, 2017). The increasing proliferation of PM methods other than SGPM (Cooper, 2014) underscores the need for SCI strategies that can accommodate requirements for collaboration and flexibility (Gaudenzi & Christopher, 2016).

2.3 Methods used to manage innovation projects

Focal firms undertaking collaborative innovation projects have several PM methods to choose from: stage-gate project management (SGPM), agile project management (APM), and hybrid project management (HPM). Each method addresses distinct project characteristics, responding to specific environmental conditions, complexity dimensions, and market dynamics, employing tailored principles for planning, execution, and monitoring activities (Meredith et al., 2021; Zasa et al., 2021).

Traditionally popular in various industries, the SGPM method provides a structured approach to PM, with sequential stages punctuated by evaluation gates (Cooper, 2008; Grönlund et al., 2010). This method supports thorough planning and risk management, enabling systematic evaluations at each stage to ensure project alignment with predefined objectives. Nevertheless, the inherent rigidity of the SGPM framework poses limitations when confronting dynamic environments characterized by rapidly evolving market conditions or unforeseen project challenges, thereby restricting adaptability and responsiveness to emergent insights throughout the project lifecycle (Gaudenzi & Christopher, 2016; Cooper & Sommer, 2018).

To address SGPM's limitations in fast-paced settings, APM has gained traction due to its adaptability and iterative processes (Salvato & Laplume, 2020). APM emphasizes ongoing development and regular feedback loops with stakeholders, which is especially advantageous for projects that require quick adjustments to meet customer needs or incorporate evolving technologies (Conforto et al., 2016; Cooper & Sommer, 2018). Initially conceived within software development, APM principles have been effectively adapted and increasingly deployed across various sectors, demonstrating notable advantages in innovation projects marked by significant technological uncertainties, rapid technological evolution, and market dynamism (Conforto et al., 2014; Reddy, 2015; Patrucco et al., 2022b).

Hybrid methods integrate the systematic discipline of SGPM with the flexibility and iterative responsiveness of APM, thereby providing a balanced approach suited for projects simultaneously requiring structured planning and agile adaptability (Cooper & Sommer, 2016; Conforto & Amaral, 2016).

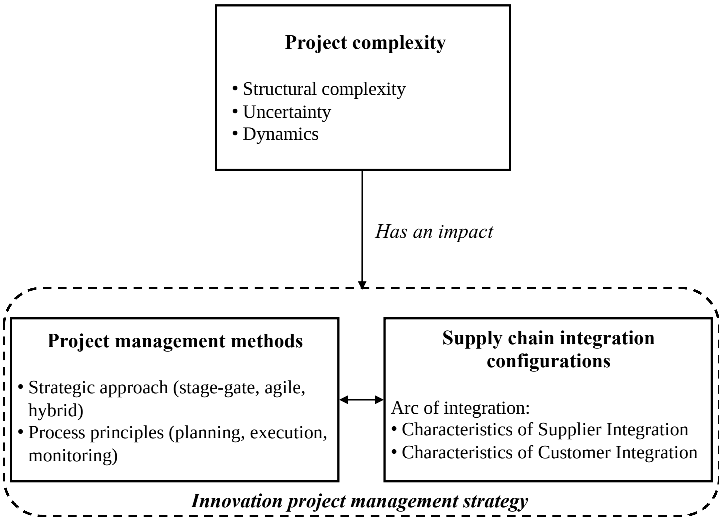
Selecting an appropriate PM method thus inherently involves careful consideration of a project's complexity dimensions, e.g., technological complexity, supply chain complexity, customization requirements, and market volatility (Pons, 2008; Papke-Shields & Boyer-Wright, 2017; Mikkelsen, 2021). For example, innovation projects that exhibit significant technological uncertainty or involve novel technologies could benefit from APM, given its inherent capacity for rapid iteration and adaptation to emergent insights. Conversely, projects characterized by high supply chain complexity or substantial stakeholder coordination requirements may benefit from HPM, leveraging the structured oversight of SGPM alongside the adaptability of agile methods to unexpected disruptions or demand changes (Sohi et al., 2016; Ciric Lalic et al., 2022; Gaudenzi & Christopher, 2016). Matching PM methods to project complexity characteristics is thus critical for successfully managing collaborative innovation projects and optimizing integration with external supply chain partners.

2.4 A project complexity theory-informed conceptual framework

To systematically explore how and why focal firms select particular PM methods and SCI configurations in collaborative innovation projects, we adopt project complexity theory as a lens (Baccarini, 1996; Williams, 1999, 2005; Bakhshi et al., 2016). Project complexity theory posits that organizations strategically align their managerial approaches, coordination structures, and decision-making practices with specific dimensions of project complexity, thus positioning complexity as a central determinant of managerial variations observed across different project contexts (Maylor & Turner, 2017). While originally developed to examine intraorganizational PM decisions, project complexity theory is useful for analyzing how different sources of complexity influence interorganizational collaboration, i.e., the integration between focal firms and their supply chain partners within innovation projects (Vaaland and Håkansson, 2003).

To conceptualize project complexity, we draw on the foundational work of Geraldi et al. (2011) and Maylor & Turner (2017), who build upon Williams' (1999) early contributions. Specifically, these authors propose that project complexity encompasses three critical dimensions: (1) structural complexity, reflecting the number and diversity of interconnected project elements; (2) uncertainty, capturing the unpredictability and ambiguity associated with achieving project outcomes; and (3) dynamics, denoting the rate and degree of change experienced throughout a project's lifecycle. In line with this theoretical perspective, we propose that project complexity shapes focal firms' strategic decisions regarding their innovation PM strategy. We define the innovation PM strategy as comprising two interdependent and complementary components (Figure 1).

Figure 1. Innovation project management strategy and project complexity: conceptual framework.



First, the *"Project management method"* dimension refers to the strategic choice among available PM methods (SGPM, APM, HPM) and associated guiding principles governing project planning, execution, and monitoring processes. As previously discussed, each PM method (SGPM, APM, and HPM) possesses distinct characteristics and strengths, making them uniquely suitable for addressing specific complexity profiles within innovation projects.

Second, the "SCI configurations" dimension captures the strategic choices that focal firms make regarding the nature, timing, and extent of integration with their supply chain partners. Building explicitly on Frohlich and Westbrook's (2001) typology of "arcs of integration," this component specifically encompasses two primary elements: a) characteristics of supplier integration, referring to the strategic roles, depth of engagement, and timing of supplier involvement in innovation activities throughout the project, and b) characteristics of customer integration, referring to the strategic roles, depth of engagement, and timing of customer involvement in innovation activities throughout the project. We employ this conceptual framework to explore how focal firms strategically structure their innovation PM strategies – defined as specific combinations of PM methods and SCI configurations – in in response to varying dimensions and degrees of project complexity.

3. Methodology

Given the scant empirical research on how project management (PM) methods influence supply chain integration (SCI) configurations at the innovation project level, we employed a multiple case-study research design (Yin, 2014). Adopting a theory-building approach (Welch et al., 2011), our objective was to investigate how distinct project complexity dimensions shape the strategic interplay between chosen PM methods and SCI practices. Our case-based research provides deep insights into complex real-world dynamics by examining decisions made by key stakeholders at both organizational and project levels. Our unit of analysis is the collaborative innovation project, as we seek to explore relationships among PM methods, SCI configurations, and complexity dimensions. This project-level analysis allowed us to examine in detail strategic and operational decision-making processes, thus elucidating how focal firms adapt PM and SCI strategies in response to collaborative innovation complexities.

3.1 Case selection

We combined criterion-based and theoretical sampling methods (Suri, 2011) to select the cases, aiming to capture a relevant and theoretically meaningful set of collaborative innovation projects. Criterion sampling was used to identify an initial pool of companies aligned with the objectives of project-level empirical research (e.g., Patrucco et al., 2022a; 2024). This involved targeting industries and supply chains where innovation serves as a key competitive driver. These sectors often feature a high frequency of innovation projects and a diverse range of approaches to PM and SCI, making them particularly suitable for the study. Within these sectors, we specifically targeted large multinational firms, reasoning that their scale and complexity naturally demand structured strategies for PM and SCI. We identified potential participant companies through multiple channels, including industry reports, business press coverage, professional networks, and targeted industry conferences. After reaching out to explain our research objectives and evaluating their suitability through initial discussions, 11 multinational companies agreed to participate.

We then employed theoretical sampling (Yin, 2014) to select specific collaborative innovation projects within these firms. This sampling prioritized projects characterized by distinct complexities, such as high uncertainty, substantial technological novelty, or extensive stakeholder involvement, and those demonstrating innovative or notable PM and SCI practices. Preliminary discussions with company representatives allowed us to select 15 innovation projects (as four companies contributed two projects each, managed by different business units) that represent various types of innovation, including product development, process improvements, and digitally enabled solutions. *Table 1* summarizes the participating companies, their industry sectors, and key characteristics of each innovation project.

3.2 Data collection

The data collection process spanned approximately three years (December 2019 to September 2022). It began with initial discussions with senior managers at each participating firm to outline our research objectives, clarify data requirements, and preliminarily identify suitable collaborative innovation projects. These interactions also allowed us to pinpoint knowledgeable informants familiar with supply chain dynamics, project management strategies, and organizational contexts (Yin, 2014). Data collection unfolded in two clearly defined stages.

Stage 1: Contextual understanding. We focused on capturing the organizational and supply chain context of each innovation project. We conducted 11 preliminary interviews (each lasting approximately 45–60 minutes) with senior supply chain, operations, procurement, and logistics managers. These initial conversations were critical in understanding how the selected innovation projects aligned with each company's broader strategic priorities and market contexts. They also informed subsequent, detailed data collection at the project level.

Stage 2: Project-level data collection. We analyzed the selected collaborative innovation projects. We conducted 25 semi-structured interviews with key project stakeholders, including project managers, supply chain and operations leaders, lasting between 60 and 120 minutes. Interviews covered project objectives, complexity sources, specific PM methods employed, collaborative practices with suppliers and customers, integration approaches, and team dynamics throughout the project lifecycle. Interviews were performed online and in-person, depending on participant availability and geographical distribution. Most interviews were conducted individually to enable participants to openly discuss complex or sensitive issues; however, in select cases, group interviews were conducted when multiple stakeholders from the same project team were simultaneously available. Group interactions provided valuable opportunities to capture diverse perspectives, explore varying viewpoints, and clarify contradictions regarding PM and SCI practices within projects.

Table 2 briefly outlines the characteristics of these 15 innovation projects, while a comprehensive analysis is presented in Section A of the online supplementary materials.

Table 1. Sample respondents (Note: the names of the companies have been anonymized for confidentiality reasons).

Company	Industry	2022 Revenues	2022 Employees	Interviews conducted	Numbers of projects discussed	Interviewee profiles[5]	Additional documents to complement interview data
Baker	Food	$2-3 B	8,500-9,000	2	1	Supply chain director (BA1); Project manager (BA2)	Project scope statement; Project organizational chart
Bee	Logistic provider	$700-800 M	900-1,000	3	2	Logistic manager 1 (BE1); Sales manager (BE2); IT manager (BE3); Logistics manager 2 (BE4)	Supplier and customer contracts; Project Gantt; Project RAM; Project performance reports
Bone	Industrial, Energy and Building Technology	$70-80 B	350-400,000	3	1	Head of supply chain (BO1); IT manager (BO2); Program manager (BO3); Operations manager (BO4)	Project Gantt; Project summary reports; Pictures of Joint Work Environment
Ctech	Chemical	$5-10 B	20-25,000	2	2	Global supply chain manager (CT1); Project manager (CT2); Product manager (CT3)	Design documents; Project RAM; Customer contracts
Enlightening	Energy	$70-80 B	25-30,000	2	1	Procurement manager (EN1); Supply Chain manager (EN2)	Project organizational chart; Project RAM
Icons	Information technology	$70-80 B	300-350,000	3	1	Head of Operations (IC1); Chief Information Officer (IC2); R&D manager (IC3)	Project Gantt; Project RAM; Project organizational chart; Project summary report
Plasty	Plastic manufacturer	$9-10 B	20-25,000	2	2	Project manager 1 (PL1); Product manager 1 (PL2); Project manager 2 (PL3); Product manager 2 (PL4)	Design documents; Supplier contracts; Supplier performance report
Signal	Information technology	$70-80 B	300-350,000	2	1	Product manager (SI1); Demand manager (SI2)	Project organizational chart; Project RAM; Project dashboards
Smelter	Gas	$2-3 B	2,500-3,000	2	1	Project innovation manager (SM1); Corporate strategy manager (SM2)	Supplier contracts; Project overview report
Sofy	Information technology	$70-80 B	100-150,000	2	2	Head of Global Services (SO1); Head of Product Engineering (SO2)	Supplier and customer contracts; Project performance dashboards; Project activity reports
Vocals	Telco	$40-50 B	90-100,000	2	1	Digital transformation manager (VO1); Vendor manager (VO2); Agile coach (VO3)	Supplier contracts; Project dashboards

[5]Interview quotes presented in the text refer to the company and the number associated with the relevant interviewee.

Stage 3: Follow-up and triangulation. To further enrich and validate our findings, we conducted follow-up communications with informants through targeted email exchanges and additional interviews as necessary. We also obtained relevant internal project documentation, including project summaries, Gantt charts, responsibility matrices, project dashboards, and anonymized supplier-customer contractual agreements. These documents provided critical objective insights into stakeholder roles, responsibilities, and collaborative practices. Employing multiple data sources allowed effective triangulation (Jick, 1979), enhancing the credibility and reliability of our analysis regarding how firms strategically align PM methods with SCI configurations under varying project complexities. Supplementary documentation also helped us to better understand the implementation of innovation PM strategies in practice.

3.3 Data coding and analysis

We and coded and analyzed our qualitative data following Miles and Huberman (1984). Two research assistants transcribed the recorded interviews verbatim to preserve participants' responses fully and accurately. Subsequently, two authors jointly developed an initial coding structure, guided by the conceptual framework outlined in Figure 1.

The coding process integrated both deductive and inductive approaches, adopting a Gioia-inspired method (Gioia et al., 2013). Deductive coding was theory-driven, employing predefined categories based on our theoretical framework, specifically relating to project complexity dimensions (structural, uncertainty, dynamics; Maylor & Turner, 2017), PM methods (SGPM, APM, HPM; Cooper & Sommer, 2016), and SCI configurations ("arcs of integration" related to supplier and customer involvement; Frohlich & Westbrook, 2001). Complementing this, inductive coding enabled us to identify additional emergent themes directly from the empirical data, specifically the role of organizational capabilities influencing collaborative innovation outcomes.

Table 2. Characteristics of the collaborative innovation projects included in the sample.

Company/Project name	Main features of the collaborative innovation projects
Ctech/Boat	Development of eco-efficient boat technology for two major customers, involving collaboration with specialized suppliers. Managed using the SGPM method. Project outcome exceeded expectations. Duration: ~12 months; Budget: ~$10 million
Ctech/Polymer	Development of a polymer product for the automotive industry, involving high supply complexity and early engagement of a battery supplier. Managed using the SGPM method. Successfully introduced in high-end models. Duration: ~9 months; Budget: ~$7 million
Baker/Snack	Development of a new kid snack involving low complexity, managed using the SGPM method. Existing suppliers engaged, except for packaging; retail customers provided input. Underestimated demand led to inventory issues post-launch. Duration: ~12 months; Budget: ~$5 million
Smelter/Safety	Development of work safety software in collaboration with IT specialists to manage supply complexity. Managed using the SGPM method. Two suppliers involved early; limited customer integration. Successfully completed. Duration: ~8 months; Budget: ~$1 million
Enlighting/Plant	Development of a manufacturing asset with high technological uncertainty and supply complexity. Managed using SGPM with ad-hoc agile practices. Three suppliers actively contributed to functionality testing. Asset increased productivity, safety, and space efficiency. Duration: ~18 months; Budget: ~$5 million
Plasty/Bottle	Development of sustainable packaging for portable water bottles, involving high supply complexity and ongoing collaboration with a bottle manufacturer; selected retailers provided input. Managed using the SGPM method. Project successful despite higher costs and lower demand. Duration: ~7 months; Budget: ~$1 million
Plasty/Fiber	Development of a construction fiber involving high technological uncertainty and supply complexity. Managed using SGPM with ad-hoc agile practices. Two suppliers and construction customers provided input. Product patented and adopted by multiple customers. Duration: ~12 months; Budget: ~$2 million
Signal/Cloud	Development of cloud migration software, highly customized for a utility company. Managed using a Hybrid PM method. Customer actively involved throughout. Successful software development and implementation. Duration: ~12 months; Budget: ~$4 million
Bee/Load	Development of customized software for a retail customer, with low technological uncertainty and supply complexity. Managed using Hybrid PM. Suppliers and customer actively involved. Delivered successfully and on time. Duration: ~12 months; Budget: ~$500,000
Bee/Schedule	Development of customized software for the construction industry, involving high technological uncertainty and low supply complexity. Managed using Hybrid PM with Scrum. Existing suppliers engaged; customer representatives integrated in project team. Customer highly satisfied with outcome. Duration: ~8 months; Budget: ~$1 million
Bone/Automation	Development of asset productivity software for industrial customers, involving high complexity. Managed using Hybrid PM. Collaboration with software and hardware suppliers; external customers provided input. Successfully implemented and adopted. Duration: ~24 months; Budget: ~$2 million.
Vocal/Website	Development of a new website for industrial customers, with high customization and technological complexity. Managed using APM (Scrum-based). Involved partnership with IT supplier and multiple customer integrations. Completed within planned timeframe. Duration: ~6 months; Budget: ~$2 million
Icons/Blockchain	Development of customized blockchain software for a logistics provider. Managed using proprietary APM. Difficulty finding expert suppliers; high customer integration throughout. Successfully developed, fully meeting customer requirements. Duration: ~4 months; Budget: ~$3 million
Sofy/Cyber	Development of customized cybersecurity software for a U.S. bank, involving high technological uncertainty and supply complexity. Managed using proprietary APM. Partnership established with new suppliers. Successfully developed within budget and timeframe. Duration: ~5 months; Budget: ~$2 million
Sofy/Migration	Development of a business application enabling rapid software migration, involving moderate customization and low technological uncertainty. Managed using proprietary APM. Strong customer and supplier integration throughout. Successfully delivered within budget and timeframe. Duration: ~3 months; Budget: ~$1 million

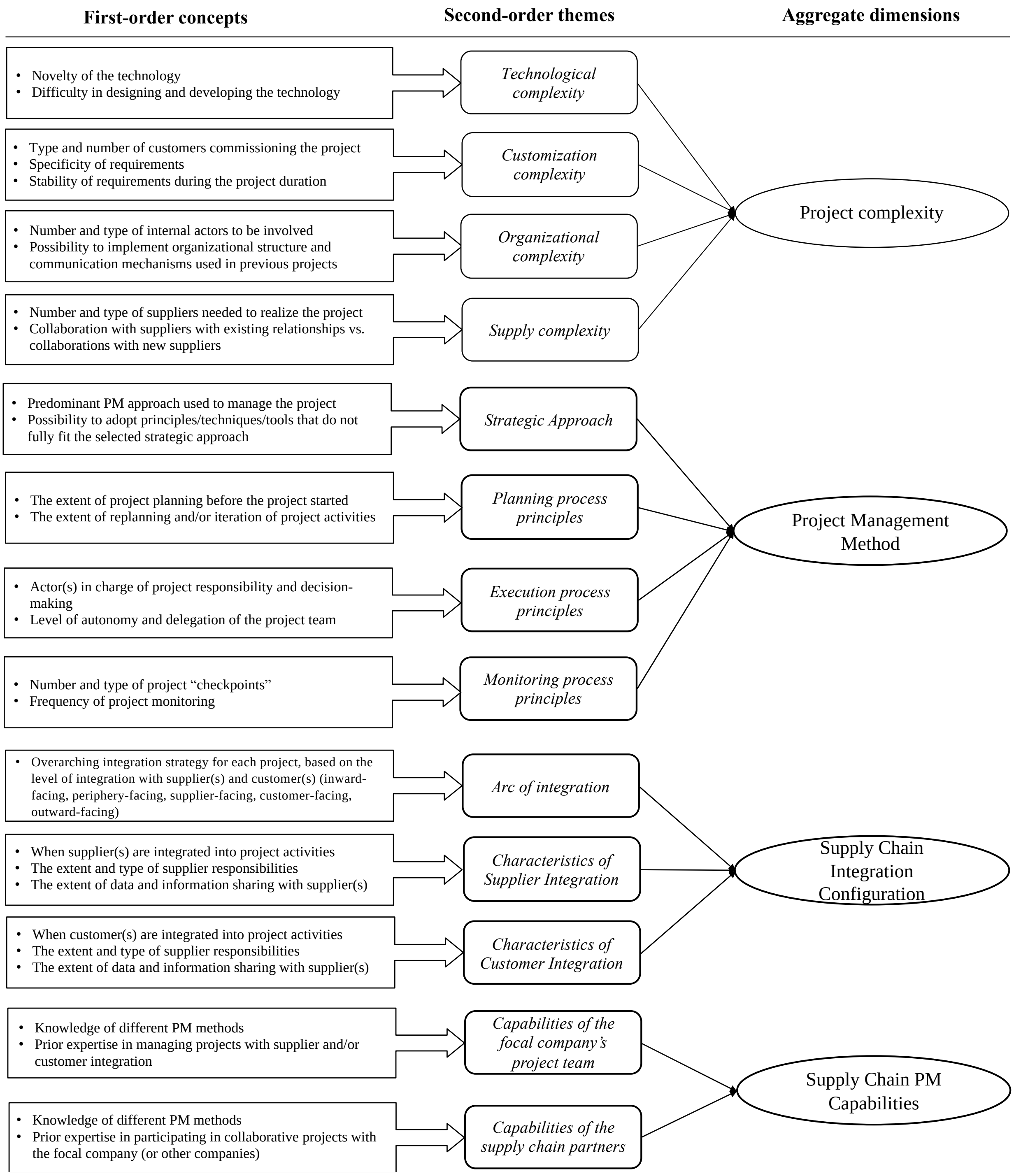
Through multiple iterations and discussions within the research team, we refined the coding structure as presented in Figure 2.

The coding of project complexity drew upon established frameworks (Geraldi et al., 2011; Maylor & Turner, 2017) and was refined through empirical insights from interviewees. Project complexity was coded along four dimensions: technological complexity, customization complexity, internal (organizational) complexity, and external (supply) complexity. For instance, for project with few, familiar suppliers, like Snack, we coded supply complexity as “low”, whereas projects demanding extensive interactions and coordination with new suppliers (e.g., Cyber) were coded as “high”. Appendix A provides detailed information on the coding of the four project complexity dimensions; further details and representative quotes are included in Section B3 of the supplementary materials.

We also coded the data according to the PM method(s) employed in each innovation project (SGPM, AMP, HPM). For instance, projects such as Snack emphasizing sequential phases and upfront planning were coded as “SGPM”, while others emphasizing iterative processes and flexibility (e.g., Cyber) and using agile methods were coded as “APM”. In addition, we coded PM practices into three first-order dimensions—planning, execution, and monitoring—following established PM frameworks (Project Management Institute, 2017). Appendix A offers details of our approach for this dimension; further details and representative quotes are included in Section B2 of the supplementary materials.

Similarly, we coded our data in terms of the SCI configurations. Initially, our analysis focused inductively on integration characteristics—specifically the timing, extent, and visibility of supplier and customer involvement (Lagrosen, 2006; Koufteros et al., 2007; Parker et al., 2008; Van Echtelt et al., 2008; La Rocca et al., 2016). These first-order concepts were subsequently mapped onto Frohlich and Westbrook’s (2001) “arcs of integration” typology, providing a coherent theoretical categorization. Appendix A offers details of our approach for this dimension; further details and representative quotes are included in Section B1 of the supplementary materials.

Figure 2. Data coding structure



As illustrated in Figure 2, "SCI configurations" is an aggregate dimension consisting of three second-order themes: “arcs of integration”, “characteristics of supplier integration”, and characteristics of customer integration”. Finally, we coded our data inductively to reflect capabilities necessary for effectively implementing different PM methods. These included “knowledge of the chosen PM methods” and “prior experience with collaborative innovation projects” (see Appendix A for more details).

We conducted within-case and cross-case analyses (Yin, 2014) to systematically examine relationships between project complexity, SCI configurations, and PM methods across the fifteen collaborative innovation projects. The within-case analysis focused on deeply understanding each project's unique characteristics, capturing how focal firms strategically aligned their SCI and PM choices in response to different complexity dimensions. Subsequently, cross-case analysis allowed us to identify commonalities and differences across cases, providing a broader understanding of recurring patterns.

We applied two analytical techniques recommended by Yin (2014). First, pattern matching involved comparing empirically observed relationships against the relationships anticipated by our conceptual framework. Specifically, we assessed whether project complexity dimensions aligned predictably with chosen SCI configurations and PM methods. For example, the Snack project exhibited low complexity in both supply and customization dimensions, an inward-facing SCI configuration, and reliance on a structured SGPM approach, aligning closely with our initial theoretical expectations. Conversely, deviations from expected patterns prompted further investigation. For example, the Boat project's unexpectedly high technological complexity led to deeper supplier involvement, which shifted the SCI from inward-facing to periphery-facing, thus refining our understanding of the nuanced relationship between (technological) complexity and integration choices.

Second, we applied explanation building to refine our initial theoretical propositions by interpreting and clarifying unexpected or complex relationships identified during the analysis. For example, when analyzing the Fiber and Polymer projects (both featuring high supply but low customization complexity), we identified consistent effectiveness of supplier-facing SCI configurations coupled with structured SGPM. However, Polymer's higher technological complexity also required the integration of agile techniques into its stage-gate framework, thus showing the nuanced influence of technological complexity on the adoption of hybrid methods.

Further methodological details and validity procedures used to support this process are summarized in Table B5 in the supplementary material document.

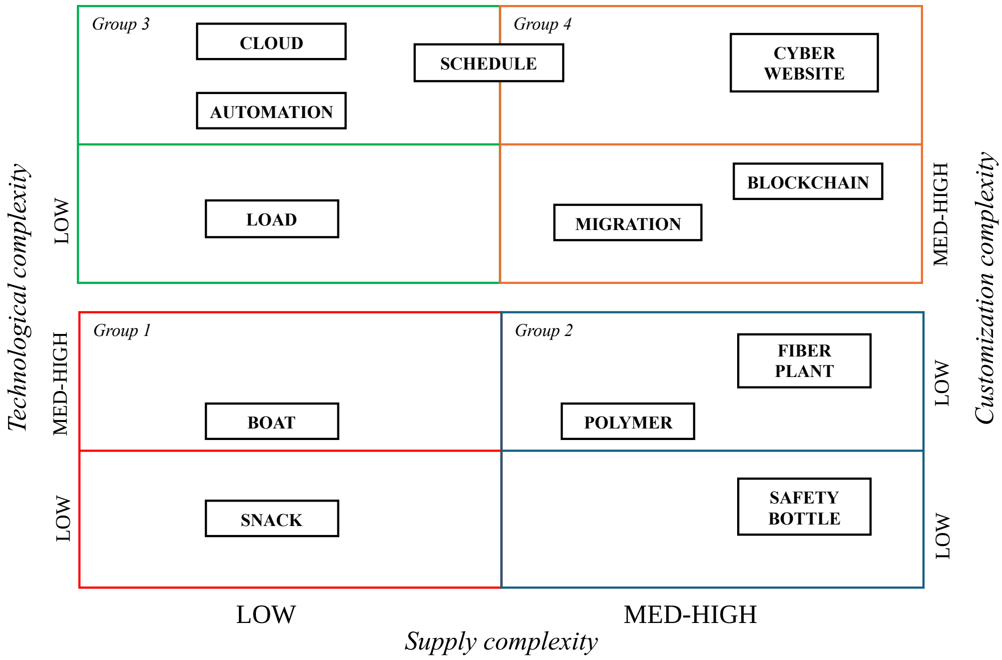
3.4. Validity and reliability

To ensure validity and reliability of our findings, we triangulated data across multiple informants within each project and solicited participants' feedback on our coding categories and associated interpretations. Specifically, detailed coding schemes, representative quotes, and our preliminary interpretations were shared with participants, whose feedback further refined the coding accuracy and analytical categories, ensuring they resonated accurately with informants' perspectives.

4. Case Study Findings

We identified distinct patterns concerning the relationships among project complexity, SCI configurations, and PM methods. Specifically, two complexity dimensions—supply complexity and customization complexity—emerged as particularly influential, guiding how focal firms structured their SCI strategies and selected PM methods. Consistent with project complexity theory, projects exhibiting similar complexity characteristics adopted similar strategic approaches (Maylor & Turner, 2017). Based on these two dimensions, we categorized the projects into four groups (G1 through G4) as shown in *Figure 3*. We position projects within a matrix defined by supply complexity (horizontal axis: low to high) and customization complexity (vertical axis: low to high). Within each group, we further consider technological complexity, noting its influence on PM method choices and adaptations, even when SCI configurations remain relatively stable. We also found that PM capabilities—specifically, the project teams' and partners' knowledge and prior experience—significantly influenced the practical implementation of SCI strategies. Tables 3-6 summarize the patterns observed within each group, while Section C of the supplementary materials offers detailed analyses.

Figure 3. Categorization of Innovation Projects Based on Sources of Complexity.



4.1 Group 1: stage-gate approaches with limited supply chain integration

The Boat and Snack projects were characterized by low levels of both supply complexity and output customization complexity (see *Table 3*). Consequently, the companies leading these projects adopted structured PM processes with limited planned integration of suppliers and customers into their project teams.

Given the low complexity, both projects were managed using the SGPM method. Activities such as product configuration, resource allocation, and project timelines were planned upfront, utilizing established organizational structures and traditional planning tools.

Decisions were primarily centralized, with operational teams having limited autonomy. Supplier involvement was confined to specific phases, and customer input was predominantly gathered during initial design stages.

Table 3. Analysis of projects characterized by low supply complexity and low level of customization

		Boat	**Snack**
PROJECT COMPLEXITY	*Customization complexity*	Low (external customers)	Low (external customers)
	Technological complexity	Medium	Low
	Organizational complexity	Medium	Medium
	Supply complexity	Low	Low
PROJECT MANAGMENT METHOD	*Strategic approach*	SGPM	SGPM
	Planning process principles	Upfront	Upfront
	Execution process principles	Project-manager driven	Project-manager driven
	Monitoring process principles	Continuous	Ad-hoc
SUPPLY CHAIN INTEGRATION CONFIGURATION	*Arc of integration*	Periphery-facing	Inward-facing
	Characteristics of supplier integration	*Timing*: During development *Extent of involvement*: Medium *Visibility*: Low	*Timing*: During development *Extent of involvement*: Low *Visibility*: Low
	Characteristics of customer integration	*Timing*: During design *Extent of involvement*: Low *Visibility*: Low	*Timing*: During design *Extent of involvement*: Low *Visibility*: Very limited
SUPPLY CHAIN PM CAPABILITIES	*PM method knowledge – Focal company project team*	SGPM (advanced) HPM/APM (NA)	SGPM (advanced) HPM/APM (NA)
	Expertise in collaborative projects – Focal company project team	SGPM (high) HPM/APM (NA)	SGPM (high) HPM/APM (NA)

	PM method knowledge – Supply Chain Partners	Suppliers: SGPM (advanced) Customers: SGPM (unclear)	Suppliers: SGPM (basic) Customers: not relevant
	Expertise in collaborative projects – Supply Chain Partners	Suppliers: SGPM (high) Customers: SGPM (moderate)	Suppliers: SGPM (high) Customers: not relevant

Despite their general similarity, the Boat project exhibited higher technological complexity compared to the Snack project, necessitating ad-hoc integration with suppliers and customers to manage uncertainty effectively. Suppliers were involved more deeply during the development phase and given moderate visibility into project activities to align component development with final product specifications. This integrative approach was facilitated by the focal company's prior experience managing collaborative innovation projects using SGPM methods. Customers were integrated early during design phases to mitigate downstream integration challenges:

> *We wanted to be sure about technology needs and avoid any integration problems in their [customer] products (…) This required extra-activities, but we planned this since the beginning, and it is part of our marketing strategy.*" (CT2)

In contrast, the Snack project, characterized by lower technological complexity, employed a more sequential and less integrated approach with suppliers. The focal firm (Baker) managed supplier interactions by identifying and addressing potential constraints upfront, without fully integrating suppliers into the project team, in line with the SGPM principles. However, both projects demonstrated the inherent rigidity of SGPM when confronted with unexpected developments. For example, the Snack project faced competitive pressures requiring substantial acceleration of project timelines:

> *We discovered that one of our competitors was having a similar idea, and they are usually faster than us to launch new products (…) we suddenly had to cut in half the*

duration of the remaining activities, and that was expensive." (BA1)

Addressing these challenges, the focal company leveraged suppliers' familiarity with SGPM to adapt to accelerated schedules, emphasizing the importance of PM method knowledge and collaborative expertise in navigating unforeseen disruptions.

4.2 Group 2: Stage-gate approaches with "ad-hoc" agile and high supplier integration

The Bottle, Safety, Polymer, Fiber, and Plant projects share the characteristic of medium-to-high supply complexity combined with low output customization complexity (see *Table 4*). High supply complexity arose primarily from the necessity to engage multiple suppliers possessing specialized competencies absent internally. Consequently, supplier integration was continuous and intensive, supporting project design, development, and delivery. Customer integration, in contrast, was limited and occurred mainly during key phases to validate demand or align functional requirements.

The Bottle and Safety projects employed SGPM predominantly, reflecting their relatively low technological complexity. Upfront planning, coupled with project-manager-driven execution, enabled effective supplier coordination by leveraging established organizational structures and communication routines. For example, the Bottle project involved early integration of a manufacturing supplier to ensure alignment regarding material feasibility and production decisions, providing suppliers real-time visibility into project progress. Similarly, the Safety project consistently involved suppliers throughout software development, relying on milestone-based monitoring to ensure delivery at critical checkpoints.

> *The traditional way to manage projects makes it easier to collaborate with suppliers, as we can replicate coordination mechanisms used in many other projects... this also limits the information-sharing efforts, as suppliers integrated into the team can still work with partial visibility on the project.* (SM1).

Table 4. Cross-case analysis: Projects characterized by high supply complexity and a low level of customization

		Bottle	**Safety**	**Polymer**	**Fiber**	**Plant**
PROJECT COMPLEXITY	*Customization complexity*	Low (external customers)	Low (internal customers)	Low (external customers)	Low (external customers)	Low (external customers)
	Technological complexity	Low	Low	Medium	High	High
	Organizational complexity	Medium	Medium	Medium	Medium	Medium
	Supply complexity	High	High	Medium	High	High
PROJECT MANAGMENT METHOD	*Strategic approach*	SGPM	SGPM	SGPM (ad-hoc APM techniques)	SGPM (ad-hoc APM techniques)	SGPM (ad-hoc APM techniques)
	Planning process principles	Upfront	Upfront	Mixed	Upfront	Mixed
	Execution process principles	Project-manager driven	Project-manager driven	Project-manager driven	Project-manager driven	Partially team-driven
	Monitoring process principles	Milestones	Milestones	Continuous and milestones	Continuous and milestones	Continuous and milestones
SUPPLY CHAIN INTEGRATION CONFIGURATION	*Arc of integration*	Supplier-facing	Supplier-facing	Supplier-facing	Supplier-facing	Supplier-facing
	Characteristics of supplier integration	*Timing*: Throughout the project *Extent of involvement*: High *Visibility*: High	*Timing*: Throughout the project *Extent of involvement*: High *Visibility*: High	*Timing*: Throughout the project *Extent of involvement*: Medium *Visibility*: Medium	*Timing*: Throughout the project *Extent of involvement*: High *Visibility*: High	*Timing*: Throughout the project *Extent of involvement*: High *Visibility*: High

	Characteristics of customer integration	*Timing*: During development *Extent of involvement*: Low *Visibility*: Low	*Timing*: During development *Extent of involvement*: Low *Visibility*: Medium	*Timing*: During development *Extent of involvement*: Medium *Visibility*: Low	*Timing*: During development *Extent of involvement*: Low *Visibility*: Low	*Timing*: During development *Extent of involvement*: Medium *Visibility*: Low
SUPPLY CHAIN PM CAPABILITIES	*PM method knowledge – Focal company project team*	SGPM (advanced) HPM/APM (NA)	SGPM (advanced) HPM/APM (NA)	SGPM (advanced) HPM/APM (basic)	SGPM (advanced) HPM/APM (basic)	SGPM (advanced) HPM/APM (basic)
	Expertise in collaborative projects – Focal company project team	SGPM (high) HPM/APM (NA)	SGPM (high) HPM/APM (NA)	SGPM (high) HPM/APM (limited)	SGPM (high) HPM/APM (limited)	SGPM (high) HPM/APM (limited)
	PM method knowledge – Supply Chain Partners	*Suppliers*: SGPM (advanced) *Customers*: not relevant	*Suppliers*: SGPM (advanced) *Customers*: not relevant	*Suppliers*: SGPM (advanced) *Customers*: not relevant	*Suppliers*: SGPM (advanced) APM (basic) *Customers*: not relevant	*Suppliers*: SGPM (advanced) APM (basic) *Customers*: not relevant
	Expertise in collaborative projects – Supply Chain Partners	Suppliers: SGPM (high) Customers: not relevant	Suppliers: SGPM (high) Customers: not relevant	Suppliers: SGPM (high) Customers: not relevant	Suppliers: SGPM (high) Customers: not relevant	Suppliers: SGPM (high) APM (limited) Customers: not relevant

The Polymer, Fiber, and Plant projects exhibited higher technological complexity, prompting focal companies to introduce ad-hoc agile techniques within their existing SGPM frameworks. For example, the Polymer project introduced Kanban boards alongside SGPM to enhance visibility, manage interdependencies, and mitigate development uncertainties. Similarly, the Fiber project leveraged Kanban tools and structured "Inspect and Adapt" sessions among suppliers to jointly evaluate development progress and risks, facilitating effective management of a complex triadic supplier relationship. The Plant project incorporated iterative approaches such as Scrum retrospectives to handle technological uncertainty, relying on an external consultant to support agile practices within the traditional stage-gate structure.

> *We needed flexibility in integrating the technologies, so we adapted with agile tools like retrospective meetings while keeping an overall stage-gate structure.* (EN2)

A key difference emerged in the suppliers' capabilities. In the Fiber and Plant projects, suppliers' prior agile experience supported seamless integration into iterative processes. Conversely, the Polymer project's supplier initially lacked agile familiarity, necessitating targeted training by the focal company to ensure effective participation and continuity in the hybrid PM approach.

Customer integration in Group 2 remained limited, occurring primarily during development phases to validate product demand or functionality. For example, in the Plant project, selected customers evaluated beta versions of the asset, while in the Polymer project, customers provided input during product testing, though their involvement remained restricted.

> *We can consult with customers in several moments at the beginning of the projects (…) we can understand how they will use the product and if specific features would change their buying choices.* (PL1)

4.3 Group 3: Hybrid approaches with high customer integration

The Cloud, Load, Schedule, and Automation projects are characterized by medium-to-high customization complexity coupled with low-to-medium supply complexity (see *Table 5*). In the Schedule project, supply complexity was categorized as medium rather than low due to the combination of existing developer suppliers and new specialized suppliers needed to address specific technical requirements[6].

Given the significant customization requirements, high levels of customer integration emerged as crucial for all projects in this group. Companies structured customer involvement throughout the project lifecycle to continuously align outcomes with evolving customer needs. Conversely, supplier integration was comparatively less intensive and primarily concentrated during development phases.

To accommodate dynamic customer requirements and maintain flexibility, these projects adopted HPM methods, integrating structured stage-gate principles with agile practices. This provided a balance between upfront planning and iterative responsiveness to customer-driven uncertainties. Agile techniques proved particularly beneficial when customer requirements were not fully defined initially, enabling frequent adjustments and collaborative iteration. As one Bone informant (BO3) stated, *"Scrum is the answer, especially when we want to keep the doors open on what technology we are going to use."*

Technological complexity influenced the extent to which agile or stage-gate components dominated within each project's HPM approach. In the Cloud and Load projects, characterized by lower technological complexity, SGPM methods predominantly structured the workflow. For example, the Load project incorporated a "partial Scrum" approach, using Scrum events for iterative replanning within a structured upfront plan. Similarly, the Cloud

[6] This distinction underscores that supply complexity in Schedule was higher compared to the other projects in this group, though not to the level observed in Group 2. This nuance did not impact the overall cross-case analysis, as the grouping remains consistent with the broader patterns.

project relied on a traditional waterfall framework complemented by "Scumban[7]" practices, granting flexibility for emergent changes. In both projects, teams had significant autonomy during execution but maintained accountability to project managers for critical decisions.

Table 5. Analysis of projects characterized by low supply complexity and high level of customization

		Cloud	Load	Schedule	Automation
PROJECT COMPLEXITY	*Customization complexity*	High (external customers)	High (external customers)	High (external customers)	Medium (internal and external customers)
	Technological complexity	Medium	Low	Medium	High
	Organizational complexity	High	High	High	High
	Supply complexity	Low	Low	Medium	Low
PROJECT MANAGMENT METHOD	*Strategic approach*	HPM (predominance of SGPM)	HPM (predominance of SGPM)	HPM (predominance of APM)	HPM (predominance of APM)
	Planning process principles	Mixed	Upfront	Mixed	Iterative
	Execution process principles	Partially team-driven	Partially team-driven	Partially team-driven	Partially team-driven
	Monitoring process principles	Milestones	Continuous and milestones	Continuous and milestones	Continuous
SUPPLY CHAIN INTEGRATION CONFIGURATION	*Type of integration*	Customer-facing	Customer-facing	Customer-facing	Customer-facing
	Characteristics of supplier integration	*Timing*: During development *Extent of involvement*: Low *Visibility*: Medium	*Timing*: During development *Extent of involvement*: Low *Visibility*: Medium	*Timing*: During development *Extent of involvement*: Medium *Visibility*: High	*Timing*: During development *Extent of involvement*: Medium *Visibility*: Medium
	Characteristics of customer integration	*Timing*: Throughout the project *Extent of involvement*: High	*Timing*: Throughout the project *Extent of involvement*: High	*Timing*: Throughout the project *Extent of involvement*: Medium	*Timing*: Throughout the project *Extent of involvement*: Medium *Visibility*: Medium

[7]Scrumban is an Agile development methodology that is a hybrid of Scrum and Kanban. In Scumban, the team follows a continuous flow process, similar to Kanban, where work items are visualized on a Kanban board and progress through different stages. Scumban incorporates the timeboxed nature of Scrum by introducing the concept of iterations, known as "Scrumban iterations" or "Scrum-like iterations." These iterations are shorter than traditional Scrum sprints and serve as checkpoints for planning, review, and retrospection.

		Visibility: Medium	*Visibility*: High	*Visibility*: High	
SUPPLY CHAIN PM CAPABILITIES	*PM method knowledge – Focal company project team*	SGPM (advanced) HPM/APM (basic)	SGPM (advanced) HPM/APM (basic)	SGPM/HPM/ APM (advanced)	SGPM/HPM/APM (advanced)
	Expertise in collaborative projects – Focal company project team	SGPM (high) HPM/APM (moderate)	SGPM (high) HPM/APM (moderate)	SGPM (high) HPM/APM (moderate)	SGPM/HPM/APM (high)
	PM method knowledge – Supply Chain Partners	Suppliers: SGPM (advanced) HPM/APM (basic) Customers: SGPM/HPM/ APM (advanced)	Suppliers: SGPM (advanced) HPM/APM (NA) Customers: SGPM (advanced) HPM/APM (NA)	Suppliers: SGPM/HPM/ APM (advanced) Customers: SGPM (advanced) HPM/APM (basic)	Suppliers: Developer Suppliers - SGPM/HPM/APM (advanced) Technology supplier - SGPM (advanced); HPM/APM (basic) Customers: SGPM/HPM/APM (advanced)
	Expertise in collaborative projects – Supply Chain Partners	Suppliers: SGPM (high) HPM/APM (NA) Customers: SGPM/HPM/ APM (high)	Suppliers: SGPM (high) HPM/APM (NA) Customers: SGPM (high) HPM/APM (NA)	Suppliers: SGPM (high) HPM/APM (moderate) Customers: SGPM (high) HPM/APM (NA)	Suppliers: Developer Suppliers - SGPM/HPM/APM (high) Technology supplier - SGPM (high); HPM/APM (low) Customers: SGPM/HPM/APM (high)

Conversely, the Schedule and Automation projects featured higher technological complexity, prompting greater reliance on agile practices. In the Schedule project, broad objectives were established upfront, but execution was iterative through Scrum sprints and Rapid Application Development, closely involving customers at each step. Automation adopted a predominantly agile-centric approach due to uncertainty around both internal and customer requirements and complexity of supplier activities. Here, upfront planning was intentionally limited, and Scrum facilitated rapid adaptability to evolving project conditions.

We still like the planning and structured waterfall approach, but this is simply not *more reliable (...) We have hundreds of customers with their own requirements, needs,*

and preferences (...) Scrum is the answer, especially when we want to keep the doors open on what technology we are going to use. (BO3)

Customer integration was continuous and extensive across all four projects, enabling iterative refinement of requirements and product outcomes. In the Load and Schedule projects, customers actively defined initial requirements and tested beta releases regularly. Similarly, in Cloud and Automation, selected customers functioned as extended team members, providing ongoing design feedback, strategic approvals, and intermediate validations. These customers were highly experienced with both SGPM and agile methods, enabling efficient collaborative project management and ensuring that outcomes consistently matched their expectations.

Supplier integration varied somewhat across the projects. In Cloud and Load, supplier involvement was limited to targeted technical support during development, with low responsibility and partial visibility. In contrast, Schedule and Automation projects involved suppliers more substantially during development, though integration experiences differed. Schedule benefited from developer suppliers experienced with agile methods, facilitating smooth collaboration. Automation, however, faced integration challenges due to suppliers' limited agile familiarity. One informant explained:

The agile-non-agile company-supplier interface represents a huge problem that will have to be managed as soon as possible, in order to avoid difficulties and inefficiencies (...) In our case, the only solution was to let the supplier work independently based on technology requirements. (BO4)

4.4 Group 4: Agile approaches with high supply chain integration

The Website, Blockchain, Cyber, and Migration projects are characterized by medium-to-high levels of both supply complexity and (output) customization complexity (see *Table 6*).

Given this dual complexity, continuous and intensive involvement of suppliers and customers was crucial. Interviewees consistently emphasized the critical role of customers, highlighting their active participation in project decisions. To manage such high levels of supply chain integration, the focal firms fully embraced APM principles and practices. The Website project employed a pure Scrum methodology, with iterative planning through bi-weekly sprints. A dedicated team of 16 members, located across Europe, ensured 24/7 collaboration via a dedicated platform. This structure enabled autonomous development of multiple releases with continuous supplier and customer input.

The Blockchain project implemented a proprietary agile approach inspired by Extreme Programming. Project responsibilities were distributed across five teams: two teams focused on direct supplier collaboration, while three concentrated on customer communication and feedback management. Similarly, in the Cyber and Migration projects, agile frameworks such as Scrum and Disciplined Agile Delivery structured the iterative execution of activities. Long-term planning was intentionally minimized, and distinct agile roles (Product Owners, Scrum Masters) were established to manage supplier and customer interactions effectively.

The successful adoption of agile practices in these projects was facilitated by advanced internal expertise in APM, as well as significant experience with collaborative innovation initiatives involving external partners. However, the implementation of agile methods had distinct implications for customer and supplier integration. Customer integration was generally effective across all projects, independent of prior customer familiarity with agile methods. In cases like Website and Migration, where customers initially lacked agile experience, focal companies proactively educated customers on agile principles. This approach fostered trust and still resulted in collaborative decision-making:

> *The customer wanted to be involved, and we wanted to involve the customer as much as possible (…) We both knew agile was the best to do so, and we decided, together,*

what approach to use (…) without too much formalization at the contract level, they trusted us! (IC2)

Table 6. Analysis of projects characterized by high supply complexity and high level of customization

		Website	**Blockchain**	**Cyber**	**Migration**
PROJECT COMPLEXITY	*Customization complexity*	High (external customers)	High (external customers)	High (external customers)	Medium (external customers)
	Technological complexity	Medium	Low	High	Low
	Organizational complexity	High	High	High	High
	Supply complexity	High	High	High	Medium
PROJECT MANAGMENT METHOD	*Strategic approach*	APM	APM	APM	APM
	Planning process principles	Iterative	Iterative	Iterative	Iterative
	Execution process principles	Team-driven	Team-driven	Team-driven	Team-driven
	Monitoring process principles	Continuous	Continuous	Continuous	Continuous
SUPPLY CHAIN INTEGRATION CONFIGURATION	*Type of integration*	Outward-facing	Customer-facing (forced)	Outward-facing	Outward-facing
	Characteristics of supplier integration	*Timing*: Throughout the project *Extent of involvement*: High *Visibility*: High	*Timing*: During development *Extent of involvement*: Medium *Visibility*: High	*Timing*: Throughout the project *Extent of involvement*: High *Visibility*: High	*Timing*: Throughout the project *Extent of involvement*: Medium *Visibility*: High
	Characteristics of customer integration	*Timing*: Throughout the project *Extent of involvement*: Medium *Visibility*: Medium	*Timing*: Throughout the project *Extent of involvement*: High *Visibility*: High	*Timing*: Throughout the project *Extent of involvement*: High *Visibility*: High	*Timing*: Throughout the project *Extent of involvement*: High *Visibility*: High
SUPPLY CHAIN PM	*PM method knowledge – Focal company project team*	SGPM/HPM/APM (advanced)	SGPM/HPM/APM (advanced)	SGPM/HPM/APM (advanced)	SGPM/HPM/APM (advanced)

	Expertise in collaborative projects – Focal company project team	SGPM/APM (high) HPM (limited)	SGPM/APM (moderate) HPM (moderate)	SGPM/ HPM/APM (high)	SGPM/ HPM/APM (high)
	PM method knowledge – Supply Chain Partners	Suppliers: SGPM (advanced) HPM/APM (basic) Customers: SGPM (advanced) HPM/APM (basic)	Suppliers: Not available Customers: SGPM/HPM/ APM (advanced)	Suppliers: SGPM/APM (advanced) Customers: SGPM/HPM/APM (advanced)	Suppliers: SGPM (advanced) APM (basic) Customers: SGPM (advanced) HPM/APM (basic)
	Expertise in collaborative projects – Supply Chain Partners	Suppliers: SGPM (high) APM (high) Customers: SGPM (high) APM (limited)	Suppliers: Not available Customers: SGPM/HPM/ APM (high)	Suppliers: SGPM (high) APM (moderate) Customers: SGPM (high) HPM (limited) APM (moderate)	Suppliers: SGPM (high) APM (moderate) Customers: SGPM/HPM/APM (high)

In contrast, Cyber and Blockchain benefited from customers already experienced with agile practices, facilitating smoother interactions and deeper integration of customer inputs..

Regarding supplier integration, effectiveness largely depended on suppliers' familiarity with agile methods. Agile-capable suppliers integrated smoothly into project activities, whereas suppliers unfamiliar with agile approaches posed significant integration challenges. In the Blockchain project, the absence of suppliers experienced in Extreme Programming led Icons to vertically integrate development activities internally, despite the associated inefficiencies. In the Website project, suppliers lacking agile experience received targeted agile training, although this resulted in additional time and costs due to synchronization challenges. The Cyber project illustrated the advantages of selecting suppliers with proven agile expertise to mitigate risk, as noted by one informant:

> *We needed a partner capable of working with our project team and helping to reduce the risks, not increase them. (SO1)*

In the Migration project, supplier selection prioritized technical quality over agile proficiency. Recognizing a gap in agile experience, the focal company provided intensive agile training to the selected supplier, ultimately ensuring effective integration despite initial capability gaps.

5. Discussion

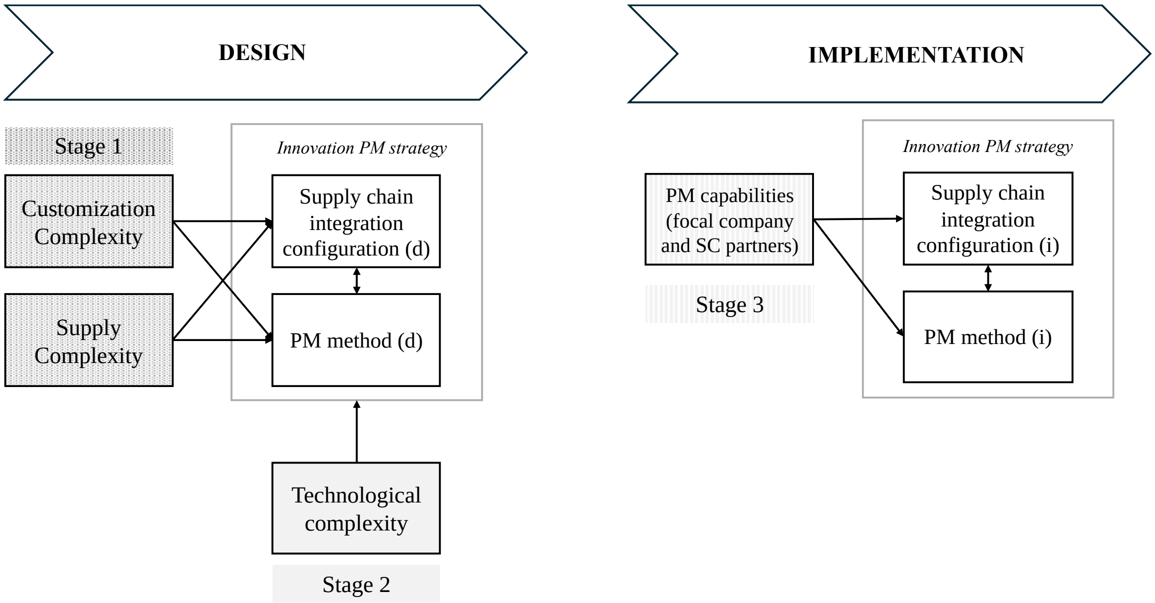
Our cross-case analysis reveals that an interplay exists between project complexity, SCI configurations, and PM methods, suggesting that innovation PM strategies evolve through distinct yet interrelated phases. Specifically, our findings indicate a logical distinction between an initial "design" phase, where project strategies are planned, and an "implementation" phase, where these strategies are enacted, adapted, and refined based on emergent project dynamics. This distinction emerged inductively from our analysis, reflecting observed patterns across the fifteen collaborative innovation projects.

In the *design phase*, focal firms formulate their initial SCI configurations and select appropriate PM methods based on the assessed complexity dimensions. This phase is characterized by two primary stages. Stage 1 involves assessing the project's levels of supply complexity and customization complexity, directly informing the initial SCI configuration. Stage 2 then considers technological complexity to guide the selection of the most suitable PM method for managing the collaborative innovation project.

Following this theoretically grounded initial design, the *implementation phase* involves iterative adjustments as initial design decisions (SCI configuration and PM method) might undergo refinement as the project progresses. This is largely due to variations in partners' PM knowledge, differing degrees of familiarity with selected PM methods, and unexpected complexities emerging during execution (Stage 3). Figure 4 presents our research model, which explicitly differentiates between the designed (d) and implemented (i) states of both SCI configurations and PM methods to capture this iterative adjustment. The distinction between

SCI configuration (d) and SCI configuration (i), as well as PM method (d) and PM method (i), reflects potential gaps or adaptations occurring between the original strategic intent and actual practice.

Figure 4. A sequential stage model of innovation PM strategies for collaborative projects (note: d = design; i = implementation).

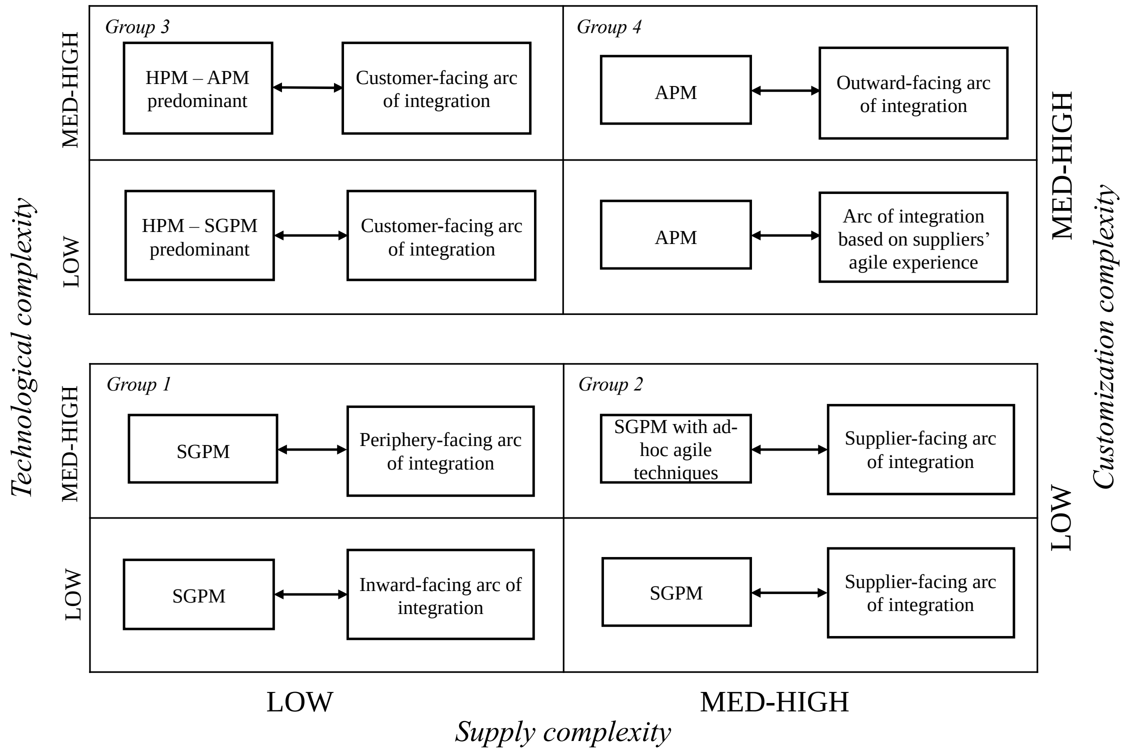


Next, we detail the relationships among project complexity dimensions, SCI configurations, and PM method choices. Appendix B presents the identified patterns, based on our use of pattern-matching and explanation-building techniques (Section 4).

5.1 Designing the innovation PM strategy: The role of project complexity

Our findings indicate that supply, customization, and technological complexity significantly influence the design of innovation PM strategies, yet their effects manifest sequentially rather than concurrently. While prior research often treats complexity dimensions as independent or simultaneous factors (e.g., Geraldi et al., 2011; Eriksson, 2015; Melander & Lakemond, 2015; Maylor & Turner, 2017), we find that focal firms first evaluate supply and customization complexity to define their initial SCI configurations and PM method choices. Technological complexity is considered subsequently, prompting further refinements to mitigate risks and uncertainties arising during the project lifecycle. This step-wise approach underscores the nuanced interplay among complexity dimensions during design. *Figure 5* summarizes these findings, illustrating the range of innovation PM strategies aligned with different combinations of complexity dimensions. The following subsections elaborate on these insights.

Figure 5. Scenarios for innovation PM strategy design (based on combinations of sources of project complexity).



5.1.1 Stage 1: Supply and customization complexity as primary drivers

At the outset, focal companies evaluate supply complexity (defined by the number, variety, and novelty of suppliers) and customization complexity, or the specificity required to meet customer needs. These dimensions significantly shape the extent and nature of supplier and customer integration (the "arcs of integration"; Frohlich & Westbrook, 2001) and directly inform the selection of the PM method. Projects involving familiar suppliers and minimal customer customization (Group 1) typically require limited external integration (inward-facing integration; Molinaro et al., 2022). Such projects are effectively managed using SGPM, given their lower complexity that allows for structured upfront planning and clear task delineation

(Pons, 2008). For example, in the Snack project, low supply complexity facilitated asynchronous collaboration with suppliers, reinforcing SGPM's suitability. Therefore, we propose:

P1. *Collaborative innovation projects characterized by low supply and low customization complexity are more likely to adopt an inward-facing SCI configuration and utilize SGPM as the PM method.*

When supply complexity increases, but customization complexity remains low (Group 2), continuous supplier collaboration becomes essential (supplier-facing integration). In these cases, SGPM remains preferable, as its structured gate reviews ensure effective supplier coordination and alignment, leveraging suppliers' resources and expertise (Koufteros et al., 2007; Patrucco et al., 2022a). Therefore, we propose:

P2. *Collaborative innovation projects characterized by high supply complexity and low customization complexity are more likely to adopt a supplier-facing SCI configuration and utilize SGPM as the PM method.*

Projects featuring high customization complexity and low supply complexity (Group 3) demand extensive, continuous integration with customers (customer-facing integration). In these contexts, customer involvement enhances understanding and responsiveness to evolving requirements, pushing focal firms toward HPM approaches. The combination of structured SGPM planning with agile adaptability allows effective management of uncertain, customer-driven requirements. This finding complements existing literature on hybrid methods (e.g., Cooper & Sommer, 2018; Zasa et al., 2021), highlighting external factors (i.e., customization complexity) that encourage HPM adoption. Therefore, we propose:

P3. *Collaborative innovation projects characterized by low supply complexity and high customization complexity are more likely to adopt a customer-facing SCI configuration and utilize HPM as the PM method.*

Finally, projects combining high supply and high customization complexity (Group 4) require simultaneous, intensive integration with both suppliers and customers (outward-facing integration). These highly complex projects benefit from adopting APM, providing flexibility, iterative responsiveness, and effective management of ongoing collaboration demands. This result extends existing insights by emphasizing that APM adoption is not solely customer-driven or market-oriented (Cooper, 2014; Conforto & Amaral, 2016; Patrucco et al., 2022a). Instead, our findings underscore that the choice to adopt APM needs to be linked to the level of supplier and customer integration imposed by the project's complexity. Thus, we propose:

> ***P4.*** *Collaborative innovation projects characterized by high levels of supply and customization complexity are more likely to adopt an outward-facing SCI configuration and utilize APM as the PM method.*

5.1.2 Stage 2: The role of technological complexity

Technological complexity significantly shapes the design of innovation PM strategies. While supply and customization complexity primarily define the initial SCI configuration and PM method (Stage 1), technological complexity introduces additional uncertainty requiring adaptive risk mitigation measures (Stage 2; Baccarini, 1996). In projects with low supply and customization complexity (Group 1), increased technological complexity amplifies development risks, prompting focal firms to expand their integration beyond an inward-facing approach to a periphery-facing arc of integration. This change enhances collaboration with selected suppliers or customers to address emerging technological uncertainties. In the Boat project, for example, greater technological complexity necessitated deeper supplier engagement to manage design risks effectively. Thus, we propose:

> ***P5.*** *Higher technological complexity in collaborative innovation projects characterized by low supply and customization complexity increases the likelihood of adopting a periphery-facing SCI configuration to mitigate development risks.*

For projects characterized by high supply complexity and low customization complexity (Group 2), technological complexity prompts firms to introduce selective agile practices within the structured SGPM framework. These ad-hoc agile techniques enhance responsiveness and task visibility, addressing technological uncertainties without abandoning structured project control. The Polymer project illustrates this, integrating Kanban tools within SGPM to improve flexibility. This approach enriches the PM method continuum between purely structured (SGPM) and fully agile (APM) approaches, effectively managing complexity (Zasa et al., 2021; Gaudenzi & Christopher, 2016; Sohi et al., 2016). Thus, we propose:

P6. *Higher technological complexity in collaborative innovation projects characterized by high supply and low customization complexity increases the likelihood of introducing ad-hoc agile practices within SGPM to mitigate development risks and enhance supplier integration effectiveness.*

For projects combining low supply complexity with high customization complexity (Group 3), technological complexity influences the predominant PM approach within hybrid methods. Projects with lower technological complexity generally retain strong SGPM elements, emphasizing upfront planning with limited agile iterations. As technological complexity increases, focal firms shift predominantly toward agile principles within HPM, employing iterative development and rapid decision cycles to manage technological uncertainties effectively. For example, the Schedule project adopted Scrum sprints and Rapid Application Development practices to handle technological complexity efficiently. This finding contrasts with prior PM literature, which suggests that SGPM tends to dominate in hybrid approaches (Cooper & Sommer, 2016; Zasa et al., 2021). Thus, we propose:

P7*. In collaborative innovation projects characterized by low supply complexity and high customization complexity, the level of technological complexity influences the* *predominance of PM methods: focal firms favor SGPM when technological complexity is low, and shift toward APM when technological complexity is high.*

For projects characterized by high supply and high customization complexity (Group 4), technological complexity determines viable strategies for supplier integration within APM. Projects with lower technological complexity allow greater flexibility, including engaging non-agile suppliers supported by tailored agile training or, alternatively, vertically integrating activities when suppliers are unable or unwilling to adopt agile methods (e.g., Blockchain project). Conversely, higher technological complexity increases development risks, necessitating suppliers with agile expertise. In the Cyber project, for example, collaboration with agile-capable suppliers minimized integration risks and delays. Thus, we propose:

P8. *In collaborative innovation projects characterized by high supply and high customization complexity, the level of technological complexity determines the supplier integration strategy adopted (e.g., selecting agile-experienced suppliers, providing agile training for non-agile suppliers, or reducing integration levels).*

5.1.3 The role of organizational complexity

In contrast to external complexity dimensions—supply, customization, and technological complexity—organizational complexity, reflecting internal structural challenges, did not directly influence the initial SCI configuration or PM method selection in our sample. Across all cases, organizational complexity remained consistently medium-to-high, characterized by diverse functional involvement, multiple departments, and geographically dispersed teams. While established R&D structures and standardized PM processes were common, firms frequently adjusted organizational structures dynamically in response to project-specific challenges (Grass et al., 2020). This aligns with existing literature suggesting organizational complexity necessitates tailored internal coordination, communication, and information-sharing mechanisms (Fernandez et al., 2018; Turkulainen et al., 2017).

However, our findings indicate that organizational complexity does influence the implementation of SCI configurations. This influence is particularly evident in differences regarding partner visibility and timing of integration observed across project groups. Specifically, in simpler projects (Groups 1 and 2), lower external complexity allowed limited external partner visibility and phased integration. In contrast, highly complex projects (Groups 3 and 4) required continuous integration with suppliers and/or customers, with higher visibility, reflecting greater internal coordination and communication demands. Thus, organizational complexity indirectly influences how SCI configurations are enacted.

5.2 Stage 3: Implementing the innovation PM strategy and the role of PM capabilities

Once an innovation PM strategy is designed, the PM capabilities of both the focal company's project team and its supply chain partners critically shape its implementation. In collaborative projects utilizing SGPM, the project team's advanced knowledge of SGPM principles and extensive collaborative experience significantly enhance risk management, planning effectiveness, and adaptability to emerging challenges. Such capabilities enable teams to proactively address disruptions and coordinate smoothly with suppliers. For example, in the Plant and Fiber projects, teams successfully leveraged their SGPM expertise to manage high supply complexity and technological uncertainty effectively. Furthermore, teams familiar with agile techniques can integrate specific agile tools (e.g., Scrum, Kanban) into SGPM when facing technological complexity. In the Polymer project, adopting Kanban within SGPM enhanced responsiveness without compromising the structured stage-gate framework, emphasizing the complementary value of agile knowledge.

Regarding supply chain partners' PM capabilities, firms prioritizing SGPM select suppliers based primarily on their collaborative innovation experience rather than explicit SGPM technical proficiency, given SGPM's widespread adoption and straightforward methodology. Suppliers experienced in collaborative projects contribute significantly to smoother integration and project alignment, as demonstrated by the Safety and Bottle projects, where experienced suppliers effectively supported successful outcomes. Thus, we propose:

***P9.** When using SGPM, the successful implementation of the innovation PM strategy hinges primarily on suppliers' and customers' prior experience with collaborative innovation projects employing SGPM.*

In projects adopting HPM or APM, focal companies' project teams require foundational agile knowledge and at least moderate experience in iterative, flexible environments to balance structured and agile approaches effectively. Teams possessing these capabilities successfully manage complexities inherent to hybrid and fully agile methods, as evidenced by the Cloud and Load projects, which integrated agile tools within structured frameworks, and the Blockchain and Cyber projects, which seamlessly combined advanced APM methods (Scrum, Extreme Programming) for efficient project execution.

The integration capabilities required of customers and suppliers differ significantly in HPM and APM contexts. Customer integration using HPM or APM does not strictly depend on customers' prior agile experience, as focal firms effectively introduce and explain agile practices to inexperienced customers. For example, in Migration and Website projects, focal firms successfully integrated customers unfamiliar with agile methods through proactive education and continuous engagement. Conversely, customers already familiar with agile methods, as in the Cyber project, facilitated more rapid integration and decision-making.

In contrast, supplier integration using HPM or APM critically depends on suppliers' agile capabilities. In purely agile contexts, suppliers' agile proficiency is essential to avoid integration difficulties. Suppliers lacking agile expertise create significant risks, requiring additional training, explicit formalization, or even insourcing activities. The Automation project illustrates such challenges, as non-agile suppliers complicated coordination, prompting the focal company to adopt extra measures for effective integration. Alternatively, in HPM projects, while suppliers' agile knowledge is beneficial, it remains less critical. Focal firms may thus choose between extensive agile training or vertical integration (see Migration and Blockchain). These distinctions refine existing concepts around supply chain partner insights (Zacharia et al., 2009) by explicitly incorporating suppliers' agile PM capabilities. Thus, we propose:

P10. *When using HPM or APM, (a) customer integration does not depend on customers' agile PM capabilities; (b) supplier integration requires agile PM capabilities, which are desirable for HPM projects but necessary for APM projects.*

6. Conclusions and contributions

Our research offers theoretical and empirical insights regarding the links among SCI configurations, PM methods, and project complexity within collaborative innovation projects. While previous studies examined SCI configurations independently (Flynn et al., 2010; Gaudenzi & Christopher, 2016; Sabet et al., 2017; Sabri et al., 2018; Molinaro et al., 2022), our study specifically examines how SCI configurations and PM methods are jointly designed and implemented to manage project-level complexity effectively.

Our study makes three key contributions. First, we introduce the concept of the innovation PM strategy, which links SCI configurations and PM methods as interdependent elements. Using this concept, we empirically examine how supply, customization, and technological complexity influence these intertwined elements. Our findings offer a systematic interpretation of how companies align these elements to manage collaborative innovation projects. In doing so, we extend prior literature by providing a nuanced understanding of managing innovation projects within supply chain contexts (e.g., Gaudenzi & Christopher, 2016; Jajja et al., 2017; Patrucco et al., 2022a; 2024). We also examine the relationship between the arcs of integration (Frohlich & Westbrook, 2001; Schoenherr & Swink, 2012) and PM methods, showing how project complexity influences their interconnections. This integration builds upon recent applications of the arc of integration framework in studies at the intersection between SCM and innovation (e.g., Ciric Lalic et al., 2022).

Second, we explicitly contribute to project complexity theory by extending it from an intraorganizational setting to the interorganizational context of collaborative innovation projects in the supply chain (Bakhshi et al., 2016; Ralston et al., 2017; Zasa et al., 2021). Our findings illustrate how different complexity dimensions distinctly and sequentially influence innovation PM strategies. Specifically, we conclude that supply and customization complexity are primary considerations informing the initial choice of SCI configurations and PM methods, while technological complexity subsequently necessitates adjustments during implementation. This step-wise approach enriches existing project complexity frameworks (Baccarini, 1996; Geraldi et al., 2011) by revealing their applicability beyond organizational boundaries and emphasizing their implications for SCI implementation in collaborative innovation projects.

Third, our results highlight the critical role of PM capabilities in executing innovation PM strategies effectively. We demonstrate that the PM knowledge and collaborative experience of focal company teams and their supply chain partners significantly influence the implementation of SCI configurations and PM methods. This insight complements prior research emphasizing collaboration capabilities in supply chains (Zacharia et al., 2009; Gaudenzi & Christopher, 2016; Selviaridis & Spring, 2025) by explicitly integrating the dimension of PM expertise. In doing so, we underscore the strategic value for focal firms to assess and actively cultivate PM capabilities within their own teams and among their supply chain partners to effectively capitalize on their collaborative innovation efforts.

6.1 Managerial implications

The findings of our study have significant implications for supply chain and project managers who manage collaborative innovation projects. Figures 3 and 4 serve as guides for managers to identify the most appropriate innovation PM strategy based on the specific characteristics and complexity levels of their innovation projects. Our results provide compelling evidence that supply complexity and customization complexity are key factors to consider when configuring SCI and selecting the PM method. Technological complexity is considered in the second stage, determining necessary adjustments to the PM method and SCI options. Subsequently, the PM capabilities, and specifically of the supply chain partners involved by the focal company, lead to further fine-tuning during the implementation of the innovation PM strategy.

These findings also show that SGPM needn't be the only reliable method for managing collaborative innovation projects. Integration with suppliers and/or customers can be realized using other methods depending on the project's complexity. We also show that full conversion to APM is not always necessary. Traditional "waterfall" techniques can still be successful in projects characterized by low complexity or complexity on the supply side, and can be combined with agile techniques, with SGPM remaining the predominant method, in projects that have high customization complexity but low technological complexity.

The use of APM seems inevitable in projects characterized by high overall complexity that require continuous integration with customers and suppliers. When implementing APM, companies must be aware of the additional risks associated with SCI, particularly concerning supplier integration and collaboration with non-agile suppliers. Firms aiming to shift towards pure APM methods in response to increasing project complexity must carefully refine their selection of suppliers to be integrated into the innovation projects. Supplier selection and integration decisions should include a thorough assessment of suppliers' capabilities and experience in agile PM methods and practices.

In the end, the implementation of different innovation PM strategies hinges on the capabilities of the focal company's project team. This highlights the importance for focal firms to develop diverse skill sets and capabilities in both innovation PM methods and SCI practices.

It emphasizes the need for continuous skill development and the establishment of cross-functional teams capable of navigating the complexities inherent in managing collaborative innovation projects. Continuous training on different PM methods and techniques for effective supplier and customer integration enables companies to adapt to varying levels of project complexity and achieve successful outcomes in their collaborative innovation efforts.

6.2 Limitations and future research

The study has limitations that open up opportunities for future research. First, our research does not explore how focal firms transition between different innovation PM strategies over time, or the key drivers behind such shifts. Investigating these dynamics through longitudinal case studies could provide deeper insights into how innovation PM strategies evolve in response to changing project requirements or uncertainty. Second, our assessment of project complexity focused on specific dimensions, such as supply, customization, and technological complexity, but excluded others, such as project pace and socio-political complexity. These additional dimensions may influence SCI configurations and PM method choices in unique ways. Future research should expand the framework to include these underexplored facets of project complexity, broadening our understanding of their impact on innovation PM strategies.

Third, while our study found a consistent medium-to-high level of organizational complexity across the sample, this uniformity limits insights into the role of varying levels of organizational complexity in shaping SCI configurations and PM methods. This reflects the typical environment of innovation-driven projects, where multi-faceted interactions across diverse stakeholders are commonplace. However, future research should examine organizational complexity across a broader range of projects, including simpler structures, to assess how varying levels of this complexity influence SCI configurations and PM strategies. Such research could also explore potential thresholds or tipping points where organizational complexity begins to significantly affect interorganizational dynamics and decision-making.

Fourth, revenue pressure for firms and the functional nature of projects are important factors that warrant further investigation. Future studies could examine how these factors impact the design and implementation of innovation PM strategies and SCI configurations, potentially offering a more nuanced understanding of collaborative innovation projects. Finally, our study was based on interviews with managers within the focal companies, thus excluding the perspectives of interviewees representing suppliers and customers. This choice may have constrained our understanding of interorganizational dynamics, such as trust, cooperation norms, and alignment of goals, which are critical to the success of collaborative innovation projects. Future research should incorporate insights from supply chain partners to examine how interorganizational relationships influence SCI configurations and PM method choices.

Notwithstanding these limitations, we are hopeful that our study paves the way for exciting future research at the intersection between collaborative innovation in supply chains and project management.

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APPENDIX A. Data coding

A1. Coding of Project Complexity

The coding of project complexity drew upon established frameworks (Geraldi et al., 2011; Maylor & Turner, 2017) and was refined through empirical insights from interviewees. Complexity was coded along four dimensions: technological complexity, customization complexity, internal (organizational) complexity, and external (supply) complexity.

- *Technological complexity* relates to uncertainty in developing the desired project outcome, particularly concerning novel or unfamiliar technologies (Baccarini, 1996). Projects using established technologies, such as Snack, were coded "low." Projects incorporating partially novel technology requiring testing, such as Boat, were coded "medium." Fully novel technologies, requiring extensive exploration, as in Automation, were coded "high."
- *Customization complexity* (or dynamics) addresses how specifically projects were tailored to customer requirements. Projects designed broadly, such as Safety, had "low" complexity. Projects with customer-specific features adaptable to other contexts (e.g., Automation) were coded "medium." Highly customized, customer-specific solutions with significant adaptability requirements (e.g., Load) were coded "high."
- *Internal structural (organizational) complexity* captures coordination challenges within the focal firm. Given the inherently cross-functional nature of innovation projects, none were coded as "low." Projects such as Bottle, which replicated existing internal structures with moderate coordination requirements, were coded "medium." Projects requiring new structures and extensive cross-functional coordination, such as Cloud, were coded "high."
- *External structural (supply) complexity* assesses coordination challenges across the supply network. Projects with few, familiar suppliers, like Snack, were "low" complexity. Those involving a mix of established and new suppliers requiring moderate coordination (e.g., Schedule) were "medium." Projects demanding extensive interactions with new suppliers, requiring rigorous selection and coordination (e.g., Cyber), were coded "high."

A2. Coding of Project Management Method

For coding the PM methods, we analyzed project management principles and approaches as described by interviewees. Projects varied significantly in their adherence to traditional SGPM, APM, or HPM. While some projects followed purely stage-gate models emphasizing sequential phases and upfront planning (e.g., Snack), others adopted entirely agile methods emphasizing iterative processes and flexibility (e.g., Cyber). Many cases applied hybrid approaches, integrating both structured planning from SGPM and adaptive principles from agile methods, with variations in the dominant approach (e.g., Fiber using predominantly SGPM with ad-hoc agile elements, Schedule favoring agile).

We coded PM practices into three first-order dimensions—planning, execution, and monitoring—following established PM frameworks (Project Management Institute, 2017):

- *Planning*: categorized as "upfront," "mixed," or "iterative," reflecting how extensively project activities were predefined or dynamically adjusted. For instance, Snack employed comprehensive upfront planning, Cloud balanced upfront macro-objectives with iterative adjustments, while Website utilized iterative, sprint-based planning with minimal initial structure.

- *Execution*: coded as "project-manager driven," "partially team-driven," or "team-driven," indicating autonomy levels of project teams. Examples include Boat's centralized, manager-driven execution, Schedule’s partially autonomous team structure, and Blockchain’s fully autonomous, team-driven model.
- *Monitoring*: classified as "ad-hoc," "milestone-based," or "continuous," based on evaluation frequency and structure. Snack employed informal ad-hoc evaluations, Safety utilized structured milestone checkpoints, and Cyber adopted continuous, iterative progress assessments through regular meetings.

Detailed examples and representative quotes for this dimension and themes are provided in Section B2 of the supplementary material document.

A3. Coding of Supply Chain Integration Configuration

We coded SCI configurations to examine the extent and nature of strategic integration with suppliers and customers during innovation projects. Initially, our analysis focused inductively on integration characteristics—specifically the timing, extent, and visibility of supplier and customer involvement (Lagrosen, 2006; Koufteros et al., 2007; Parker et al., 2008; Van Echtelt et al., 2008; La Rocca et al., 2016). These first-order concepts were subsequently mapped onto Frohlich and Westbrook’s (2001) “arcs of integration” typology, providing a coherent theoretical categorization. As illustrated in Figure 2, "SCI configurations" is an aggregate dimension consisting of three second-order themes:

- Arc of integration: overall strategic orientation, categorized as inward-facing (limited integration), periphery-facing (moderate integration with either suppliers or customers), supplier-facing (high supplier integration), customer-facing (high customer integration), or outward-facing (high integration with both).
- Characteristics of supplier integration: coded based on timing (when suppliers joined), extent (decision-making responsibility), and visibility (access to project information).
- Characteristics of customer integration: similarly coded based on timing, extent, and visibility.

Detailed examples and representative quotes for this dimension and themes are provided in Section B1 of the supplementary material document.

Coding of Supply Chain PM Capabilities

The case analysis revealed an additional, inductively derived theme not initially included in our conceptual framework (Figure 1), i.e., supply chain PM capabilities. Informants frequently highlighted two specific capabilities necessary for effectively implementing different PM methods: (1) knowledge of the chosen PM methods, and (2) prior experience with collaborative innovation projects utilizing these methods.

- *Knowledge of specific PM methods* was categorized as either advanced or basic, reflecting team familiarity and comfort with the chosen methodology. Teams with advanced knowledge demonstrated proficiency in adapting the PM method to dynamic project conditions. For instance, the Cyber project team's extensive Agile PM knowledge facilitated seamless integration of Scrum practices and iterative sprints. In contrast, basic knowledge indicated foundational familiarity, necessitating additional training or guidance. In the Snack project, suppliers unfamiliar with the SGPM methodology required targeted training from the focal firm to ensure effective implementation.

- *Prior experience in collaborative innovation projects* assessed how extensively teams had previously applied specific PM methods. This dimension was coded as high, moderate, or limited experience. High expertise characterized teams with extensive prior experience, such as the Website project, whose team had completed multiple Agile projects successfully. Moderate experience was evident when teams had managed only a few similar projects (e.g., Schedule), gaining familiarity but encountering occasional implementation challenges. Limited experience indicated minimal prior exposure, exemplified by the Plant project team initially struggling with Agile implementation before gradually developing proficiency.

Detailed examples and representative quotes for this dimension and themes are provided in Section B4 of the supplementary material document.

APPENDIX B. Patterns emerging from the cases and case evidence.

Patterns identified	Case evidence	Explanation
Collaborative innovation projects with low supply and customization complexity adopt inward-facing SCI and SGPM	• In the Snack project, the project team managed activities internally, with suppliers providing essential updates and approvals. SGPM was followed to maintain control and a clear sequence. • Higher technological complexity in the Boat project necessitated ad-hoc supplier involvement to mitigate risks, deviating toward a periphery-facing integration.	• P1: The low supply and customization complexity justified limited supplier integration and reliance on a structured, sequential PM approach. • P5: Technological complexity drove the need for deeper supplier involvement despite low supply/customization complexity.
Projects with high supply complexity and low customization complexity adopt supplier-facing SCI and SGPM	• In the Fiber project, complex logistics and material design required deeper supplier integration while maintaining a structured SGPM approach. • SGPM was the primary method used in the Polymer project, but ad-hoc agile techniques (Scrum) were introduced to address unexpected technological challenges.	• P2: The high supply complexity aligned with closer supplier-facing integration. • P6: Higher technological complexity led to hybrid PM methods to manage supplier integration.
Projects with low supply complexity and high customization complexity adopt customer-facing SCI and HPM.	• In the Load project, high customization required continuous feedback from customers, leading to customer-facing SCI and a hybrid PM approach. • High customization and technological advancements (e.g., Schedule projects) necessitated a predominance of agile methods in a hybrid PM approach.	• P3: Customization complexity drove greater interaction and flexibility via HPM. • P7: Agile components helped manage technological uncertainty while maintaining customer-facing integration.
Projects with high supply and customization complexity adopt outward-facing SCI and APM	• In the Migration project, high complexity required continuous collaboration with both customers and suppliers. A flexible, agile approach was necessary to meet all demands. • The high technological complexity in the Cyber project, mandated suppliers with agile expertise to	• P4: The combination of high supply and customization complexity made outward-facing integration and APM essential. • P8: Agile-experienced partners were critical to manage technological risks.

	ensure rapid iterations and smooth collaboration. • In the Blockchain project, the development risks and technological complexity of the solutions did not make possible to train non-agile suppliers to reach the desired level of agile expertise.	
SGPM implementation depends on the expertise of supply chain partners.	• In the Boat project, the decision to increase the supplier integration was also based on "their familiarity with the collaborative process. • In the Snack project, suppliers with basic SGPM knowledge required additional training to ensure alignment with the structured method. • In the Safety project, the previous expertise of one of the IT suppliers in collaborative projects (using SGPM) was considered vital to manage the complexity of the virtual supply chain.	• P9: Limited supplier expertise hindered seamless integration, highlighting the importance of experience. Existing experience with SGPM facilitated effective implementation.
For APM/HPM, customer integration is independent of customer capabilities; supplier-facing integration depends on supplier capabilities.	• In the Website project, customers with limited APM experience actively participated and provided valuable input throughout the project. • In the Automation project, working with non-agile suppliers created challenges, requiring them to work independently with limited interaction • In the Cyber project, it was essential that the supplier partner was adept at agile practices. Without this, the iterative and rapid development cycle would have been impossible to manage effectively.	• P10a: Customer-facing integration proceeded effectively, independent of the customers' APM expertise • P10b: Supplier-facing integration was hindered by the supplier's lack of APM capabilities